Param Poojya Dr. Babasaheb Ambedkar Smarak Samiti's

Dr. Ambedkar College

Deeksha Bhoomi, Nagpur

RE-ACCREDITED WITH '**A**' GRADE BY NAAC **CGPA: 3.45**

RECOGNIZED AS "COLLEGE WITH POTENTIAL FOR EXCELLENCE" BY UGC

3.3.1

Number of research papers per teachers in the Journals notified on UGC website during the last five years

Academic Year: 2021-22

Criterion 3

3.3.1. Number of research papers per teachers in the Journals notified on UGC website during the last five years

S N.	Title of Research Article	Author(s)	Journal	Department	UGC Care Listed	Page No.
1	In silico Identification of Genes and Molecular Pathways during Aging in Drosophila Brain.	Parakh, A., **D. Begde**, and N. Dhingra	Advances in Aging Research	Biochemistry and Biotechnology	Yes	**1-19**
2	Adipokines in Insulin Resistance: Current Updates	**Utpal Jagdish Dongre**	Biosciences Biotechnology Research Asia	Biochemistry and Biotechnology	Yes	**20-29**
3	Investigation of anti-swarming, anti-biofilm and anti-quorum sensing potential of some organic tea of different brands from india	**P. V. Hirapure, S. A. Paranjape**, T. V. Bind, K. K. Bawankar and V. J. Upadhye	IJPSR	Biochemistry and Biotechnology	Yes	**30-46**
4	Evaluation of Cytotoxicity and Genotoxicity of Water from Nag River, Nagpur, India	**P. V. Hirapure, S. A. Paranjape**, V. S. Sarodaya, **B. A. Mehere** and V. J. Upadhye	Nature Environment and Pollution Technology an International Quarterly Scientific Journal	Biochemistry and Biotechnology	Yes	**47-53**
5	Extremophiles: Potential Sources of Valuable Biomolecules	**Hirapure Pradip** and Shanware Arti	Research Journal of Biotechnology	Biochemistry and Biotechnology	Yes	**54-59**
6	A review on eco-friendly approach for green synthesis of zinc oxide nanoparticles using plant leaf extracts, Journal of Advanced Scientific Research, 2021, 12(2), 1-16	**Dr. N. G. Telkapalliwar**	Journal of Advanced Scientific Research	Chemistry	No	**60-75**
7	Structural and Electrical Studies of Aluminium-doped Nickel Cobalt Ferrite Nanoparticles.	S P. Waghmare**, D. M. Borikar**. M. A. Borikar, K. G. Rewatkar	Jordan Journal of Physics	Chemistry	Yes	**76-77**
8	A Study of Covid -19 Pandemic Relief Package and Government Policy Stance Impact on Financial Inclusion through PMJDY.	**Mrs. Shefali Rai**	Journal of Interdisciplinary Cycle Research	Commerce	Yes	**78-90**
9	A study of Financial Inclusion under Pradhan Mantri Jan Dhan Yojana with reference to Financial Management Framework.	**Mrs. Shefali Rai**	Journal of Interdisciplinary Cycle Research	Commerce	Yes	**91-100**
10	कोरोना-१९महामारीच्या दरम्यान ऑनलाइन शिक्षणात येणारी आव्हाने आणि मिळणाऱ्या सुवर्णसंधी Online Teaching During The Corona-19 Pandemic	**Dr. D. H. Puttewar**	RESEARCH NEBULA An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Arts, Commerce, Education & Social Sciences	Commerce & Management	No	**101-106**

11	COVID-19 and its Implications on the Digital Marketing	**Dr. D. H. Puttewar**	B. Aadhar' International Peer-Reviewed Indexed Research Journal	Commerce & Management	No	**107-110**
12	Role of Skill Development Programs on the Entrepreneurship Development in line with the New Education Policy	**Dr. D. H. Puttewar**	B. Aadhar' International Peer-Reviewed Indexed Research Journal	Commerce & Management	No	**111-116**
13	Impact of data warehousing and data mining in business	**Dr. P. V. Nimbalkar**	Interdisciplinary Peer-Reviewed Indexed Journal	Computer Science	No	**117-126**
14	Summarization of automatic text simplification using natural language processing	**Dr. P. V. Nimbalkar**	Interdisciplinary Peer-Reviewed Indexed Journal	Computer Science	No	**127-131**
15	Classification and Performance of Biometric Authentication	**Dr. Vijeet H. Meshram**, Dr. Ashish B. Sasankar	International Journal of Scientific Research in Computer Science, Engineering and Information Technology	Computer Science	Yes	**132-136**
16	Study of Deep Reinforcement Learning	**Dr. Avinash H. Hedaoo**	International Journal of Research Publication and Reviews	Computer Science	No	**137-148**
17	Generative Adversarial Networks: A Review	**Dr. Avinash H. Hedaoo**	international journal for science and advance research in technology	Computer Science	No	**149-159**
18	Study of Convolutional Neural Network	**Dr. Avinash H. Hedaoo**	International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)	Computer Science	No	**160-173**
29	Study of Convolutional Neural Network	**Dr. Avinash H. Hedaoo**	International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)	Computer Science	No	**174-187**
20	Deep Learning and its Application: A Review	**Dr. Avinash H. Hedaoo**	International Journal of Research Publication and Reviews	Computer Science	No	**188-200**
21	Machine Learning and It's Application: A Survey	**Dr. Avinash H. Hedaoo**	International Journal for Science and Advance Research in Technology	Computer Science	No	**201-210**
22	Applications of Deep Learning Techniques in Agriculture: A Review	**Dr. Avinash H. Hedaoo**	International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)	Computer Science	No	**211-222**

23	चंद्रपूर जिल्यातील आदिवासी शेतकर्यांच्या आर्थिक समस्या	**Dr. Harish m. Bawangade**	RESEARCH HUB	Economics	Yes	**223**
24	चंद्रपूर जिल्यातील आदिवासी शेतकाक्र्यांच्या उत्पन्नानचे आर्थिक अधयायन	**Dr. Harish m. Bawangade**	GALAXY LINK	Economics	Yes	**224-227**
25	चंद्रपूर जिल्यातील आदिवासी शेत्कार्यांसाठी राबविण्यात येणाऱ्या कृषी विषयक योजना	**Dr. Harish m. Bawangade**	UPA NATIONAL E JOURNAL	Economics	Yes	**228**
26	चंद्रपूर जिले के आदिवासी किसानो का दर्द	**Dr. Harish m. Bawangade**	Global Research Canvas	Economics	Yes	**229**
27	Application of Fuzzy logic Technique for Oil drilling problem	**K.Y.Rokde,** S.S.Shende	International Journal of Scientific research in Science, Engineering and Technology [IJSRSET]	Electronics	Yes	**230-234**
28	Implementation of Low- cost Data Acquisition System for Temperature Measurement	**K.Y.Rokde,** S.S.Shende, S.R.Sharma	World Wide Journal of Multidisciplinary research and Development	Electronics	Yes	**235-239**
29	Melang Of Cultures in Amitav Ghosh's Ibis Trilogy	**Dr. Anita Tirpude**	LangLit An International Peer-Reviewed Open Access Journal	English	No	**240-246**
30	1) Rabindranath Tagore and the English Language	**Dr. Priti Singh**	1) Knowledge Resonance, A Half Yearly Peer Reviewed Research Journal.	English	No	**247-249**
31	Driven to discover–indian english writers	**Mr Manoj Andraskar**	Indian Writings in English -A Review	English	No	**250-258**
32	Passive resistance of landless people in maharashtra (1959)	**Avinash Fulzele**	THIRD CONCEPT An International Journal of Ideas	Hiistory	Yes	**259-261-264**
33	Bharatiya Sangit Parampara me marathi lokagiton ka yogadan	S Y Meshram, **A D Fulzele**, R H Meshram	SWAR SINDHU National Peer-Reviewed /Refereed Journal of Music	Hiistory	Yes	**265-271**
34	Shidnak Mahar: an unknown warrior among untouchables	**Avinash Fulzele**	SAMPRITI Double blind Peer Reviewed National Research Journal of Humanities and Social Sciences	Hiistory	Yes	**272-278-284**
35	Dr Ambedkar and formation of united maharashtra	**Avinash Fulzele**	THIRD CONCEPT An International Journal of Ideas	Hiistory	Yes	**285-290**
36	An Assessment of the Role of Disaster Management Authority and Community during Covid-19 Outbreak in India"	**Mrs. Vaishali A. Sukhdeve**	International Journal of Law Supremo Amicus	Law	No	**291-299**

37	Effects of Climate Change on Public Health in India: A Concern of 21st Century	**Dr. Sandhya Kalamdhad**	International Journal of Research & Analytical Review (IJRAR),	Law	No	**300-316**
38	"Intergenerational Equity: A Socio-Legal Framework for Climate Change"	**Dr. Sandhya Kalamdhad**	International Journal of Multidisciplinary Research & Development, International Journal of Multidisciplinary Research Development	Law	No	**317-323**
39	"New Consumer Protection Act, 2019- A positive step towards Reformation of consumer Laws and Rights in India	**Dr. Pratima R. Lokhande**	Rainbow Multidisciplinary Peer Reviewed Annual Journal Vol.7 2021	Law	No	**324-329-332**
40	Study of Geographical Indication Protection to Tirupati Laddu in The Light of Objective of GI Law in India	**Shilpa Rathod**	International Journal of Multidisciplinary Educational Research (IJMER) Journal	Law	No	**333-339**
41	Critical Evaluation of Maintenance and Care of Parents and Senior Citizens Act,2007	**Dr. Hema Menon** and Dr. Swati.R.Chiney	Indian Journal of Law and Legal Research	Law	Yes	**340-353**
42	"Where Are the Women in IPR? An Endeavour in Bridging the Gender Gap in Intellectual Property Rights"	**Shilpa Rathod**	B Aadhar Journal Peer Reviewed and Referred Indexed Multidisciplinary International Research Journal	Law	Yes	**354-358-361**
43	Influence of Bi3+ ions substitution on structural, magnetic, and electrical properties of lead hexaferrite	Y.D. Choudhari , **K.G. Rewatkar**	Journal of Magnetism and Magnetic Materials	Physics	Yes	**362-373**
44	Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu3+ doped strontium hexa-aluminate nanophosphors for lighting application	**Priti Chaware**, Amol Nande, SJ Dhoble, **KG Rewatkar**	Optical Materials	Physics	Yes	**374-383**
45	Photoluminescence and Judd-Ofelt analysis of Eu3+ doped akermanite silicate phosphors for solid state lighting	**P.J. Chaware**, Y.D. Choudhari , D.M. Borikar , **K.G. Rewatkar**	Optical Materials	Physics	Yes	**384-395**
46	Analysis of structural, electric and magnetic features of Bi3+ substituted nanocrystalline calcium hexaferrite	Y.D. Choudhari, **K.G. Rewatkar**	Materials Today: Proceedings	Physics	Yes	**396-403**
47	Photoluminescence and Judd-Ofelt analysis of Eu3+ doped akermanite silicate phosphors for solid state lighting	**PJ Chaware**, YD Choudhari, **DM Borikar**, **KG Rewatkar**	Optical Materials	Physics, Chemistry	Yes	**404-415**
48	Synthesis and structural characterization of zinc substituted calcium W-type hexagonal ferrite	Smita Tolani, **Kishorchandra Rewatkar**	Materials Today: Proceedings	Physics	Yes	**428-429**

49	Impact of La on Structural, Morphological and Magnetic Properties of NiCoFe2O4 Nano Ferrites	PK Nagpure, **AK Nandanwar**, VM Nanoti, **KG Rewatkar**	Jordan Journal of Physics	Physics	Yes	**430-436**
50	Analysis of structural, electric and magnetic features of Bi3+ substituted nanocrystalline calcium hexaferrite	YD Choudhari, **KG Rewatkar**	Materials Today: Proceedings	Physics	Yes	**437-438**
51	Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu3+ doped strontium hexa-aluminate nanophosphors for lighting application	**Priti Chaware**, Amol Nande, SJ Dhoble, **KG Rewatkar**	Optical Materials	Physics	Yes	**439-448**
52	Mahatama Phule ani Streemukti	**Vidhya Chourpagar**	RAINBOW Multidisciplinary Peer Reviewed Annual Journal	Political Science	No	**449-457**
53	स्त्रियांची राजकीय सत्ताहीनता	**Vidhya Chourapagar** and Dr. Vikas Jambhulkar	परिवर्तनाचा वाटसरू	Political Science	Yes	**458-464-498**
54	**1.** Kluver-Barrera Demonstration of different apparatus of Olfactory System in Garra mullya	**R S Bagade**	New International Insistent Research Journal	Zoology	No	**502-508**
55	Surface cellular details of the olfactory rosette: a scanning electron microscopic (sem) study in hill stream cyprinidiae, garra mullya (sykes)	**R S Bagade, DVNS Suresh**	International Journal of Research in Biosciences, Agriculture & Technology	Zoology	No	**509-518**
56	Reproductive Phase-related Plasma Proteins in Labeo rohita	**R S Bagade, DVNS Suresh**	International Journal of Life Sciences	Zoology	No	**519-524**
57	Partial Characterization of Sex-Hormone binding Globulin (SHBG) in Labeo rohita.	**R S Bagade, DVNS Suresh**	International Journal of Research in Biosciences, Agriculture & Technology	Zoology	No	**525-534**
58	Phytochemical Screening and antibacterial activity of leaves extract of Sterculia urens Roxb.	Khadse, P. D.; **Sawant R. C**.	J. Pharm. Sci. & Res.	Chemistry	Yes	**535-537**
59	Nanoparticles for sustainable agriculture: innovative potential with current and future perspectives	SR Somkuwar, **RC Sawant**, PP Ingale, DT Masram, RR Chaudhary	Biogenic Sustainable Nanotechnology, Elsevier	Chemistry	Yes	**538-555**
60	Review on Synthesis Route of Quinazoline Based Hybrid Derivatives	**Dr. D. Y. Panhekar**	Asian Journal of Chemistry	Chemistry	Yes	**556-578**

Advances in Aging Research, 2021, 10, 78-96
https://www.scirp.org/journal/aar
ISSN Online: 2169-0502
ISSN Print: 2169-0499

Insilico Identification of Genes and Molecular Pathways during Aging in *Drosophila* Brain

Arpita Parakh[1], Deovrat Begde[2], Naveen Dhingra[1*], Deepak Sinha[1]

[1]Institute of Biological Science, SAGE University, Indore, India
[2]Department of Biochemistry and Biotechnology, Dr. Ambedkar College, Deeksha Bhoomi, Nagpur, India
Email: *navlifescience@gmail.com

How to cite this paper: Parakh, A., Begde, D., Dhingra, N. and Sinha, D. (2021) Insilico Identification of Genes and Molecular Pathways during Aging in *Drosophila* Brain. *Advances in Aging Research*, **10**, 78-96.
https://doi.org/10.4236/aar.2021.104005

Received: December 9, 2020
Accepted: July 19, 2021
Published: July 22, 2021

Copyright © 2021 by author(s) and Scientific Research Publishing Inc.
This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).
http://creativecommons.org/licenses/by/4.0/
Open Access

Abstract

The regulation of gene expression in brain vicissitudes during aging is still not much known and explored. Differential gene expression and regulation is a key factor involved to identify the important landmarks within the brain transcriptome to study neuronal aging. Recently, transcriptomic studies are highly explored to understand and depict diseased versus normal as next generation sequencing enables to capture the complete biological context to the entire genome. Study of gene expression during aging compared to young flies provides a signature and scenario of gene expression and regulation during aging. In this study, we took advantage of NGS raw data of young and old flies head from SRA database of NCBI and decrypted the gene expression regulation during normal aging in drosophila model. We identified 350 genes with significant differential expression between young and old flies having 0.01% FDR. Various pathways in context to identified genes which are involved in aging include autophagy *i.e.* cell death and apoptosis, proteolysis, oxidative stress, declination grey and white matter and neurotransmitter levels, mitochondrial discrepancy, electron transport chain, sugar degradation pathways, activation of transcription factors involved in epigenetic changes, regulators involved in negative and positive regulation WNT signaling pathways, G protein coupled receptor etc. as all these factors contribute to neurodegeneration and possibly dementia in normal aging. So, to find the specific genes and regulators which are differentially expressed in normal aging, we investigate brain transcriptome of normal aging flies compared to young flies which offer a repertoire of genes, regulators and factors involved in network of neurodegeneration to establish direct correlation between aging and dementia. We also identified the pathways which are involved in aging and corresponding gene regulation in these pathways in aging flies brain. It is found that there are some common pathways whose genes and regulators are highly differentially regulated in both aging and dementia.

Keywords

Neurodegeneration, Brain Aging, Dementia, Gene Regulation Pathways

1. Introduction

Aging is followed by cognitive decline in brain and basic risk factor for neurodegenerative disorders. There are many toxic proteins involved in brain aging giving rise to many disorders like Alzhiemer's, parkinsons, memory loss and synaptic plasticity. The toxic protein aggregation is influential factor involved in neurodegeneration [1]. This aging may lead to progression of age related disorder, Alzhiemer's disorder. Amyeloid beta plagues and neurofibrillary tangles are undoubtedly major hallmarks of Alzhiemer's which is increased due to accumulation of these toxic proteins, and remarkable pathways are associated with Alzhiemer's like oxidative stress and low amount of antioxidants [2]. A recent publication showed that AD is not only a neurodegenerative, but it is systemic too [3] which evidences repotire of genes involved in neurodegeneration which are not only expressed in brain but also in other tissue parts. So, before finding distinctive features defined as tangles and plagues, we can identify hallmark regulators which are responsible for this accumulation.

Global transcriptome analysis provides important information about brain aging in various animal models including *Drosophila* which is relatively easy to handle due to its small brain size and capacity to acquire genetic manipulations. Fly brain studies are useful to untangle various neurological disorders like Alzhiemers's [4], Parkinson's [5] that occurs with the effect of aging and to understand the role of various pathways and regulators which play or interplay in the aging and neurodegeneration. Several groups demonstrated the gene expression modulation in aging in mammals [6] [7] [8] containing many tissue types including brain and have used the microarray data which have much more contamination and more false positives than that of RNA sequencing. Single cell RNA technique was also used to identify the brain aging precluding the gene expression changes and specific pathway information related to aging [9]. Recently, the whole transcriptome brain profiling of aging flies is published which includes both the sexes and ages with the coexpression module of genes affecting learning and memory [10] but has not shown the correlation of neurodegenerative disorders with aging.

Here, we provide the differential gene expression studies of whole fly brain of both the sexes young versus old and also the common pathways and its genes involved in aging and dementia commonly.

2. Materials and Method

In this study we have used eight different samples of paired end RNA sequence of fly heads in which 4 samples are from brain tissue of 5 days (1 male and 1 fe-

male) and 10 days (1 male and 1 female) young flies. Another 4 samples contains 20 days (1 male and 1 female) and 30 days (1 male and 1 female) brain tissue of old fly heads taken from sequence read archive database from NCBI (http://www.ncbi.nlm.nih.gov.in/SRA) under accession no. PRJNA418957. The young and old samples are bifurcated accordingly considering one male and 1 female in each age group. The RNA-seq data contains sequence reads as there are some experimental and sequencing errors which may create noise including adapters and hence they need to removed and trimmed off. The sequence reads are filtered using a cutadapt program which is used to remove adapter sequence from the reads and sequencing errors.

2.1. Mapping and Alignment of Reads

The filtered reads are aligned and mapped against the drosophila whole genome to identify the regions which are expressed in both young and old fly heads. The mapping is done using bowtie 2.0 to get the BAM file containing header, mapping quality and reads which are sequenced. There are 16 sets obtained containing reverse as well as forward reads aligned and a set of regions which are not aligned.

2.2. Counting the Reads to Annotate against the Respective Genes

The aligned reads are obtained from BAM files generated by bowtie. These reads are further counted against the protein coding gene to obtain the annotation of reads. For this featurecount program is used to obtain the counts. The reads which are overlapped with the genes are counted and annotated. The number of overlapping reads also depends upon the depth of the sequence and quality of the sequencing. The count file is simple tabular file generated containing gene IDs and number of reads against them.

2.3. Differential Gene Expression Analysis and Gene Annotation

The obtained count file is used as input for differential analysis [11] [12] of the gene *i.e.* the reads which are counted against the gene is analysed for differential expression in young flies and old flies to find out the gene regulation in brain of old age flies compared to young flies. Limma voom [13] [14] package is used for finding differential expression of gene. The tool is used to analyse mean variance of the samples and normalisation of each sample count file. The mean variance analysis and statistical analysis is the measure of expression of gene in each sample which can further filtered to get the most differential expression of the gene [15] [16] [17]. The differentially expressed genes are established for gene ontology analysis to get the biological function of each gene and pathways in which these genes are involved. The pathways are also designed and deduced for identifying the actual connection of each gene with the other and hence gene regulatory network of the complete highly expressed genes is obtained.

3. Results

3.1. Identification of Genes Mapped with Young and Old Fly Heads of Male and Female

Sequences obtained from different samples of aging male and female flies from SRA dataset are raw sequences containing noise and unwanted sequencing errors hence it needs to go through quality check to get efficient results, for this trimmomatic and cutadapt [18] program is used to remove noise and adapter sequences and it was found that around 60% reads are unique in reverse and 48.5% reads are unique in forward strand in paired end RNAseq data of aging flies' heads. The refined and filtered data is deployed for mapping which is done by bowtie2.0 program against the reference genome of drosophila melanogaster to identify the genes which are affected in old flies in comparison to young flies. The mapping statistics is shown in (**Figure 1**) which indicates 40% - 60% of alignment which is found to be unique and round 20% - 40% reads are unaligned with the drosophila genome.

The BAM file is obtained as output file of mapping which is actually compressed form containing mapping information which is further inspected and visualised through IGV (integrated genome viewer) [19] [20] which shows mapped reads at each position and connecting lines between the aligned reads indicate reads mapped against introns (**Figure 2**).

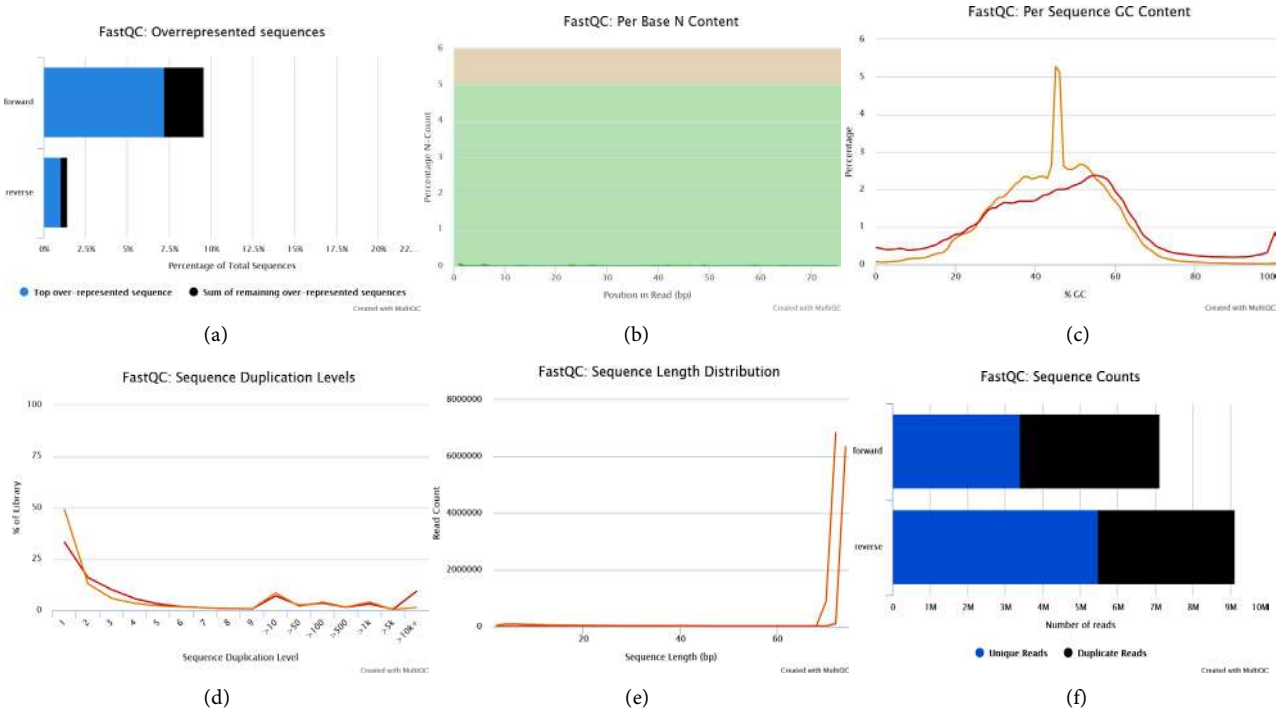


Figure 1. The quality of reads generated from RNAseq of flies head obtained after using trimmomatic and cutadapt function. (a) Shows the percent of overrepresented sequences in forward and reverse strands. (b) Shows N content left after trimmomatic function applied over the reads. (c) Showing GC content present in each sequence of forward and reverse strand. (d) Shows duplication level of the sequence in each strand. (e) Shows length distribution of the reads. (f) Shows sequence counts in both forward and reverse strand.

3.2. Counting Number of Reads per Annotated Genes

For counting the number of reads many programs are there [21] [22] [23] corresponding to each annotated gene we used featurecount [15] program which takes the mapped BAM input and type of strandness as we have unstranded RNAseq data hence we got the counts in forward as well as reverse direction both. We also used a gtf. file as input to get the annotated genes against the reads. 20% - 30% of reads are mapped with genes and the numbers are found to be less due to use of a particular tissue type against the whole genome of flies (**Figure 3**).

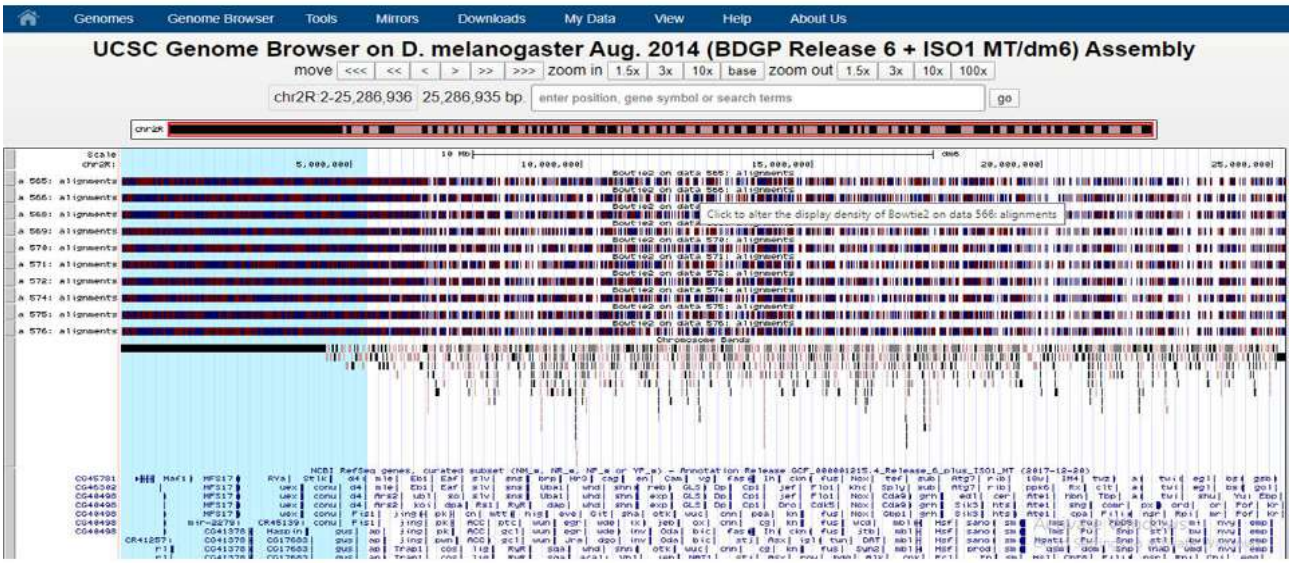


Figure 2. The mapping regions present on the chromosome X of all the 8 samples and regions of each samples are mapped differently shows the differential expression of regions.

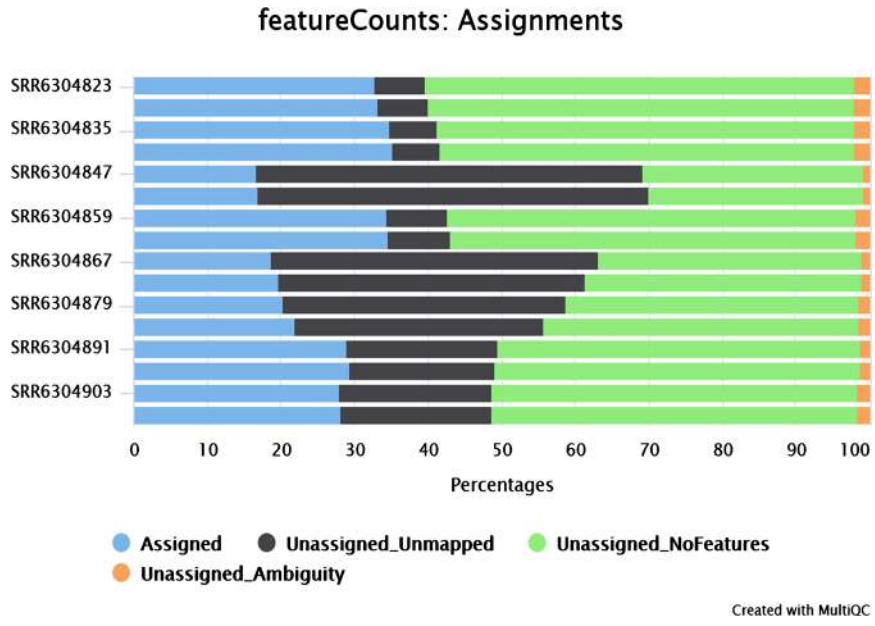


Figure 3. X-axis shows percent of reads assigned to the genes and Y-axis show the sample number. The graph shows basic statistics of reads which are mapped against the gene.

3.3. Identification of Differentially Expressed Features

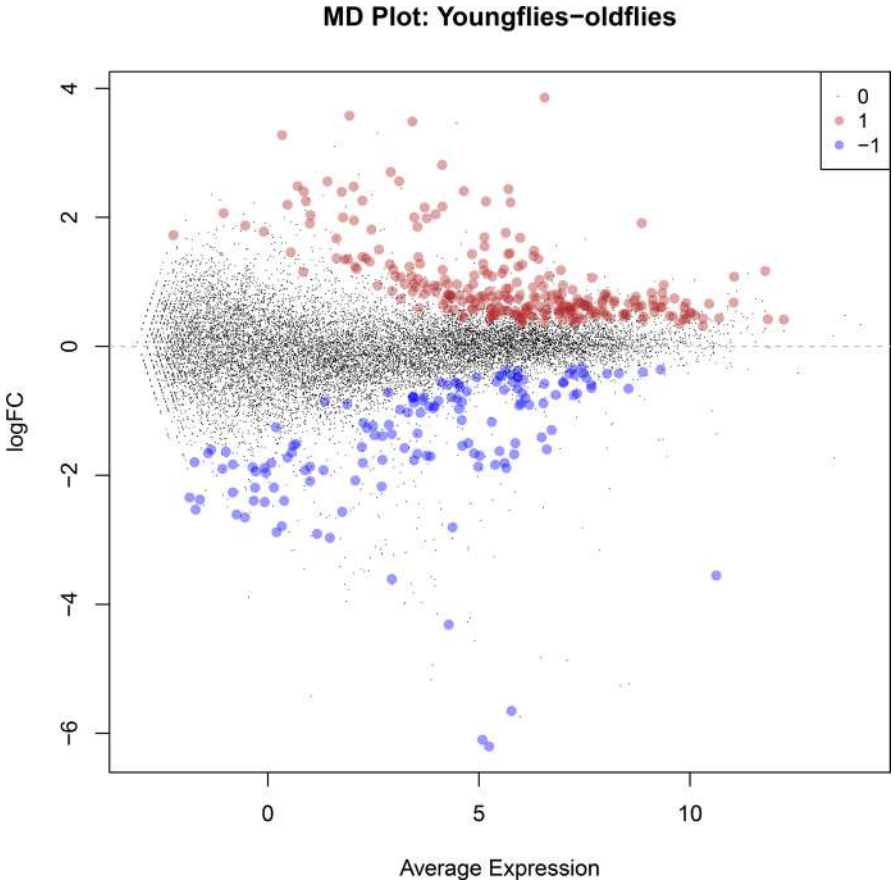
To be able to identify differential gene expression [24] in old flies all dataset of total 8 samples having forward and reverse strands are analysed. 4 samples of young flies *i.e.* 5 days and 10 days old and 4 samples of old flies having 30 days and 40 days old are analysed and as we have already 8 files containing forward and reverse counts against each gene. Some samples have more reads compared to other samples which shows higher sequencing depths of the samples hence mapping of reads against the gene also depends on sequencing depth and length of the gene, longer the gene higher the reads found against them. So, to deal with such situation normalization of data is done and for that limmavoom [13] [14] is used to run Differential gene expression. The R script is used for limma package to normalise the count table obtained from different samples and this step is done to equalise the relative abundance of each gene in a RNA sample as in some cases small number of genes are highly expressed in one sample compare to another which may cause false positives hence normalisation is used for equalising the abundance. Here, we incorporated a factor called aging of flies comprising young flies and old flies. The data generated here contains the differential regulation of genes of old flies compared to young flies. And it was found that 141 genes are upregulated and 262 genes are down regulated in old flies as compared to young flies out of approx. 17,555 genes. The summary table is obtained containing gene identifiers, mean of normalised counts average to all samples, fold change in log2, standard error estimate for log2 fold change, wald statistics, p value, p value adjusted to multiple testing which controls FDR. A graphical summary of results is obtained which contains mean variance plot, mds and box plots and volcano plot (**Figures 4-6**) which show the variance and similarity in the gene expression of different samples.

3.4. Extraction and Annotation of Differentially Expressed Genes

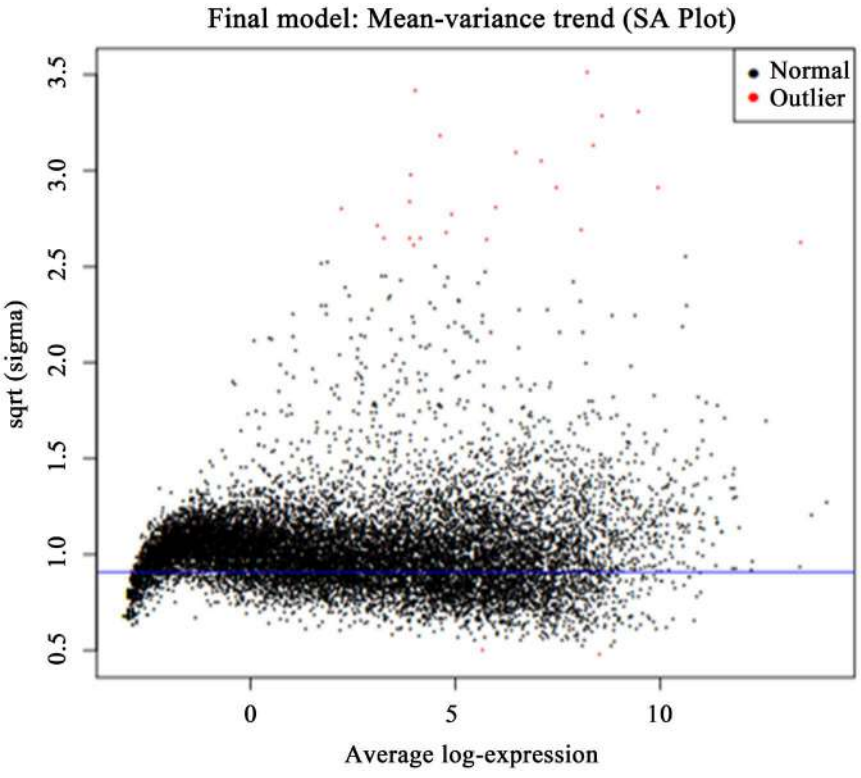
This obtained data is filtered to extract and annotate differentially expressed genes by identifying absolute fold change greater than 2 and for that first the significant adjusted p value is calculated by filtering all values less than 0.05 and found 430 genes which are significantly expressed further this result is narrowed down by filtering abs log 2 fold value greater than 1. It was found that there are 350 genes which are expressed differentially with significant adjusted p value. The mean variance of table is calculated and Z scores are calculated and annotated using DAVID. The top 32 genes with Z scores are shown in heatmap (**Figure 6**).

3.5. Gene Ontology Analysis

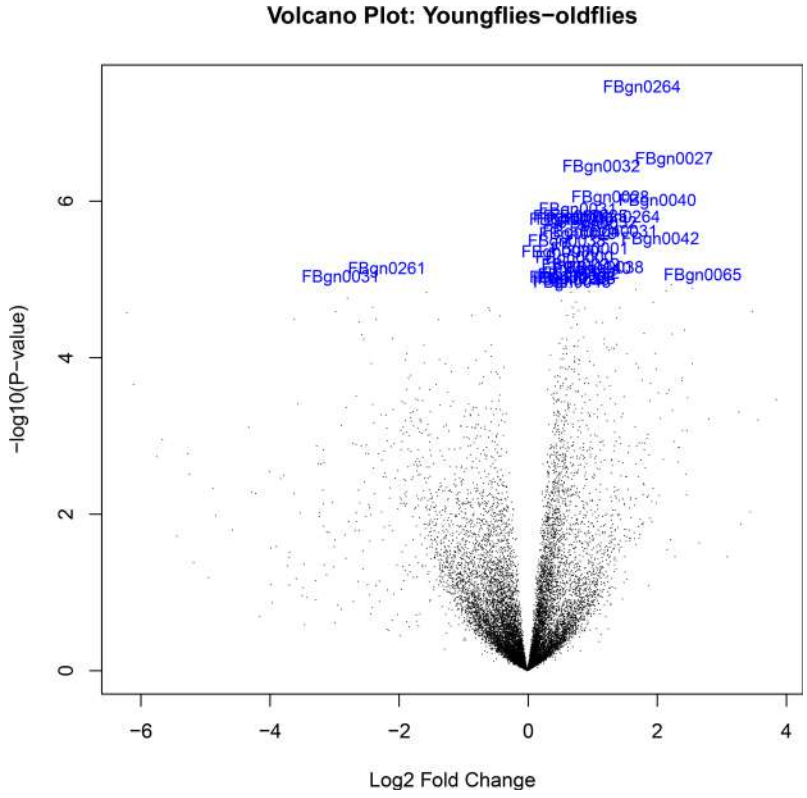
The genes are further analysed to identify their presence in various biological pathways and to understand the process of aging in more depth. The Go analysis reduces the complexity by linking the gene directly to its biological and molecular function. Goseq program is used to identify the pathways related to these genes. The wallneius Rank category method is used to get corresponding GO


MD Plot: Youngflies−oldflies
0
1
−1
logFC
4
2
0
−2
−4
−6
0
5
10
Average Expression

(a)

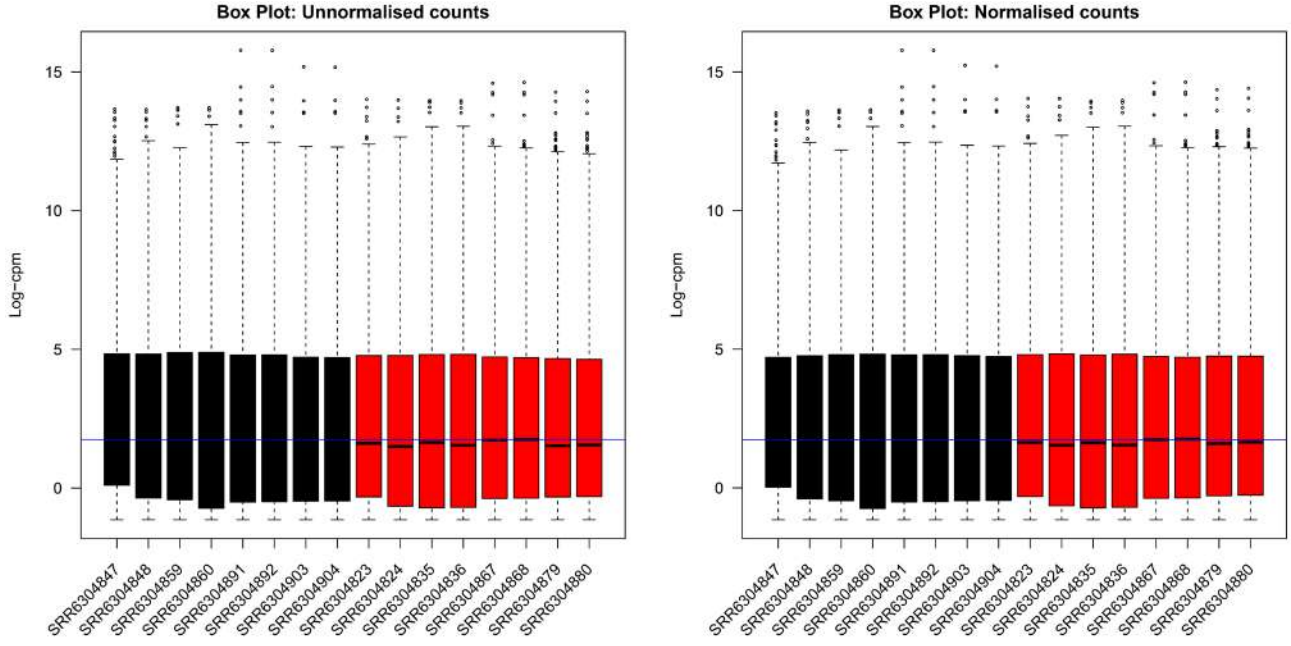

Final model: Mean-variance trend (SA Plot)
Normal
Outlier
sqrt (sigma)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
5
10
Average log-expression

(b)

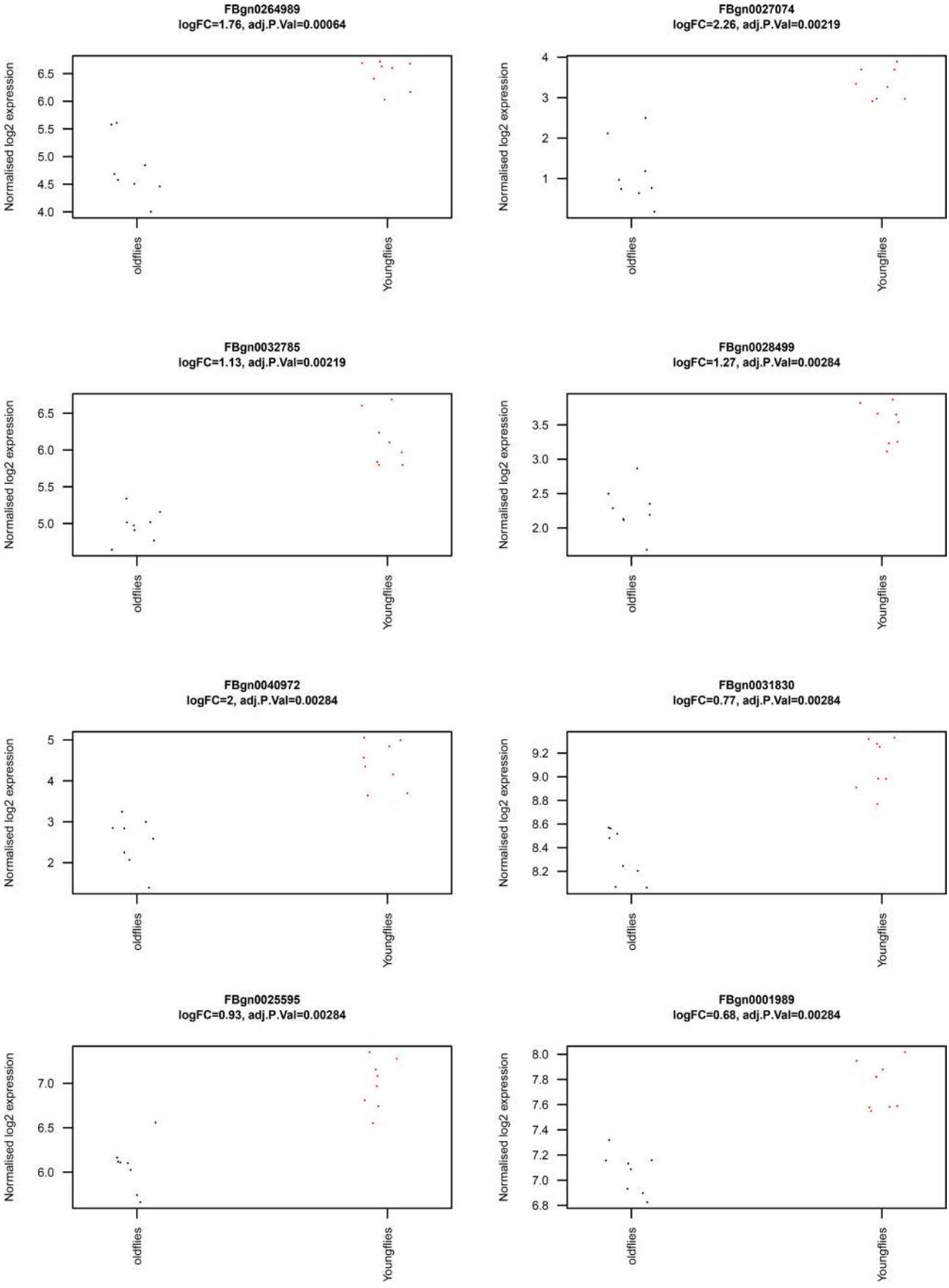


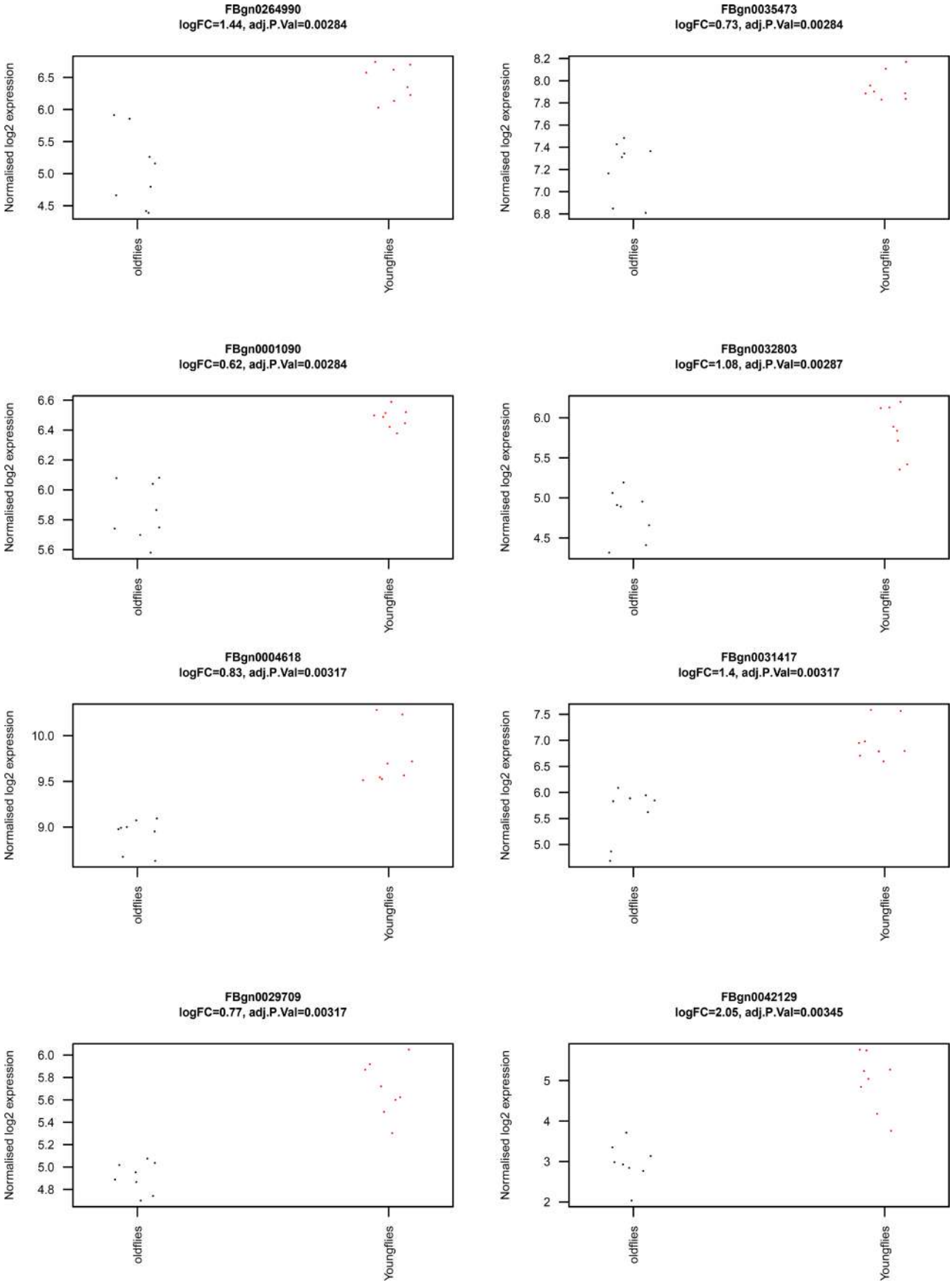
(c)

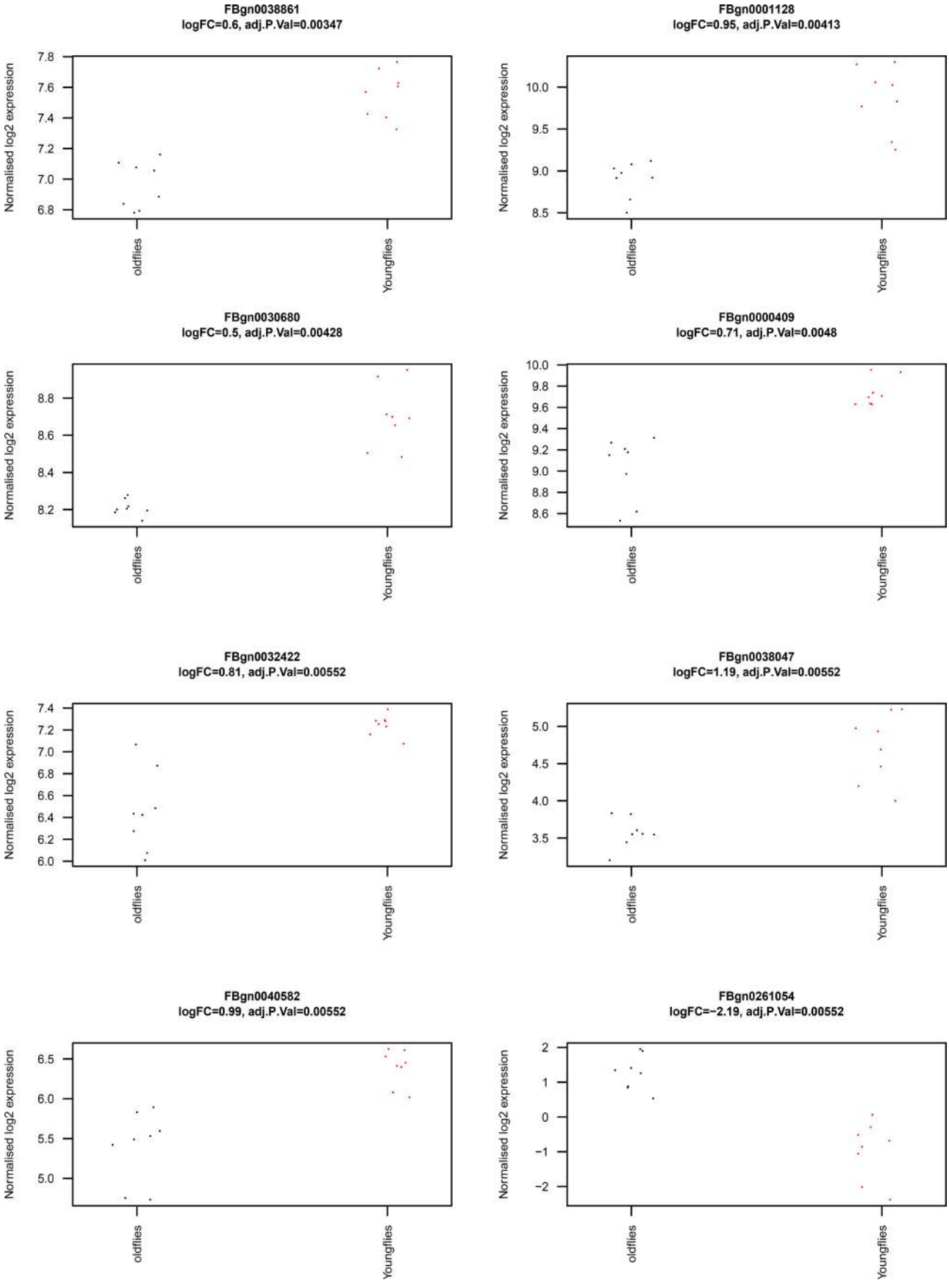
Figure 4. (a) shows fold change value red dots signifies genes having positive values *i.e.* genes which are upregulated and blue dots shows gene having negative log fold value *i.e.* genes are down regulated. (b) mean variance model shows number of genes present in outliers and the values of genes fall under mean variance value. (c) shows log fold change value of gene *i.e.* the negative values plotted shows the down-regulated genes and positive values show the up-regulated genes.

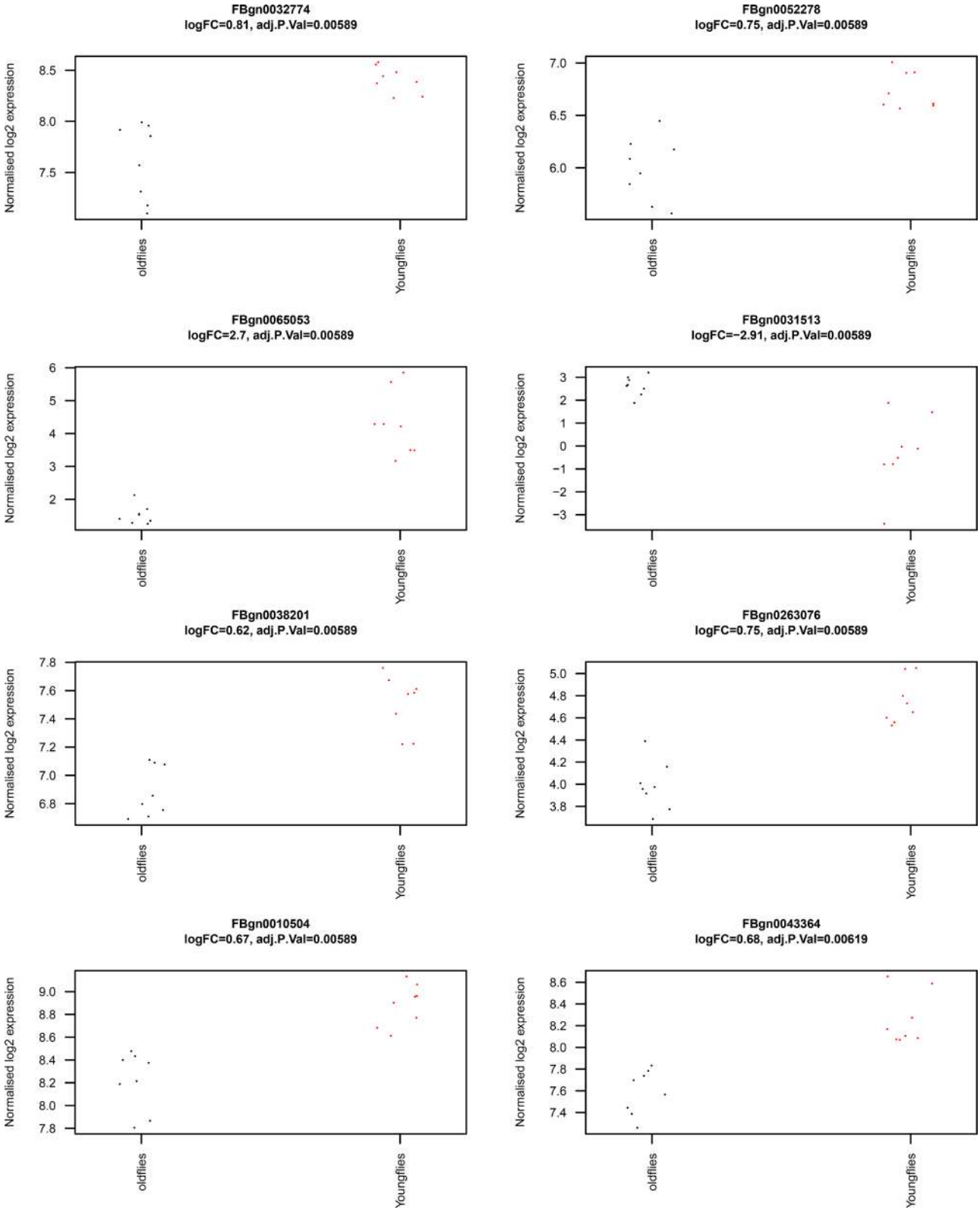


(a)


FBgn0264989
logFC=1.76, adj.P.Val=0.00064
FBgn0027074
logFC=2.26, adj.P.Val=0.00219
FBgn0032785
logFC=1.13, adj.P.Val=0.00219
FBgn0028499
logFC=1.27, adj.P.Val=0.00284
FBgn0040972
logFC=2, adj.P.Val=0.00284
FBgn0031830
logFC=0.77, adj.P.Val=0.00284
FBgn0025595
logFC=0.93, adj.P.Val=0.00284
FBgn0001989
logFC=0.68, adj.P.Val=0.00284
Normalised log2 expression
oldflies
Youngflies


FBgn0264990
logFC=1.44, adj.P.Val=0.00284
FBgn0035473
logFC=0.73, adj.P.Val=0.00284
FBgn0001090
logFC=0.62, adj.P.Val=0.00284
FBgn0032803
logFC=1.08, adj.P.Val=0.00287
FBgn0004618
logFC=0.83, adj.P.Val=0.00317
FBgn0031417
logFC=1.4, adj.P.Val=0.00317
FBgn0029709
logFC=0.77, adj.P.Val=0.00317
FBgn0042129
logFC=2.05, adj.P.Val=0.00345
Normalised log2 expression
oldflies
Youngflies


FBgn0038861
logFC=0.6, adj.P.Val=0.00347
FBgn0001128
logFC=0.95, adj.P.Val=0.00413
FBgn0030680
logFC=0.5, adj.P.Val=0.00428
FBgn0000409
logFC=0.71, adj.P.Val=0.0048
FBgn0032422
logFC=0.81, adj.P.Val=0.00552
FBgn0038047
logFC=1.19, adj.P.Val=0.00552
FBgn0040582
logFC=0.99, adj.P.Val=0.00552
FBgn0261054
logFC=−2.19, adj.P.Val=0.00552
Normalised log2 expression
oldflies
Youngflies



(b)

Figure 5. The figure shows box plots of the normalized and unnormalised counts *i.e.* log count per million value is considered to normalize the counts of different samples. (b) shows strip charts of the genes which are differentially expressed according to logFc value and adjusted P value.

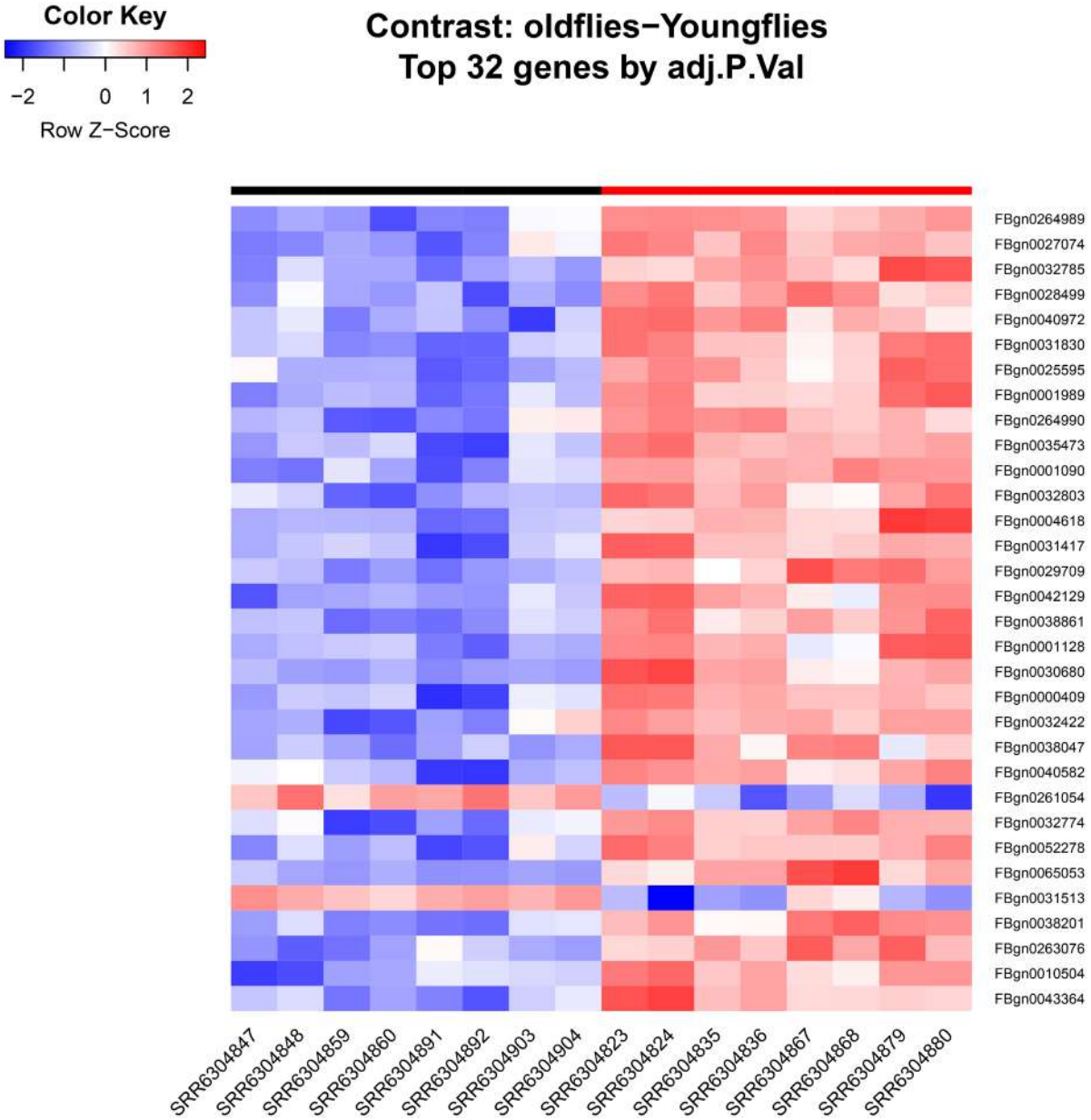


Figure 6. Showing heatmap of topmost differentially expressed genes. The rows represents name of the genes and column represents name of samples. Blue color shows negative scores *i.e.* down regulated genes in the samples and Red colour shows upregulated genes in the sample heads of old flies and young flies.

term over represented p value, under represented p value, number of differentially expressed genes, number of genes in this category and details of the term is calculated. A graph of top 10 over represented GO term is given in the (**Figure 7**) which shows that genes involved in stress response, apoptotic process, histone modification, covalent chromatin modification, protein modification by small protein and protein ubiquitination, immune and defence response regulation. The KEGG pathways plotted using pathview [25] against topmost expressed genes are also generated which shows complete information about the genes and their role in pathways involved in aging and dementia (**Figure 8**).

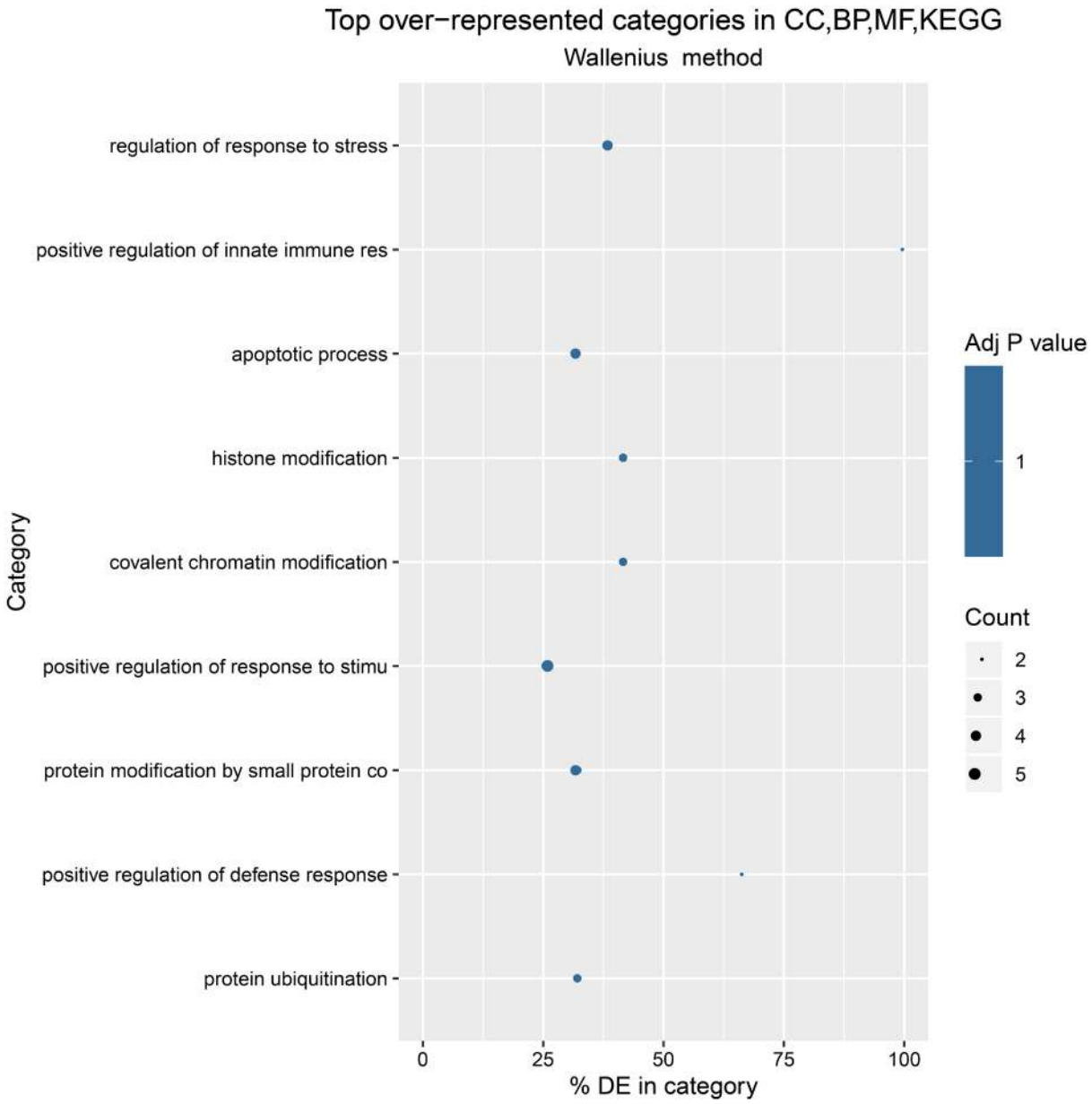


Figure 7. Topmost overrepresented GO term against the corresponding genes which are differentially expressed in old flies as compared to young flies.

Our result provides the link between aging brain and dementia which can be further deployed to establish therapeutics against neurodegeneration and aging brain. As, the data shows that both run parallel to each other and factors affecting brain aging strongly contributes to neurodegeneration and dementia.

4. Conclusion

Mitochondrial DNA damage and oxidative stress run parallel during aging and lead to dementia as reactive oxygen species production surpasses cellular antioxidants defence system which contains antioxidant enzymes and this declination can be easily seen in AD brain [8]. It is also evidenced that AD affects brain

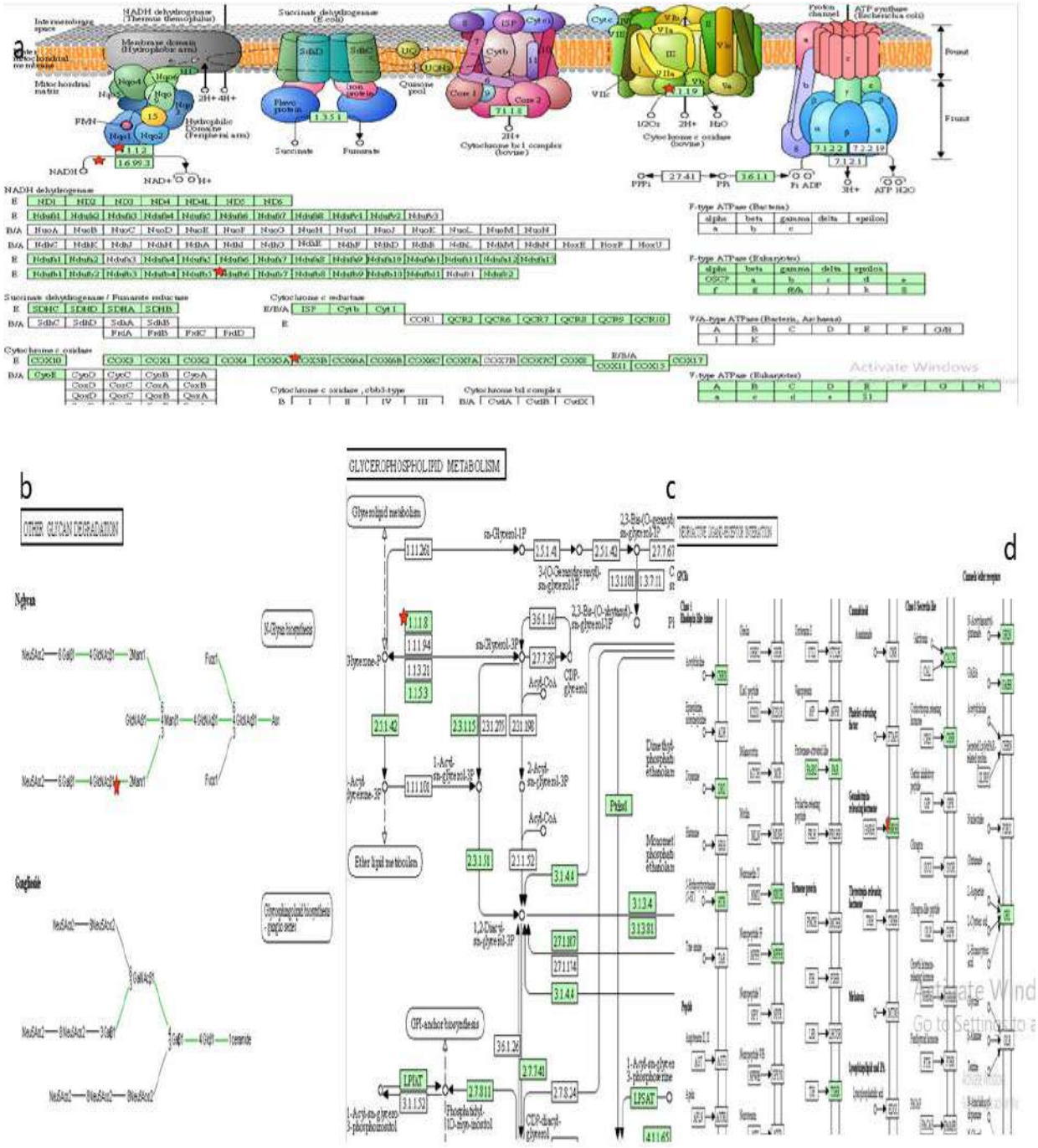


Figure 8. This figure shows different metabolic and biological pathways in which the genes are present which are differentially expressed in aging flies. The red star shown in the pathway is denoting a gene which is found to be expressed differentially. (a) is showing oxidative phosphorylation pathway and metabolic pathway. (b) is glycan degradation pathway (c) glycerophospholipid metabolism (d) is neuroactive ligand receptor interaction.

and periphery in which many causative pathways play/interplay significant role and simultaneously many factors risk AD like diabetes, obesity, hypertension, stroke and other cardiovascular risk factors [26]. Neurodegeneration and Aging are inseparable but who is under who is still a debate because of along with aging function of brain changes and aggregation of toxic protein increase. At the same

time, apoptosis occurs, leading to reduction in brain volume [27]. Once again mitochondrial energy production decreases due to increase in oxidative stress and finally decline in mitochondrial function is a cause of aging.

Recently the brain transcriptome change in the aging flies is being published [9] showing the pathways and genes involved in aging. In our study, we found 262 genes are down regulated in old flies which are associated with many pathways required for normal functioning of brain and body and are required to promote neuronal growth and neurogenesis in aging brain. A recent discovery of progressive increase of many genes involved in high level of nucleic acid oxidation genes in mitochondrial DNA with aging and in AD cases leads to oxidative stress [28] [29] [30] and contributes strongly in aging and in dementia as here also gene ontology analysis of genes we identified CG10211, CG13280, CG16761, ND6 gene in drosophila shows high amount of expression of nucleic acid oxidation genes present in mitocondrial DNA. Dementia is a common consequence of diabetes as insulin level may affect neurotransmission, cell survival and amyloid trafficking [31] [32]. The differential expression data in our study also shows many genes like CG7985, Glucosidase 2 alpha subunit, involved in insulin modulation. Inflammatory proteins in plasma are also associated with severity of dementia [33]. Lactin-galC1, Drosomycin like gene is also found to be down regulated and provides defence against fungal infection. Okouchi M *et al.*, evidenced change in apotosis regulation leads to many neurodegenerative disorders like Alzhiemer's, Parkinson's, Huntington's (HD) diseases, amyotrophic lateral sclerosis (ALS), spinal muscular atrophy (SMA), and diabetic encephalopathy. In flies, our results show that Drep3, DNA pol alpha, psn (presinilin) are differentially regulated with aging in flies. Signal transduction pathways, epigenetic regulation, immune system, vascular system and angiogenesis aberrant regulation are major causes of neurogenesis and we found out various genes, receptors and harmon related to these pathways showing change in expression in adult flies [34]. Many genes, peptides and receptors are mapped with the reads of adult (aging) and young flies show change in expression related to neurogenesis and neurotransmitter decline like chemosensory protein, calcinuerin, Pyrokinin 2 receptor, mucin, Adipokinetic harmone, spatzle, suppressor of zeste, pleiohomeotic and mthl. Hence, in depth study of these genes, receptors, peptides and regulators will also help us in construing specific genes which can be controlled during aging to make the brain function normally by using medical therapeutic technique.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Yankner, B.A., Lu, T. and Loerch, P. (2008) The Aging Brain. *Annual Review of*

Pathology: *Mechanisms of Disease*, **3**, 41-66.
https://doi.org/10.1146/annurev.pathmechdis.2.010506.092044

[2] Mecocci, P., Boccardi, V., Cecchetti, R., *et al.* (2018) A Long Journey into Aging, Brain Aging, and Alzheimer's Disease Following the Oxidative Stress Tracks. *Journal of Alzheimer's Disease*, **62**, 1319-1335. https://doi.org/10.3233/JAD-170732

[3] Parker, W.D., Filley, C.M. and Parks, J.K. (1990) Cytochrome Oxidase Deficiency in Alzheimer's Disease. *Neurology*, **40**, 1302-1303.
https://doi.org/10.1212/WNL.40.8.1302

[4] Moloney, A., Sattelle, D.B., Lomas, D.A. and Crowther, D.C. (2010) Alzheimer's Disease: Insights from *Drosophila melanogaster* Models. *Trends in Biochemical Sciences*, **35**, 228-235. https://doi.org/10.1016/j.tibs.2009.11.004

[5] Haywood, A.F. and Staveley, B.E. (2006) Mutant Alpha-Synuclein-Induced Degeneration Is Reduced by Parkin in a Fly Model of Parkinson's Disease. *Genome*, **49**, 505-510. https://doi.org/10.1139/g06-011

[6] Zhan, M., Yamaza, H., Sun, Y., Sinclair, J., Li, H. and Zou, S. (2007) Temporal and Spatial Transcriptional Profiles of Aging in *Drosophila melanogaster*. *Genome Research*, **17**, 1236-1243. https://doi.org/10.1101/gr.6216607

[7] Girardot, F., Lasbleiz, C., Monnier, V. and Tricoire, H. (2006) Specific Age-Related Signatures in Drosophila Body Parts Transcriptome. *BMC Genomics*, **7**, 69.
https://doi.org/10.1186/1471-2164-7-69

[8] Kim, T.S., Pae, C.U., Yoon, S.J., Jang, W.Y., Lee, N.J., Kim, J., Lee, S.J., Lee, C., Paik, I.H. and Lee, C.U. (2006) Decreased Plasma Antioxidants in Patients with Alzheimer's Disease. *International Journal of Geriatric Psychiatry*, **21**, 344-348.
https://doi.org/10.1002/gps.1469

[9] Davie, K., Janssens, J., Koldere, D., *et al.* (2018) A Single-Cell Transcriptome Atlas of the Aging Drosophila Brain. *Cell*, **174**, 982-998.e20.
https://doi.org/10.1016/j.cell.2018.05.057

[10] Pacifico, R., MacMullen, C.M., Walkinshaw, E., Zhang, X. and Davis, R.L. (2018) Brain Transcriptome Changes in the Aging *Drosophila melanogaster* Accompany Olfactory Memory Performance Deficits. *PLoS ONE*, **13**, e0209405.
https://doi.org/10.1371/journal.pone.0209405

[11] Robinson, M.D., McCarthy, D.J. and Smyth, G.K. (2010) edgeR: A Bioconductor Package for Differential Expression Analysis of Digital Gene Expression Data. *Bioinformatics*, **26**, 139-140. https://doi.org/10.1093/bioinformatics/btp616

[12] Robinson, M.D. and Smyth, G.K. (2007) Moderated Statistical Tests for Assessing Differences in Tag Abundance. *Bioinformatics*, **23**, 2881-2887.
https://doi.org/10.1093/bioinformatics/btm453

[13] Law, C.W., Chen, Y., Shi, W., *et al.* (2014) Voom: Precision Weights Unlock Linear Model Analysis Tools for RNA-seq Read Counts. *Genome Biology*, **15**, R29.
https://doi.org/10.1186/gb-2014-15-2-r29

[14] Liu, R.J., Holik, A.Z., Su, S.A., Jansz, N., Chen, K.L., Leong, H.S., Blewitt, M.E., Asselin-Labat, M.-L., Smyth, G.K. and Ritchie, M.E. (2015) Why Weight? Modelling Sample and Observational Level Variability Improves Power in RNA-seq Analyses. *Nucleic Acids Research*, **43**, e97. https://doi.org/10.1093/nar/gkv412

[15] Liao, Y., Smyth, G.K. and Shi, W. (2013) Feature Counts: An Efficient General Purpose Program for Assigning Sequence Reads to Genomic Features. *Bioinformatics*, **30**, 923-930. https://doi.org/10.1093/bioinformatics/btt656

[16] Anders, S., Pyl, P.T. and Huber, W. (2015) HTSeq—A Python Framework to Work

with High-Throughput Sequencing Data. *Bioinformatics*, **31**, 166-169.
https://academic.oup.com/bioinformatics/article/31/2/166/2366196
https://doi.org/10.1093/bioinformatics/btu638

[17] Kim, D., Langmead, B. and Salzberg, S.L. (2015) HISAT: A Fast Spliced Aligner with Low Memory Requirements. *Nature Methods*, **12**, 357-360.
https://www.nature.com/articles/nmeth.3317
https://doi.org/10.1038/nmeth.3317

[18] Marcel, M. (2011) Cutadapt Removes Adapter Sequences from High-Throughput Sequencing Reads. *EMBnet Journal*, **17**, 10-12. https://doi.org/10.14806/ej.17.1.200

[19] Robinson, J.T., Thorvaldsdóttir, H., Winckler, W., Guttman, M., Lander, E.S., *et al.* (2011) Integrative Genomics Viewer. *Nature Biotechnology*, **29**, 24-26.
https://pubmed.ncbi.nlm.nih.gov/21221095/
https://doi.org/10.1038/nbt.1754

[20] Wang, L., Wang, S. and Li, W. (2012) RSeQC: Quality Control of RNA-seq Experiments. *Bioinformatics*, **28**, 2184-2185.
https://www.ncbi.nlm.nih.gov/pubmed/22743226
https://doi.org/10.1093/bioinformatics/bts356

[21] Kim, D., Pertea, G., Trapnell, C., Pimentel, H., Kelley, R., *et al.* (2013) TopHat2: Accurate Alignment of Transcriptomes in the Presence of Insertions, Deletions and Gene Fusions. *Genome Biology*, **14**, R36.
https://doi.org/10.1093/bioinformatics/bts356
https://genomebiology.biomedcentral.com/articles/10.1186/gb-2013-14-4-r36

[22] Loerch, P.M., Lu, T., Dakin, K.A., *et al.* (2008) Evolution of the Aging Brain Transcriptome and Synaptic Regulation. *PLoS ONE*, **3**, e3329.
https://doi.org/10.1371/journal.pone.0003329

[23] Dobin, A., Davis, C.A., Schlesinger, F., Drenkow, J., Zaleski, C., *et al.* (2013) STAR: Ultrafast Universal RNA-seq Aligner. *Bioinformatics*, **29**, 15-21.
https://academic.oup.com/bioinformatics/article/29/1/15/272537
https://doi.org/10.1093/bioinformatics/bts635

[24] Love, M.I., Huber, W. and Anders, S. (2014) Moderated Estimation of Fold Change and Dispersion for RNA-seq Data with DESeq2. *Genome Biology*, **15**, Article No. 550. https://genomebiology.biomedcentral.com/articles/10.1186/s13059-014-0550-8
https://doi.org/10.1186/s13059-014-0550-8

[25] Luo, W. and Brouwer, C. (2013) Pathview: An R/Bioconductor Package for Pathway-Based Data Integration and Visualization. *Bioinformatics*, **29**, 1830-1831.
https://academic.oup.com/bioinformatics/article-abstract/29/14/1830/232698
https://doi.org/10.1093/bioinformatics/btt285

[26] Nelson, M.E., Rejeski, W.J., Blair, S.N., *et al.* (2007) Physical Activity and Public Health in Older Adults: Recommendation from the American College of Sports Medicine and the American Heart Association. *Medicine & Science in Sports & Exercise*, **39**, 1435-1445. https://doi.org/10.1249/mss.0b013e3180616aa2

[27] Cho, S.G. and Choi, E.J. (2002) Apoptotic Signaling Pathways: Caspases and Stress-Activated Protein Kinases. *Journal of Biochemistry and Molecular Biology*, **35**, 24-27. https://doi.org/10.5483/BMBRep.2002.35.1.024

[28] Haddadi, M., Jahromi, S.R., Sagar, B.K., Patil, R.K., Shivanandappa, T. and Ramesh, S.R. (2014) Brain Aging, Memory Impairment and Oxidative Stress: A Study in *Drosophila melanogaster*. *Behavioural Brain Research*, **259**, 60-69.
https://doi.org/10.1016/j.bbr.2013.10.036

[29] Okouchi, M., Ekshyyan, O., Maracine, M. and Aw, T.Y. (2007) Neuronal Apoptosis

in Neurodegeneration. *Antioxidants & Redox Signaling*, **9**, 1059-1096. https://academic.oup.com/bioinformatics/article/31/2/166/2366196 https://doi.org/10.1089/ars.2007.1511

[30] Grotewiel, M.S., Martin, I., Bhandari, P. and Cook-Wiens, E. (2005) Functional Senescence in *Drosophila melanogaster*. *Ageing Research Reviews*, **4**, 372-397. https://doi.org/10.1016/j.arr.2005.04.001

[31] Morris, J.K., Vidoni, E., Honea, R.A. and Burns, J.M. (2014) Impaired Glycemia and Alzheimer's Disease. *Neurobiology of Aging*, **35**, e23. https://doi.org/10.1016/j.neurobiolaging.2014.04.018

[32] Sandhir, R. and Gupta, S. (2015) Molecular and Biochemical Trajectories from Diabetes to Alzheimer's Disease: A Critical Appraisal. *World Journal of Diabetes*, **6**, 1223-1242. https://doi.org/10.4239/wjd.v6.i12.1223

[33] Leung, R., Proitsi, P., Simmons, A., Lunnon, K., Güntert, A., Kronenberg, D., Pritchard, M., Tsolaki, M., Mecocci, P., Kloszewska, I., Vellas, B., Soininen, H., Wahlund, L.O. and Lovestone, S. (2013) Inflammatory Proteins in Plasma Are Associated with Severity of Alzheimer's Disease. *PLoS ONE*, **8**, e64971. https://doi.org/10.1371/journal.pone.0064971

[34] Horgusluoglu, E., Nudelman, K., Nho, K. and Saykin, A.J. (2017) Adult Neurogenesis and Neurodegenerative Diseases: A Systems Biology Perspective. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, **174**, 93-112. https://doi.org/10.1002/ajmg.b.32429

BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, June 2021. Vol. **18**(2), p. 357-366

Adipokines in Insulin Resistance: Current Updates

Utpal Jagdish Dongre

Department of Biochemistry, Assistant Professor Dr Ambedkar College, Deekshabhoomi, Nagpur 440010, Maharashtra, India.

http://dx.doi.org/10.13005/bbra/2922

(Received: 12 April 2021; accepted: 16 June 2021)

Obesity is a chronic metabolic disease that affects both the pediatric and adult populations. Adipose tissue acts as an endocrine organ which secretes various adipokines involved in fat mass regulation and energy balance via modulating the metabolic signalling pathways. Altered secretion of adipokines promotes multiple complications, including insulin resistance. The primary mechanism of action that underlines the involvement of adipokines in the development of insulin resistance includes phosphorylation/de-phosphorylation of insulin receptor substrate-1 (IRS-1) facilitate by other signalling molecules like a suppressor of cytokine signalling 1 (SOCS-1). Adipokines mediated insulin resistance further contribute to the development of atherosclerosis, dyslipidemia, fatty liver disease, cancer etc. Thus, this review provides recent updates on the role of resistin, lipocalin-2, RBP-4, chemerin, TNF-alpha and IL-6 adipokines in the progression of insulin resistance.

Keywords: Adipose Tissue; Adipokines; Fatty Liver Diseases; Insulin resistance; Insulin Receptor Substrate-1 (IRS-1).

Obesity is emerging as an epidemic in both developed and developing countries. As per the current statistics, in the United States, approximately 42.4% adult men and women are affected with obesity [1], while for India a rise of 30.5% from the prevailing percentage has been forecasted by the year 2040 [2]. Obesity usually promotes type 2 diabetes mellitus, hypertension, atherosclerosis and cardiovascular diseases [3]. But, amid them, type 2 diabetes mellitus can be more severe due to insulin resistance in the liver, muscle cells and other peripheral tissues [4]. In this regard, it can be assumed that obesity is a metabolic disorder that further increases the diabetes burden apart from the pathophysiology of insulin. Over nutrition or high-calorie intake deposits lipids in the form of triglycerides in adipose tissue, resulting in obesity [5]. The severity of obesity is often accompanied by low exercise and stressful lifestyle [6]. In mammals, adipose tissue cluster pre-adipocytes, mature adipocytes, stromal vascular cells, macrophages and endothelial cells. However, adipose tissue is no longer considered as a mere fat storage depot; instead, it is now considered as an endocrine organ due to the secretion of adipokines such as adiponectin, leptin, visfatin, omentin etc., which regulate energy/metabolic homeostasis [7,8]. Deposition of excess energy causes adipose tissue

*Corresponding author E-mail: utpal24dongre@gmail.com

This is an Open Access article licensed under a Creative Commons license: Attribution 4.0 International (CC-BY).
Published by Oriental Scientific Publishing Company © 2021

dysfunction, which usually exhibits a low-grade chronic inflammation due to higher secretion of inflammatory and pro-inflammatory cytokines like IL-6 and TNF-alpha. This chronic inflammation favours insulin resistance by modulating various metabolic pathways [9]. The present review discusses the basic pathophysiology of adipokines with their current updates in the aetiology of insulin resistance.

Adipose tissue physiology

Adipose tissues are classified as brown adipose tissue (BAT) and white adipose tissue (WAT), originated from mesoderm and the mesenchymal stem cells during embryogenesis. BAT is rich in mitochondria; hence appear brown and predominantly involved in thermogenesis (heat production) via uncoupling proteins [7]. Conversely, WAT is organ-specific and is further divided into visceral (mesenteric, retroperitoneal, omental and pericardial) and subcutaneous (beneath the skin) adipose depots; thus obesity-related consequences are primarily regulated by WAT [10]. To store extra energy pre-adipocyte differentiates into mature adipocytes under the strict regulation of CCAAT/enhancer-binding proteins (C/EBPs) and peroxisome proliferator-activated receptor-gamma (PPARã) transcriptional factors [11]. This causes WAT expansion through a rise in adipocyte number (hyperplasia) and/or increasing adipocyte volume/ size (hypertrophy). The rise in adipocyte number favours severe obesity, while increased adipocytic volume contributes to obesity, overweight and diabetes. In- vivo studies showed that in adults, adipocytic numbers are usually constant; however, adipocytic volume increases [12]. This suggests the severity of obesity in the onset of type 2 diabetes mellitus in adult patients. Earlier, adipose tissue was considered as an inert fat storage organ, but the discovery of leptin revealed the endocrine functions of this organ, which secrete proteins/ hormones/factors/cytokines, collectively called as "adipokines" [13]. Obesity promotes altered secretion of adipokines, which work as endocrine, paracrine and autocrine way and modulate lipid (lipogenesis and lipolysis) and glucose metabolism [14]. A growing body of evidence proves the role of various adipokines in the pathophysiology of insulin resistance, which includes, resistin, lipochalin-2, retinol-binding protein-4 (RBP-4), chemerin, TNF-alpha and IL-6 [15,16].

Resistin

Resistin a 114 amino acid (10 kDa) containing adipokine also called as an adipose tissue-specific secretory factor (ADSF) was discovered by Dr Mitchell A. Lazar in the year 2001 [17,18]. Resistin is a member of a cysteine-rich protein termed as resistin like molecule (RELM) and circulates as a hexamer and trimer. Hexameric form of this adipokine is more abundant, while trimeric form induces severe insulin resistance [19]. The mechanism by which resistin causes the insulin resistance includes the activation of suppressor of cytokine signalling-3 (SOCS-3), which attenuates insulin-arbitrate signalling in adipocytes [20]. In association with the toll-like receptor (TLR-4), resistin stimulates insulin resistance in different cells. In the hypothalamus, resistin directly binds with the TLR-4, which suppresses signalling pathways via stimulation of MyD88 and TIRAP adaptor protein accumulation and debilitates insulin response in the hypothalamus by phosphorylation of insulin receptor, AKT and ERK1/2. The activation of Resistin/TLR-4 pathway also upregulated the activity of SOCS-3 and protein-tyrosine phosphatase 1B (PTP1B) and thereby promote insulin resistance [21].

The fibroblast growth factor (FGF)-21 is an important hormone that regulates many metabolic activities. The FGF-21 works as insulin-sensitizing hormone as like of adiponectin. Study on the chronic intracerebroventricular mechanism revealed that resistin infusion in the brain of mice downregulates adiponectin synthesis via regulating its adaptor protein known as APPL1 in both hypothalamus and liver. Resistin also inhibits expression of FGF-21 receptors on the hypothalamus and the peripheral tissues, resulting in FGF-21 resistance. This effect of resistin was abolished in TLR4 knockout mice, suggesting the role of Resistin/TLR-4 pathways in FGF-2 resistance/ insulin sensitivity [22]. Further, studies on mice reported resistin/TLR-4 pathway for increased hypertension, insulin resistance [23] and breast cancer progression [24]. It has been evidenced that aerobic exercise prevents insulin resistance in type 2 diabetes mellitus via miR-382-3p/Resistin [25] and miR-492/Resistin axis [26]. Recent studies exhibit the role of resistin in endothelial related insulin resistance. Treatment of resistin on human umbilical vein endothelial cells (HUVC) showed

that oxidative stress in the endoplasmic reticulum promotes insulin resistance and impairment in the endothelium [27]. Also, tunicamycin induced oxidative stress in endoplasmic reticulum reported increased resistin mRNA in human THP-1 monocytes [28].

Lipocalin-2

The lipocalin-2 (Lcn2) is a 25 kDa adipokine also known as neutrophil gelatinase-associated lipocalin (NGAL), sidrocalin and 24p3 belong to the lipocalin superfamily and reported for altered glucose metabolism and insulin resistance [29]. Lcn2 is highly expressed in adipocytes, liver, kidney and on macrophages and regulates apoptosis and innate immunity [30]. The primary mechanism underlines the effect of Lcn2 on insulin resistance include the modulation of 12-lipoxygenase activity and TNF-á levels in adipose tissue [31]. The level of this adipokine increases during pre-adipocyte differentiation into mature adipocyte. With the help of a small cavity like hydrophobic structures Lcn2 binds and transport distinct lipophilic compounds like steroids, retinoids and arachidonic acids [32]. Study on LCN2"/" mice showed increased hepatic gluconeogenesis, debilitate lipid metabolism, impaired oxidation capacity of mitochondria, elevated inflammation favouring dyslipidemia due to diet-induced obesity, fatty liver disorders and insulin resistance [33].

Systems genetics analyses studies revealed the sex-specific role of Lcn-2. Overexpression of this adipokine in adipose tissue has been reported for elevated fat mass, glucose intolerance and insulin resistance only in females via mitochondrial dysregulation [34]. Studies using synthetic glucocorticoids and dexamethasone in the regulation of Lcn-2 expression in adipose tissue explore the role of sex steroids [35]. In postmenopausal women, 17-â-estradiol (E2) increases the Lcn-2 expression in subcutaneous adipose tissue. There are two estrogen receptors (ERá and ER-â), which facilitates the effects of steroids on adipose tissue, however, among them; ERâ plays a significant role in the binding of â-estradiol [36]. Synthetic dexamethasone increases ERâ pathway and decreases the ERá pathway and thus responsible for glucocorticoid-induced insulin resistance in human adipose tissue via Lcn-2 adipokine [37]. Many other studies also implicate the role of steroids in the induction of Lcn-2 induced insulin resistance [38,39]. Moreover, Lcn-2 showed inhibition of autophagy and insulin resistance induction in H9c2 cells derived from rat heart ventricle [40].

Retinol Binding Protein-4 (RBP-4)

Retinol binding protein-4 (RBP-4) is another crucial adipokine that attributes in insulin resistance. Apart from adipocyte RBP-4 is also expressed in liver and macrophages [41]. Higher expression of this adipokine in the adipocyte is inversely associated with the GLUT-4 expression in the adipocyte. Thus, decreased GLUT-4 in adipocytes promotes higher expression of RBP-4, which inhibits insulin-mediated insulin receptor substrate-1 (IRS-1) phosphorylation that can contribute to insulin resistance [42]. During obesity, RBP-4 is preferentially produced by visceral fat depot than subcutaneous fat depot, suggesting the role of intra-abdominal adipose tissue in insulin resistance [43]. The thiazolidinedione, a peroxisome proliferator-activated gamma (PPARã) stimulating drug suppresses RBP-4 production in adipose tissue and thereby stimulate insulin sensitivity of tissues (skeletal muscle) [44]. However, RBP-4 mediated insulin resistance also play a pivotal role in the development of cardiovascular diseases (CVDs). Increased production of RBP-4 in adipose tissue stimulates the higher production of adhesion molecules like vascular cell adhesion molecule-1 (VCAM), intercellular adhesion molecule-1 (ICAM) and E-selectin in the endothelial cells, resulting in atherosclerosis-related CVDs and hypertension [45].

Of note, the prevalence of RBP-4 related insulin resistance is considered as a significant risk factor for the pediatric cardiometabolic system [46]. Also, RBP-4 in association with adiponectin and Fatty Acid–Binding Protein 4 (FABP-4) are reported to be associated with the increased rate of CVDs in male patients of type 2 diabetes mellitus [47], while in adolescent girls the increased CVDs are associated with waist circumference in overweight/ obese [48]. Thus, RBP-4 and insulin resistance suggest the role of sex hormones in the progression of CVDs and coronary artery diseases [49]. Furthermore, assessment of the levels of RBP-4 for ten years during childhood can help in the prediction of future cardiometabolic risks [50]. Apart from the CVDs elevated RBP-4 related insulin resistance can be correlated with the progression

of rheumatoid arthritis [51] and non-alcoholic fatty liver disease [52].

Chemerin

Chemerin is secreted from adipose tissue as an inactive pre-pro chemerin (163 amino acids). After the intracellular hydrolytic cleavage of N terminal polypeptide (20 amino acid), it releases in the serum as 18-kDa inactive pro-protein, which then converts into 16-kDa active chemerin by serine protease cleavage of the C-terminal portion [53]. The estimated concentration of chemerin in plasma and serum of mice was reported 0.6 and 0.5 nM, respectively, while in human 3.0 and 4.4 nM, respectively [54]. This adipokine is also called as tazarotene-induced gene 2 (TIG2) encoded by the retinoic acid receptor responder 2 (Rarres2) gene and acts as an endocrine, paracrine as well as an autocrine way [55]. Chemerin is a pro-inflammatory adipokine predominantly produced by white adipose tissue (WAT) and act as a ligand for G-protein-coupled receptor CMKLR1 [56]. Chemerin regulates the immune system (adaptive and innate), adipogenesis and metabolic homeostasis [57]. Overexpression of chemerin in adipose tissue causes insulin resistance in human skeletal muscles by modulating IRS-1, glucose uptake, Akt, glycogen synthase kinase 3 phosphorylation (GSK3P), nuclear factor-êB (NF-kB), p38 mitogen-activated protein kinase and extracellular signal-regulated kinase (ERK)-1/2 [58].

Non-alcoholic fatty liver disease (NAFLD) is a common phenomenon in obesity, which is closely associated with chemerin induced increased insulin resistance [60]. However, outdoor aerobic exercise improves the status of chemerin induced insulin resistance and thereby NAFLD [61]. Overexpression of CMKLR1 promotes insulin resistance. During low-grade inflammation (a common feature of obesity), both chemerin and CMKLR1 exhibit inverse expression, manifesting in the progression of insulin resistance [62]. Tumour necrosis factor-alpha (TNF-alpha) is a potent inflammatory cytokine that in association with chemerin induces insulin resistance. This effect of chemerin-TNF-alpha is overcome by the high-intensity interval training (HIIT), further suggesting the role of exercise in the prevention of insulin resistance [63]. However, another study in women with multiple sclerosis proves that the continuous chronic aerobic exercise lowers the chemerin, insulin and thereby suppresses insulin resistance [64]. Chemerin can be used as an adipokine marker for uremic insulin resistance in chronic kidney diseases at stages 3, 4, and 5 [65]. Moreover, a growing body of recent evidences revealed the role of chemerin induced insulin resistance in the development and the prognosis of polycystic ovary syndrome (PCOS) in adult women. A recent study on 45 patients with PCOS showed higher chemerin levels in obese PCOS group as compared to the lean PCOS, obese and the non-obese groups [66]. These finding described above and other recent studies [67-68] signify the role of chemerin induced insulin resistance in the progression of PCOS.

Adipokines such as resistin, Lpn-2, RBP-4, chemerin, TNF-á and IL-6 secreted during obesity altered numerous metabolic signalling pathways that result in insulin resistance and related diseases. TLR-4: Toll-like receptor-4, Irs-P: Insulin receptor phosphorylation, SOCS-3: suppressor of cytokine signalling-3, FGF-21: Fibroblast growth factor, Lpn-2: Lipocalin-2, TNF-á: Tumour necrosis factor-á, ER-â: Estrogen receptor-â, RBP-4: Retinol binding protein-4, GLUT: Glucose transporter, IRS-1-P: Insulin receptor substrate-1-phosphorylation, GSK-3: Glycogen synthase kinase 3 phosphorylation, NF-kB: Nuclear factor-êB (NF-kB), ERK: Extracellular signal-regulated kinase, NOS: Nitric oxide synthase, NO: Nitric oxide, PTEN: Phosphatase and tension homologue, IR: Insulin resistance, IL-6: Interleukin-6, STAT-3: signal transducer and activator of transcription 3.

TNF-á

Tumour necrosis factor-á (TNF-á) is secreted by adipose tissue often considered as an adipocytokine. A 26 kDa transmembrane monomer of this adipokine converts into 17-kDa soluble TNF-á molecule by an enzyme TNF-á converting enzyme (TACE). It acts as an inflammatory cytokine that affects distinct cellular and biological functions including apoptosis, cell differentiation, energy metabolism and immune system [69]. TNF-á adipocytokine induces insulin resistance via decreasing the tyrosine kinase activity of the insulin receptor [70]. This causes altered signalling pathways that can induce insulin resistance and related diseases. One of such signalling pathway that modulated by TNF-á is Akt/eNOS (nitric oxide synthase)/NO. In mice with fed by a high-fat diet, overexpression of TNF-á in adipose tissue

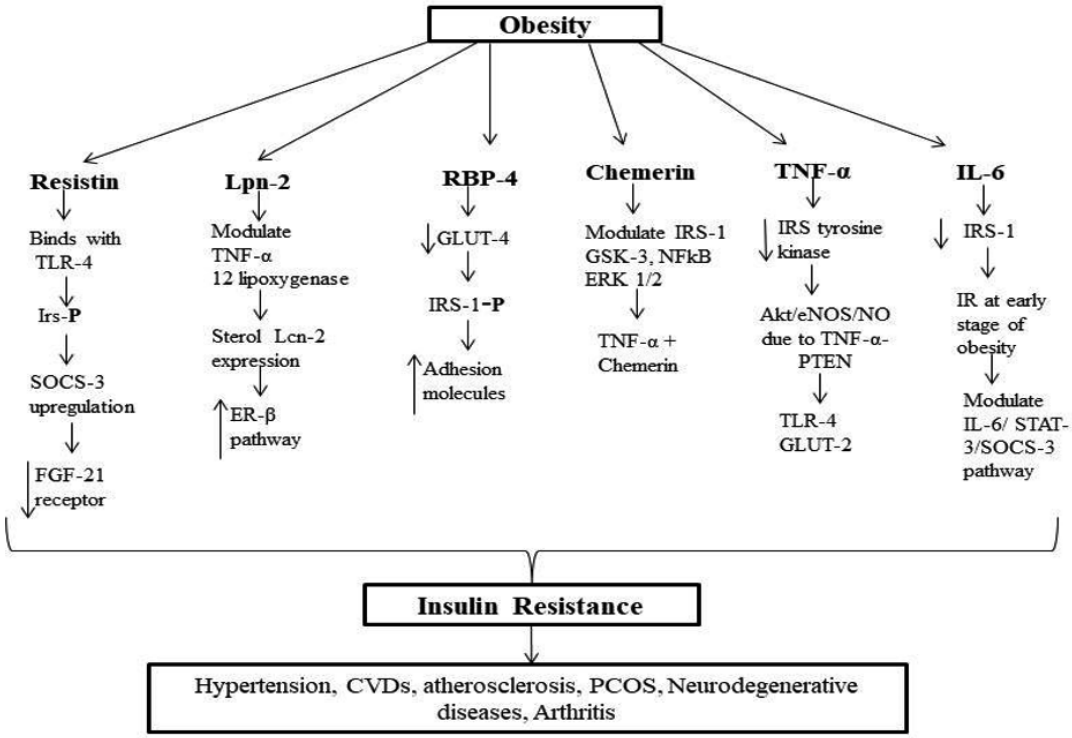


Fig. 1. Schematic diagram representing the role of adipokines in insulin resistance and related diseases

positively modulates phosphatase and tension homologue (PTEN) and suppresses Akt/eNOS/NO signalling pathways in a vascular wall, leading to insulin resistance [71]. Thus, TNF-á/PTEN pathway can be targeted as a therapeutic to treat insulin resistance and vascular complications in obesity. During diabetes, in hepatic cells, TNF-attenuation improves the insulin receptor substrate 1 (IRS-1) via phosphorylation [72] at serine residues 636/639 and inhibiting the tyrosine phosphorylation of IRS-1. This phosphorylation/dephosphorylation is governed by c-jun N-terminal kinase (JNK) and an extracellular signal-regulated kinase (ERK) phosphorylation [73]. Apart from the IRS-1, toll-like receptors TLRs and GLUT-2 pathways modulate other signalling pathways that results in insulin resistance [74,75]. Further, the PPAR á/ã agonist aleglitazar [76], GW501516 [77] and TACE selective inhibitor JTP-96193 [78] have been reported for the inhibition of TNF-á arbitrate inflammatory reactions and insulin resistance. However, through independent pathways, insuin resistance due to this adipocytokine induces neuroinflammation in immortalised hypothalamic neuronal cells, which may promote neurodegenerative diseases [79].

IL-6

Interleukin-6 is a pro-inflammatory cytokine secreted by many different cell types and tissues, including adipose tissue, which regulates growth and development of distinct tissues and plays a significant role in the immune response [80]. This adipocytokine contributes to low-grade chronic inflammatory state responsible for adipose tissue dysfunction via altered lipid and carbohydrate metabolism, coronary artery diseases (atherosclerosis), CVDs diabetes and insulin resistance [81]. The mechanism of action by which this cytokine imparts its role in insulin resistance involves inhibitory effects on the gene transcription of PPAR gamma, GLUT-4 and IRS-1. This causes a reduction in IRS-1, insulin-stimulated tyrosine phosphorylation. In hepatocytes, SOCS inhibit insulin receptor signalling that stimulates insulin resistance [82, 83]. Obesity-related insulin resistance due to IL-6 promotes impaired adipogenesis in subcutaneous fat in humans, suggesting the role

of IL-6 in the modulation of signalling pathways [84]. By emphasizing the role of IL-6 in T cells, it has been corroborated that through a classical signalling pathway IL-6 stimulates inflammation and insulin resistance at the early stages of obesity development [85]. However, studies in humans showed an association between the amount of IL-6 and the size of the visceral adipose tissue favours insulin resistance [86]. Further, IL-6 in association with signal transducer and activator of transcription 3 (STAT3) modulates a variety of signalling pathways that imparts their role in insulin resistance/sensitivity and related diseases. It has been reported that the treatment of myo-Inositol in rat PCOS model downregulates the insulin resistance in association with IL-6-STAT-3 signalling pathway [87]. Whereas, atmospheric fine particles (PM2.5) increases the IL-6 levels in rat liver and suggest an essential role in the regulation of type 2 diabetes mellitus through IL-6/STAT3/SOCS3 pathway [88]. Pu-erh tea extract mitigates insulin resistance and non-alcoholic steatohepatitis through IL-6/STAT3 signalling pathway in mice [89]. However, the blocking of IL-6 receptor improves insulin sensitivity in patients with rheumatoid arthritis and non-diabetic [90].

CONCLUSION

Dysfunctional adipose tissue secretes altered levels of adipokines that are associated with many health problems, including insulin resistance. Adipokines imparts their deleterious effects in the development and the progression of insulin resistance mostly through IRS-1/STAT-3/SOCS signalling pathways. Recent findings exhibit the role of adipokine induced insulin resistance as a major risk factor for the development of chronic diseases like neurodegenerative diseases, non-alcoholic fatty liver disease, chronic kidney diseases, cardiovascular diseases etc. However, determining the role of adipokines in the aetiology of insulin resistance may provide new opportunities for developing novel therapeutics for obesity arbitrates insulin resistance.

REFERENCES

1. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of Obesity and Severe Obesity Among Adults: United States, 2017-2018. *NCHS Data Brief.* 2020; **360**:1-8.
2. Luhar S, Timæus IM, Jones R, et al. Forecasting the prevalence of overweight and obesity in India to 2040. *PLoS One*. 2020; **15**(2):e0229438.
3. Apovian CM. Obesity: definition, comorbidities, causes, and burden. *Am J Manag Care*. 2016; **22**(7):s176-s185.
4. Li Y, Ding L, Hassan W, Abdelkader D, & Shang J. Adipokines and hepatic insulin resistance. Journal of diabetes research, 2013: 170532.
5. Sacks G, Vanderlee L, Robinson E, et al. BIA-Obesity (Business Impact Assessment-Obesity and population-level nutrition): A tool and process to assess food company policies and commitments related to obesity prevention and population nutrition at the national level. *Obes Rev*. 2019; **20**(2):78-89.
6. van den Berk-Clark C, Secrest S, Walls J, et al. Association between posttraumatic stress disorder and lack of exercise, poor diet, obesity, and co-occuring smoking: A systematic review and meta-analysis. *Health Psychol*. 2018; **37**(5):407-416.
7. Zwick RK, Guerrero-Juarez CF, Horsley V, Plikus MV. Anatomical, Physiological, and Functional Diversity of Adipose Tissue. *Cell Metab.* 2018; **27**(1):68-83.
8. Bozkurt L, Göbl CS, Rami-Merhar B, et al. The Cross-Link between Adipokines, Insulin Resistance and Obesity in Offspring of Diabetic Pregnancies. *Horm Res Paediatr*. 2016; **86**(5):300-308.
9. Stolarczyk E. Adipose tissue inflammation in obesity: a metabolic or immune response?. *Curr Opin Pharmacol*. 2017; **37**:35-40.
10. Hou B, Zhao Y, He P, et al. Targeted lipidomics and transcriptomics profiling reveal the heterogeneity of visceral and subcutaneous white adipose tissue. *Life Sci*. 2020; **245**:117352.
11. Kuri-Harcuch W, Velez-delValle C, Vazquez-Sandoval A, Hernández-Mosqueira C, Fernandez-Sanchez V. A cellular perspective of adipogenesis transcriptional regulation. *J Cell Physiol.* 2019; **234**(2):1111-1129.
12. Cox AR, Chernis N, Masschelin PM, Hartig SM. Immune Cells Gate White Adipose Tissue Expansion. *Endocrinology*. 2019; **160**(7):1645-1658.
13. Wronska A, Kmiec Z. Structural and biochemical characteristics of various white adipose tissue depots. Acta Physiol (Oxf). 2012; **205**(2):194-208.
14. Francisco V, Pino J, Gonzalez-Gay MA, et al. Adipokines and inflammation: is it a question of weight?. *Br J Pharmacol.* 2018; **175**(10):1569-

1579.
15. Monzillo LU, Hamdy O, Horton ES, et al. Effect of lifestyle modification on adipokine levels in obese subjects with insulin resistance. *Obes Res.* 2003; **11**(9):1048-1054.
16. Cãtoi AF, Suciu [a], Pârvu AE, et al. Increased chemerin and decreased omentin-1 levels in morbidly obese patients are correlated with insulin resistance, oxidative stress and chronic inflammation. *Clujul Med*. 2014; **87**(1):19-26.
17. Kim KH, Lee K, Moon YS, Sul HS. A cysteine-rich adipose tissue-specific secretory factor inhibits adipocyte differentiation. *J Biol Chem.* 2001; **276**(14):11252-11256.
18. Barnes KM, Miner JL. Role of resistin in insulin sensitivity in rodents and humans. *Curr Protein Pept Sci*. 2009; **10**(1):96-107.
19. Steppan CM, Bailey ST, Bhat S, et al. The hormone resistin links obesity to diabetes. *Nature.* 2001; **409**(6818):307-312.
20. Steppan CM, Wang J, Whiteman EL, Birnbaum MJ, Lazar MA. Activation of SOCS-3 by resistin. *Mol Cell Biol*. 2005; **25**(4):1569-1575.
21. Benomar Y, Taouis M. Molecular Mechanisms Underlying Obesity-Induced Hypothalamic Inflammation and Insulin Resistance: Pivotal Role of Resistin/TLR4 Pathways. Front Endocrinol (Lausanne). 2019; **10**:140.
22. Benomar Y, Amine H, Crépin D, et al. Central Resistin/TLR4 Impairs Adiponectin Signaling, Contributing to Insulin and FGF21 Resistance. *Diabetes*. 2016; **65**(4):913-926.
23. Jiang Y, Lu L, Hu Y, et al. Resistin Induces Hypertension and Insulin Resistance in Mice via a TLR4-Dependent Pathway. *Sci Rep*. 2016; **6**: 22193. Published 2016 Feb 26.
24. Wang CH, Wang PJ, Hsieh YC, et al. Resistin facilitates breast cancer progression via TLR4-mediated induction of mesenchymal phenotypes and stemness properties. *Oncogene.* 2018; **37**(5):589-600.
25. Liu SX, Zheng F, Xie KL, Xie MR, Jiang LJ, Cai Y. Exercise Reduces Insulin Resistance in Type 2 Diabetes Mellitus via Mediating the lncRNA MALAT1/MicroRNA-382-3p/Resistin Axis. *Mol Ther Nucleic Acids.* 2019; **18**: 34-44.
26. Cai Y, Xie KL, Zheng F, Liu SX. Aerobic Exercise Prevents Insulin Resistance Through the Regulation of miR-492/Resistin Axis in Aortic Endothelium. *J Cardiovasc Transl Res*. 2018; **11**(6):450-458.
27. Luo J, Huang L, Wang A, et al. Resistin-Induced Endoplasmic Reticulum Stress Contributes to the Impairment of Insulin Signaling in Endothelium [published correction appears in Front Pharmacol. 2018 Dec 10;9:1446]. Front Pharmacol. 2018;9:1226. Published 2018 Oct 26.
28. Hamada J, Onuma H, Ochi F, et al. Endoplasmic reticulum stress induced by tunicamycin increases resistin messenger ribonucleic acid through the pancreatic endoplasmic reticulum eukaryotic initiation factor 2á kinase-activating transcription factor 4-CAAT/enhancer binding protein-á homologous protein pathway in THP-1 human monocytes. *J Diabetes Investig*. 2016; **7**(3):312-323.
29. Yan QW, Yang Q, Mody N, et al. The adipokine lipocalin 2 is regulated by obesity and promotes insulin resistance. *Diabetes.* 2007; **56**(10):2533-2540.
30. Flo TH, Smith KD, Sato S, et al. Lipocalin 2 mediates an innate immune response to bacterial infection by sequestrating iron. *Nature*. 2004; **432**(7019): 917-921.
31. Law IK, Xu A, Lam KS, et al. Lipocalin-2 deficiency attenuates insulin resistance associated with aging and obesity. *Diabetes*. 2010; **59**(4):872-882.
32. Esteve E, Ricart W, Fernández-Real JM. Adipocytokines and insulin resistance: the possible role of lipocalin-2, retinol binding protein-4, and adiponectin. *Diabetes Care*. 2009; **32** Suppl 2(Suppl 2):S362-S367.
33. Guo H, Jin D, Zhang Y, et al. Lipocalin-2 deficiency impairs thermogenesis and potentiates diet-induced insulin resistance in mice. *Diabetes*. 2010; **59**(6):1376-1385.
34. Chella Krishnan K, Sabir S, Shum M, et al. Sex-specific metabolic functions of adipose Lipocalin-2. *Mol Metab*. 2019; **30**:30-47.
35. Li D, Yan Sun W, Fu B, Xu A, Wang Y. Lipocalin-2-The myth of its expression and function. *Basic Clin Pharmacol Toxicol*. 2020; **127**(2): 142-151.
36. Kamble PG, Pereira MJ, Almby K, Eriksson JW. Estrogen interacts with glucocorticoids in the regulation of lipocalin 2 expression in human adipose tissue. Reciprocal roles of estrogen receptor á and â in insulin resistance?. *Mol Cell Endocrinol.* 2019; **490**:28-36.
37. Kamble PG, Pereira MJ, Sidibeh CO, et al. Lipocalin 2 produces insulin resistance and can be upregulated by glucocorticoids in human adipose tissue. *Mol Cell Endocrinol*. 2016; **427**:124-132.
38. Bhusal A, Lee WH, Suk K. Lipocalin-2 in Diabetic Complications of the Nervous System: Physiology, Pathology, and Beyond. *Front Physiol*. 2021; **12**: 638112.
39. Park YM, Pereira RI, Erickson CB, Swibas TA, Cox-York KA, Van Pelt RE. Estradiol-mediated improvements in adipose tissue insulin sensitivity are related to the balance

of adipose tissue estrogen receptor á and â in postmenopausal women. *PLoS One*. 2017; **12**(5):e0176446. Published 2017 May 4.

40. Chan YK, Sung HK, Jahng JW, Kim GH, Han M, Sweeney G. Lipocalin-2 inhibits autophagy and induces insulin resistance in H9c2 cells. *Mol Cell Endocrinol.* 2016; **430**:68-76.
41. Wolf G. Serum retinol-binding protein: a link between obesity, insulin resistance, and type 2 diabetes. *Nutr Rev*. 2007; **65**(5):251-256.
42. Kojta I, Chaciñska M, B³achnio-Zabielska A. Obesity, Bioactive Lipids, and Adipose Tissue Inflammation in Insulin Resistance. *Nutrients.* 2020; **12**(5):1305. Published 2020 May 3.
43. Jung UJ, Choi MS. Obesity and its metabolic complications: the role of adipokines and the relationship between obesity, inflammation, insulin resistance, dyslipidemia and nonalcoholic fatty liver disease. *Int J Mol Sci.* 2014; **15**(4):6184-6223. Published 2014 Apr 11.
44. Majerczyk M, Olszanecka-Glinianowicz M, Puzianowska-KuŸnicka M, Chudek J. Retinol-binding protein 4 (RBP4) as the causative factor and marker of vascular injury related to insulin resistance. Postepy Hig Med Dosw (Online). 2016;70(0):1267-1275.
45. Sun X, Zhang Z, Ning H, Sun H, Ji X. Sitagliptin down-regulates retinol-binding protein 4 and reduces insulin resistance in gestational diabetes mellitus: a randomized and double-blind trial. *Metab Brain Dis*. 2017; **32**(3):773-778.
46. Lin WT, Lin PC, Lee CY, et al. Effects of insulin resistance on the association between the circulating retinol-binding protein 4 level and clustering of pediatric cardiometabolic risk factors. *Pediatr Diabetes*. 2018; **19**(4):611-621.
47. Liu G, Sun Q. Response by Liu and Sun to Letter Regarding Article, "Plasma Levels of Fatty Acid-Binding Protein 4, Retinol-Binding Protein 4, High-Molecular-Weight Adiponectin, and Cardiovascular Mortality Among Men With Type 2 Diabetes: A 22-Year Prospective Study". *Arterioscler Thromb Vasc Biol.* 2017; **37**(5):e57.
48. Klisiæ A, Kavariæ N, Bjelakoviæ B, Soldatoviæ I, Martinoviæ M, Kotur-Stevuljeviæ J. The Association Between Retinol-Binding Protein 4 and Cardiovascular Risk Score is Mediated by Waist Circumference in Overweight/Obese Adolescent Girls. *Acta Clin Croat*. 2017; **56**(1):92-98.
49. Wang H, Zhou P, Zou D, Liu Y, Lu X, Liu Z. The role of retinol-binding protein 4 and its relationship with sex hormones in coronary artery disease. *Biochem Biophys Res Commun.* 2018; **506**(1):204-210.
50. Li G, Esangbedo IC, Xu L, et al. Childhood retinol-binding protein 4 (RBP4) levels predicting the 10-year risk of insulin resistance and metabolic syndrome: the BCAMS study. *Cardiovasc Diabetol*. 2018; **17**(1):69. Published 2018 May 14.
51. Wei Y, Xia N, Zhang W, et al. Serum retinol-binding protein 4 is associated with insulin resistance in patients with early and untreated rheumatoid arthritis. *Joint Bone Spine*. 2019; **86**(3):335-341.
52. Boutari C, Perakakis N, Mantzoros CS. Association of Adipokines with Development and Progression of Nonalcoholic Fatty Liver Disease. *Endocrinol Metab (Seoul)*. 2018; **33**(1):33-43.
53. Goralski KB, McCarthy TC, Hanniman EA, et al. Chemerin, a novel adipokine that regulates adipogenesis and adipocyte metabolism. *J Biol Chem*. 2007; **282**(38):28175-28188.
54. Zabel BA, Zuniga L, Ohyama T, et al. Chemoattractants, extracellular proteases, and the integrated host defense response. *Exp Hematol.* 2006; **34**(8):1021-1032.
55. Helfer G, Wu QF. Chemerin: a multifaceted adipokine involved in metabolic disorders. *J Endocrinol*. 2018; **238**(2):R79-R94.
56. Kennedy AJ, Yang P, Read C, et al. Chemerin Elicits Potent Constrictor Actions via Chemokine-Like Receptor 1 (CMKLR1), not G-Protein-Coupled Receptor 1 (GPR1), in Human and Rat Vasculature. *J Am Heart Assoc.* 2016; **5**(10):e004421. Published 2016 Oct 14.
57. Stojek M. The role of chemerin in human disease. Postepy Hig Med Dosw (Online). 2017; **71**(0):110-117. Published 2017 Feb 15.
58. Sell H, Laurencikiene J, Taube A, et al. Chemerin is a novel adipocyte-derived factor inducing insulin resistance in primary human skeletal muscle cells. *Diabetes*. 2009; **58**(12):2731-2740.
59. Zhang Z, Wang J, Wang H. Correlation of blood glucose, serum chemerin and insulin resistance with NAFLD in patients with type 2 diabetes mellitus. *Exp Ther Med.* 2018; **15**(3):2936-2940.
60. Ren SM, Mei L, Huang H, Cao SF, Zhao RH, Zheng PY. Zhonghua Gan Zang Bing Za Zhi. 2019; **27**(5):369-375.
61. Kim DI, Lee DH, Hong S, Jo SW, Won YS, Jeon JY. Six weeks of combined aerobic and resistance exercise using outdoor exercise machines improves fitness, insulin resistance, and chemerin in the Korean elderly: A pilot randomized controlled trial. *Arch Gerontol Geriatr.* 2018; **75**:59-64.
62. Corona-Meraz FI, Navarro-Hernández RE, Ruíz-Quezada SL, et al. Inverse Relationship of the

CMKLR1 Relative Expression and Chemerin Serum Levels in Obesity with Dysmetabolic Phenotype and Insulin Resistance. *Mediators Inflamm*. 2016;2016:3085390.

63. Skuratovskaia D, Zatolokin P, Vulf M, Mazunin I, Litvinova L. Interrelation of chemerin and TNF-á with mtDNA copy number in adipose tissues and blood cells in obese patients with and without type 2 diabetes. *BMC Med Genomics.* 2019; **12**(Suppl 2):40. Published 2019 Mar 13.
64. Lakhdar N, Landolsi M, Bouhlel E, Tabka Z. Effect of diet and diet combined with chronic aerobic exercise on chemerin plasma concentrations and adipose tissue in obese women. *Neuro Endocrinol Lett*. 2019; **40**(6):262-270.
65. El-Khashab SO, Gamil M, Ali AY, et al. Chemerin level and the relation to insulin resistance in chronic kidney disease. *Saudi J Kidney Dis Transpl*. 2019; **30**(6):1381-1388.
66. Yang X, Quan X, Lan Y, et al. Serum chemerin level in women with PCOS and its relation with the risk of spontaneous abortion. *Gynecol Endocrinol.* 2018; **34**(10):864-867.
67. Foda AA, Foda EA, El-Negeri MA, El-Said ZH. Serum chemerin levels in Polycystic Ovary Syndrome after metformin therapy. *Diabetes Metab Syndr*. 2019; **13**(2):1309-1315.
68. Abruzzese GA, Gamez J, Belli SH, et al. Increased chemerin serum levels in hyperandrogenic and normoandrogenic women from Argentina with polycystic ovary syndrome. *Gynecol Endocrinol*. 2020; **36**(12):1057-1061.
69. Cawthorn WP, Sethi JK. TNF-alpha and adipocyte biology. *FEBS Lett*. 2008; **582**(1):117-131.
70. Hotamisligil GS, Peraldi P, Budavari A, Ellis R, White MF, Spiegelman BM. IRS-1-mediated inhibition of insulin receptor tyrosine kinase activity in TNF-alpha- and obesity-induced insulin resistance. *Science*. 1996; **271**(5249):665-668.
71. da Costa RM, Neves KB, Mestriner FL, Louzada-Junior P, Bruder-Nascimento T, Tostes RC. TNF-á induces vascular insulin resistance via positive modulation of PTEN and decreased Akt/eNOS/NO signaling in high fat diet-fed mice. *Cardiovasc Diabetol.* 2016; **15**(1):119.
72. Alipourfard I, Datukishvili N, Mikeladze D. TNF-á Downregulation Modifies Insulin Receptor Substrate 1 (IRS-1) in Metabolic Signaling of Diabetic Insulin-Resistant Hepatocytes. Mediators Inflamm. 2019;2019:3560819.
73. Takaguri A. Yakugaku Zasshi. 2018; **138**(11):1329-1334.
74. Tian S, Wang M, Liu C, Zhao H, Zhao B. Mulberry leaf reduces inflammation and insulin resistance in type 2 diabetic mice by TLRs and insulin Signalling pathway. *BMC Complement Altern Med*. 2019; **19**(1):326.
75. Xuguang H, Aofei T, Tao L, Longyan Z, Weijian B, Jiao G. Hesperidin ameliorates insulin resistance by regulating the IRS1-GLUT2 pathway via TLR4 in HepG2 cells. *Phytother Res*. 2019; **33**(6):1697-1705.
76. Massaro M, Scoditti E, Pellegrino M, et al. Therapeutic potential of the dual peroxisome proliferator activated receptor (PPAR)á/ã agonist aleglitazar in attenuating TNF-á-mediated inflammation and insulin resistance in human adipocytes. *Pharmacol Res*. 2016; **107**:125-136.
77. Kim WJ, Lee W, Jung Y, Jang HJ, Kim YK, Kim SN. PPARâ/ä agonist GW501516 inhibits TNFá-induced repression of adiponectin and insulin receptor in 3T3-L1 adipocytes. *Biochem Biophys Res Commun*. 2019; **510**(4):621-628.
78. Maekawa M, Tadaki H, Tomimoto D, et al. A Novel TNF-á Converting Enzyme (TACE) Selective Inhibitor JTP-96193 Prevents Insulin Resistance in KK-A^y Type 2 Diabetic Mice and Diabetic Peripheral Neuropathy in Type 1 Diabetic Mice. *Biol Pharm Bull*. 2019;**42**(11):1906-1912.
79. Clemenzi MN, Wellhauser L, Aljghami ME, Belsham DD. Tumour necrosis factor á induces neuroinflammation and insulin resistance in immortalised hypothalamic neurones through independent pathways. *J Neuroendocrinol*. 2019; **31**(1):e12678.
80. Keller C, Keller P, Marshal S, Pedersen BK. IL-6 gene expression in human adipose tissue in response to exercise—effect of carbohydrate ingestion. *J Physiol*. 2003; **550**(Pt 3):927-931.
81. Unamuno X, Gómez-Ambrosi J, Rodríguez A, Becerril S, Frühbeck G, Catalán V. Adipokine dysregulation and adipose tissue inflammation in human obesity. *Eur J Clin Invest*. 2018; **48**(9):e12997.
82. Rotter V, Nagaev I, Smith U. Interleukin-6 (IL-6) induces insulin resistance in 3T3-L1 adipocytes and is, like IL-8 and tumor necrosis factor-alpha, overexpressed in human fat cells from insulin-resistant subjects. *J Biol Chem*. 2003; **278**(46):45777-45784.
83. Senn JJ, Klover PJ, Nowak IA, et al. Suppressor of cytokine signaling-3 (SOCS-3), a potential mediator of interleukin-6-dependent insulin resistance in hepatocytes. *J Biol Chem*. 2003; **278**(16):13740-13746.
84. Almuraikhy S, Kafienah W, Bashah M, et al. Interleukin-6 induces impairment in

human subcutaneous adipogenesis in obesity-associated insulin resistance. *Diabetologia*. 2016;**59**(11):2406-2416.

85. Xu E, Pereira MMA, Karakasilioti I, et al. Temporal and tissue-specific requirements for T-lymphocyte IL-6 signalling in obesity-associated inflammation and insulin resistance. *Nat Commun.* 2017;**8**:14803.
86. Kuo FC, Huang YH, Lin FH, et al. Circulating Soluble IL-6 Receptor Concentration and Visceral Adipocyte Size Are Related to Insulin Resistance in Taiwanese Adults with Morbid Obesity. *Metab Syndr Relat Disord*. 2017;**15**(4):187-193.
87. Zhang Y, Li C, Zhang W, Zheng X, Chen X. Decreased Insulin Resistance by Myo-Inositol Is Associated with Suppressed Interleukin 6/ Phospho-STAT3 Signaling in a Rat Polycystic Ovary Syndrome Model. *J Med Food*. 2020; **23**(4):375-387.
88. Long MH, Zhang C, Xu DQ, et al. $PM_{2.5}$ aggravates diabetes via the systemically activated IL-6-mediated STAT3/SOCS3 pathway in rats' liver. *Environ Pollut*. 2020; **256**:113342.
89. Cai X, Fang C, Hayashi S, et al. Pu-erh tea extract ameliorates high-fat diet-induced nonalcoholic steatohepatitis and insulin resistance by modulating hepatic IL-6/STAT3 signaling in mice. *J Gastroenterol*. 2016; **51**(8):819-829.
90. Cai X, Fang C, Hayashi S, et al. Pu-erh tea extract ameliorates high-fat diet-induced nonalcoholic steatohepatitis and insulin resistance by modulating hepatic IL-6/STAT3 signaling in mice. *J Gastroenterol.* 2016; **51**(8):819-829.

IJPSR (2022), Volume 13, Issue 11 **(Research Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 24 March 2022; received in revised form, 12 May 2022; accepted, 24 May 2022; published 01 November 2022

INVESTIGATION OF ANTI-SWARMING, ANTI-BIOFILM AND ANTI-QUORUM SENSING POTENTIAL OF SOME ORGANIC TEA OF DIFFERENT BRANDS FROM INDIA

P. V. Hirapure [*1], S. A. Paranjape [1], T. V. Bind [1], K. K. Bawankar [1] and V. J. Upadhye [2]

Department of Biochemistry and Biotechnology [1], Dr. Ambedkar College Deekshabhoomi, Nagpur - 440010, Maharashtra, India.
Department of Microbiology [2], Parul Institute of Applied Sciences (PIAS), Parul University, Vadodara - 391760, Gujarat, India.

Keywords:

Anti-quorum sensing, Biofilm disruption, Anti-swarming, Tea extract, Bacterial communication

Correspondence to Author:
Pradip Hirapure

Assistant Professor,
Department of Biochemistry and Biotechnology, Dr. Ambedkar College Deekshabhoomi, Nagpur - 440010, Maharashtra, India.

E-mail: pradiphirapure@gmail.com

ABSTRACT: The emergency to find a solution to multidrug resistance of bacteria due to the abuse of antibiotics leads to the search for new antibacterial pathways. Quorum sensing (QS), or bacterial cell to cell communication, is a cell-density-dependent bacterial response. It is mediated by hormone-like compounds called autoinducers (AIs). QS-dependent regulation of gene expression controls various phenotypes, including bioluminescence, biofilm formation, drug resistance, virulence factors expression, and motility. Therefore, the inhibition of QS is considered a new promising target of antimicrobial pathways as anti-virulence compounds that can repress the gene expression of QS. Green tea is one of the most commonly consumed teas in the world. Green tea extract is also a great source of compounds like polyphenols, amino acids, enzymes, pigments, and carbohydrates. Hence, green tea has recently received considerable attention as a new source of safe and effective QS inhibitory substances. In the present study, methanolic and ethanolic various tea extracted were prepared and tested to inhibit quorum sensing mediated bacterial virulence factors such as anti-swarming, and antibiofilm potential against organism P*seudomonas aeruginosa*. Quorum sensing inhibition against *Chromobacterium violaceum MTCC* 2656 has been carried out. The study's outcome shows that most of the methanolic and ethanolic extracts of various tea products show significantly Anti-quorum sensing Potential up to 83% swarming inhibition with P*seudomonas aeruginosa*, inhibition *violaceum pingment* and biofilm disruption were also quite high in most of the Tea extract of ethanol and methanol.

INTRODUCTION: The problem of multidrug-resistant bacteria is becoming a worldwide concern nowadays. This pathogenic organism became resistant to a large range of antibiotics that possess a problem with treating various diseases [1]. Antibacterial drugs are the foremost effective of all medicines. Their success is reflected by their continuous use and thus the decreased morbidity and mortality from bacterial infections over the past 50 years.

However, the continued emergence and spread of multidrug-resistant bacteria have predicted that we are re-entering the predominant era [2]. The event of antibiotic resistance is the key reason for the development of pathogenicity. The microorganism dwelling within the biofilm often develops antibiotic resistance against common disinfectants and antiseptics that are regularly used [3]. So to beat the rapid spread of multidrug resistance, the event

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.13(11).4620-27

This article can be accessed online on www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.13(11).4620-27

of recent antimicrobial or antipathogenic agents that influence new microbial targets has become an extremely pressing priority.

Because of the proven fact that quorum sensing is involved in microbial pathogenesis, research efforts have recently focused on developing antipathogenic agents to manage bacterial diseases by inhibiting quorum sensing [4].

Quorum sensing is the ability to detect and reply to cell population density by gene regulation and intracellular communication between bacteria using bacterial products. This population density-dependent mechanism is mediated through small signaling molecules called autoinducers by which bacteria regulate gene expression in gram-negative bacteria; the autoinducers are AHLs that are acyl-homoserine lactone [5].

Quorum sensing enables bacteria to limit the expression of specific genes to high cell densities at which the resulting phenotypes are visiting be most beneficial. QS-dependent regulation of gene expression controls many phenotypes, including bioluminescence, biofilm formation, drug resistance, virulence factors expression, and motility.

Therefore, the inhibition of QS is considered a fresh, promising target of antimicrobial pathways as anti-virulence compounds that could repress the gene expression essential for basic metabolism in vitro, rather than the microorganisms themselves [6].

Quorum sensing might be a good drug target because, unlike antibiotics and biocides that kill bacteria, interfering with signaling system or cell to cell communication relies on the principle that when one bacterium releases autoinducers into the environment, their concentration is just too low to detect, hence when sufficient bacteria present concentration of autoinducers reach threshold level that permits the bacteria to sense critical cell population and to activate target genes [7].

In Gram-negative bacteria, the foremost common autoinducers are N-acyl-homoserine lactones (AHLs), a signalling molecule in higher concentrations that can bind to and activate a transcriptional activator or R protein which successively induces the expression of target genes. Whereas Gram-positive bacteria usually utilize peptides as autoinducers [8].

In recent years, Green tea is becoming increasingly popular worldwide, partly because of many documented evidence about its beneficial effects on health.

Tea contains numerous components, including catechins, caffeine, amino acids, carbohydrates, proteins, chlorophyll, volatile compounds, fluoride, minerals, and other undefined compounds. Several biological properties are associated with tea polyphenols (TP); tea extract can modulate the Quorum sensing [9].

We hypothesize that a variety of its antimicrobial properties is additionally contributed by the QSI phytochemicals present in it.

Therefore, within the current study, we aimed to research the anti-quorum sensing and anti-biofilm potentials of herb polyphenol extract against *Chromobacterium violaceum* CV026 and *Pseudomonas aeruginosa* at sub-inhibitory concentration.

Furthermore, the influence of tea extract on *P. aeruginosa* quorum-sensing- regulated virulence factors production, motility, and biofilm formation were also assayed [10].

MATERIALS AND METHODS:

Chemicals, Bacterial Strains and Culture Medium: All the chemicals and media were used for carrying out this study purchased from High-media Pvt.Ltd and Sigma Aldrich. *Chromobacterium violaceum MTCC* 2656, a pathogenic strain, was procured from MTCC Chandīgarh, India.

Pseudomonas aeruginosa with a trait of swarming motility isolated from soil collected from the campus of Dr. Ambedkar College Deekshabhoomi Nagpur and isolates were maintained on Nutrient Agar medium slant at 2-8°C.

Tea Samples Collection: Organic tea and various brands of tea were purchased from nearby local markets, twelve tea samples were purchased from local market of Nagpur city. India. Which are listed in **Table 1**. The tested tea samples are listed below.

TABLE 1: THE TESTED TEA SAMPLES AND STOCK AND WORKING CONCENTRATION OF TEA EXTRACT

S. no.	Name of extract	Stock Concentration of methanol Extract mg/ml	Stock Concentration of ethanol Extract mg/ml	Concentration of Working methanol & ethanol extract mg/ul
1	Lipton	700	650	1.0
2	Himalaya wellness tea	630	600	1.0
3	Organic India	890	720	1.0
4	24 Mantra Organic Green Tea	820	870	1.0
5	LaPlant Green Tea	670	630	1.0
6	Twinings Green Tea	540	590	1.0
7	Tetley	810	760	1.0
8	Taaza	760	700	1.0
9	Tulsi Green Tea	680	570	1.0
10	TajMahal Green Tea	530	780	1.0
11	Tata tea	520	610	1.0
12	The Indian Tea	660	530	1.0

Preparation of Tea Extract: A modification of previously described procedures (Raaman, 2006), was used to prepare the Methanolic and ethanolic extract of the tea Product. The dried Tea materials (2 gm) were mixed with 20 ml 70% (v/v) ethanol and 20 ml Methanol separately for 8 h in a Soxhlet extractor. The extract was then allowed to evaporate in an oven at 37°C for at least three days. Some of the extracts were dried using IR Concentrator. The dried extract was stored in a refrigerator until used (extracts were tested within 2 weeks of extraction).

Preparation of Stock Solutions: Stock solutions of crude ethanol and methanol extracts were prepared, filter-sterilized (0.25 µm), and stored at 4°C. **Table 1**. Shows the concentration of each stock solutions concentrations working solution.

Swarming Inhibition Assay: Swarming Inhibition assay was conducted with a nutrient medium containing 0.8% agar. Swarm plates were allowed to dry in the incubator before being used. Prepared Swarm plates were then divided into four regions by using a marker and inoculated with the overnight grown bacterial culture of *Pseudomonas aeruginosa* in Nutrient broth. 0.5 µl of culture inoculated over 1µl of tea extract and allowed to absorb sample drop in the medium. These plates were then incubated for 48 h at 37°C. Inhibition in the swarming motility was determined by measuring the diameters of the swarm zones compared to the negative control.

Quorum Sensing Inhibition Assay using *Chromobacterium violacein* CV026: A paper disc diffusion assay was performed to test for Quorum sensing inhibition using. *Chromobacterium violaceum MTCC* 2656. 100 microliter of the. *Chromobacterium violaceum MTCC* 2656 overnight culture grown was spread on agar plates and allowed it to dry. Paper discs were dipped into the extracts and placed on the culture-grown plates. The plates were incubated at 37°C for 24 hrs; then, plates were observed for any pigment inhibition zones and examined for violacein production. Quorum sensing inhibition was detected by a colourless, opaque, but viable halo around the disc. Methanol and ethanol were also used as a negative control [10].

Biofilm Inhibition Assay using Tube Method: In this assay 100 µL of bacterial culture *Pseudomonas aeruginosa* were transferred to glass test tubes containing 5 mL Nutrient Broth and 150 µl of tea extract, and tubes were incubated at 37°C for 24 h. Three controlled tubes were also prepared, one containing culture media only and the other two of ethanol and methanol as a negative control. The media was then removed, and the tubes were washed with distilled water. The tubes are stained with crystal violet and rinsed twice to discharge the extra stain and air-dried. The occurrence of the blue ring above on the wall at the bottom of the tube indicates biofilm production. Two control tubes of ethanol and methanol were also taken for comparison[11].

RESULTS:

Anti-swarming Assay: Ethanol and methanol extract of various Tea extracts were tested for the ability to inhibit swarming in *Pseudomonas aerogenosa*.

The result of this assay was interpreted in a way that is the reduction in the diameter of the swarm zones as compared to control. Data represented in **Table 2** shows no significant variations in ethanolic and methanolic extract, but the Highest Swarming inhibition was found in methanolic and ethanolic extract of Lipton. The size of swarm zones of *Pseudomonas aerogenosa* was significantly reduced in the presence of these extracts as compared to control. In some extracts pattern of motility was found to be different. All the Tea brands significantly effective as an Anti-swarming Agent for the tested organism *Pseudomonas aerogenosa*

TABLE 2: RESULT OF ANTI-SWARMING POTENTIAL OF VARIOUS TEA EXTRACTS

S. no.	Tea Extracts	Diameter of Swarm zone in cm	
		Methanol (% of Swarming inhibition)	Ethanol (% of Swarming inhibition)
	Negative control	1.6	1.8
1	Lipton	0.3 (81.25%)	0.3 (83.33 %)
2	Himalaya wellness tea	0.4 (75%)	0.4(77.77 %)
3	Organic India	0.3 (81.25%)	0.6 (66.66 %)
4	24 Mantra Organic Green Tea	0.5 (68.75)	0.5 (72.22%)
5	LaPlant Green Tea	0.6 (62.5 %)	0.4(77.77%)
6	Twinings Green Tea	0.3 (81.25 %)	0.4(77.77%)
7	Tetley	0.5 (68.75 %)	0.5 (72.22%)
8	Taaza	0.9 (43.75)	1.3 (27.77%)
9	Tulsi Green Tea	0.5 (68.75%)	0.4(77.77%)
10	TajMahal Green Tea	0.5 (68.75%)	0.4(77.77%)
11	Tata tea	0.4 (75%)	0.5 (72.22%)
12	The Indian Tea	0.4 (75%)	0.5 (72.22%)
		The values of swarm zones presented as Mean	

Anti-quorum Sensing Bioassay using *Chromobacterium violaceum MTCC* 2656: The pigment production is one of the phenomena controlled by quorum sensing regulatory mechanism in *Chromobacterium violaceum MTCC* 2656. The paper disc diffusion assay was performed for pigment inhibition in which various Tea extracts tested for only the pigment inhibition and no growth inhibition. The area of colorless turbid zone indicates that the extract is allowing inhibition of the quorum sensing mechanism in the organism. Data of Pigment Production inhibition in *Chromobacterium violaceum MTCC* 2656 presented in **Table 3.**

TABLE 3: PIGMENT PRODUCTION INHIBITION IN *CHROMOBACTERIUM VIOLACEUM* MTCC 2656

S. no.	Sample	Methanol Extract	Ethanol extract
1	Lipton	+++	++
2	Himalaya wellness tea	-ve	+++
3	Organic India	+++	+
4	24 Mantra Organic Green Tea	+++	+++
5	LaPlant Green Tea	+	++
6	Twinings Green Tea	++	+
7	Tetley	-ve	-ve
8	Taaza	-ve	-ve
9	Tulsi Green Tea	+++	+++
10	TajMahal Green Tea	+	+
11	Tata tea	-ve	+++
12	The Indian Tea	++	+++

+++ High, ++ Moderate, + Least

Biofilm Disruption Assay by Tube Method: *P. aeruginosa* shows strong biofilm formation; the different Tea extracts were screened for their biofilm disruption Potential against *P. aeruginosa*. The crystal violates staining method is easily and widely used to measure biofilms' formation and inhibition in a tube. The results of this assay are presented in **Table 4**. All most all the methanol and ethanol extract were showed significant Biofilm reduction as compared to negative control except for ethanol and methanol extract of Taza

TABLE 4: RESULT OF BIOFILM DISRUPTION ASSAY BY TUBE METHOD

S. no.	Sample	Methanol Extract	Ethanol extract
1	Lipton	+++	++
2	Himalaya wellness tea	++	+++
3	Organic India	+++	++
4	24 Mantra Organic Green Tea	+++	++
5	LaPlant Green Tea	+++	++
6	Twinings Green Tea	++	+
7	Tetley	+	+
8	Taaza	-ve	-ve
9	Tulsi Green Tea	++	+++
10	TajMahal Green Tea	+++	+++
11	Tata tea	+	+
12	The Indian Tea	++	+++

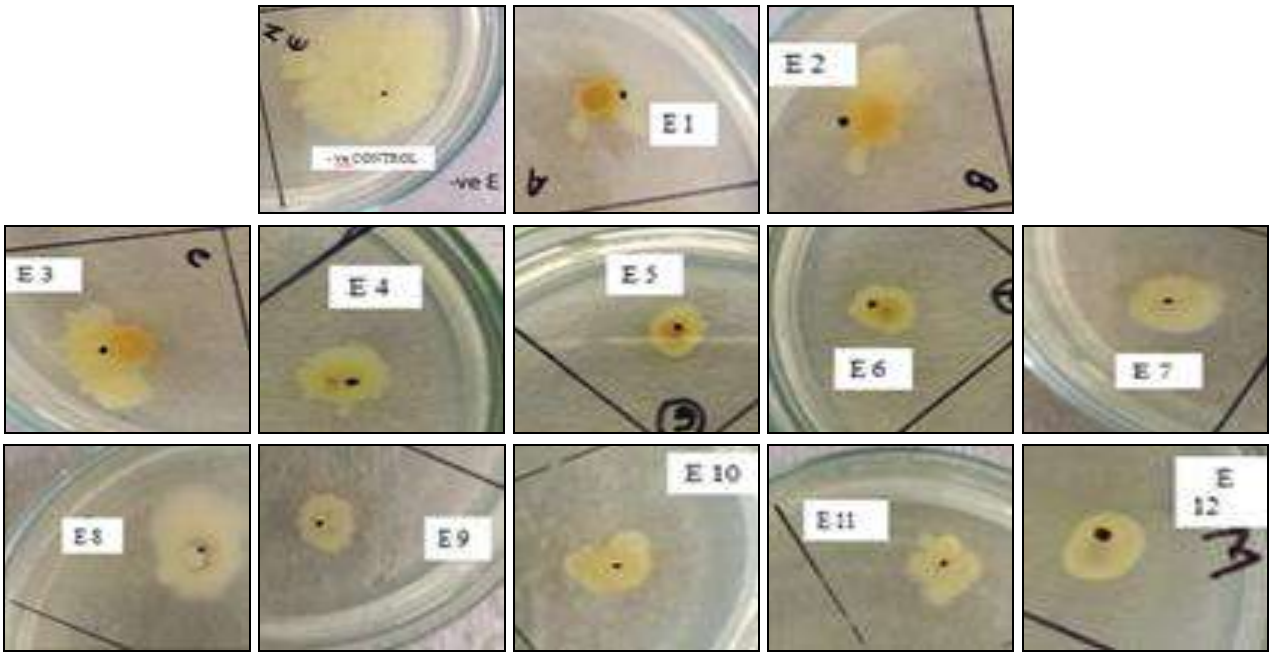


FIG. 1: THE PHOTOGRAPH OF SWARMING INHIBITION ASSAY BY ETHANOLIC TEA EXTRACTS USING *PSEUDOMONAS AERUGINOSA*

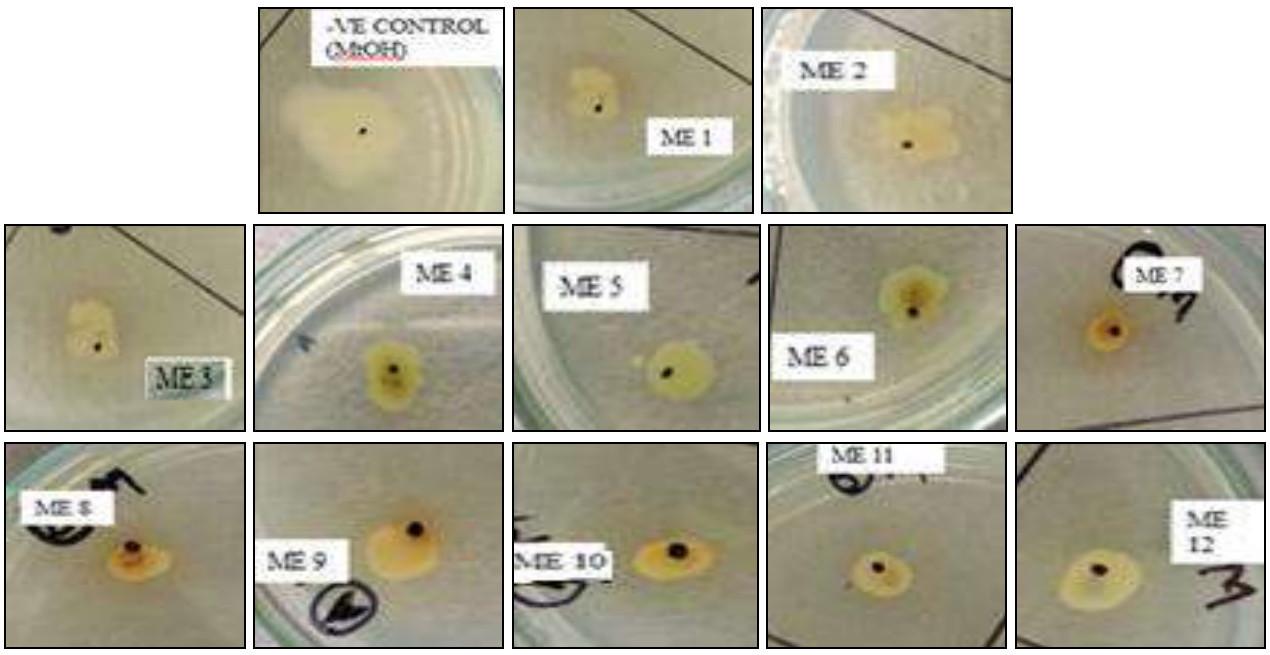


FIG. 2: THE PHOTOGRAPH OF SWARMING INHIBITION ASSAY BY MTHANOLIC TEA EXTRACTS USING *PSEUDOMONAS AERUGINOSA*

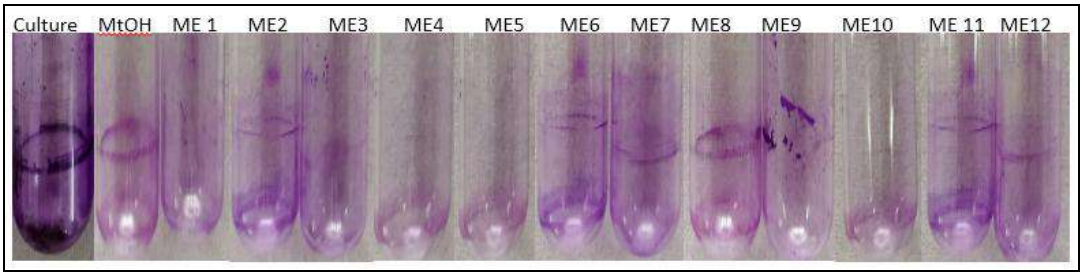


FIG. 3: RESULT OF BIOFILM DISRUPTION ASSAY USING *PSEUDOMONAS AERUGINOSA* BY METHANOLIC EXTRACT OF DIFFERENT TEA

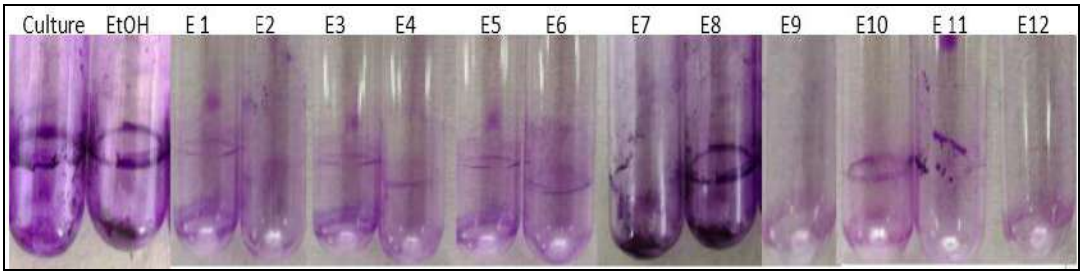


FIG. 4: RESULT OF BIOFILM DISRUPTION ASSAY USING *PSEUDOMONAS AERUGINOSA* BY ETHANOLIC EXTRACT OF DIFFERENT TEA

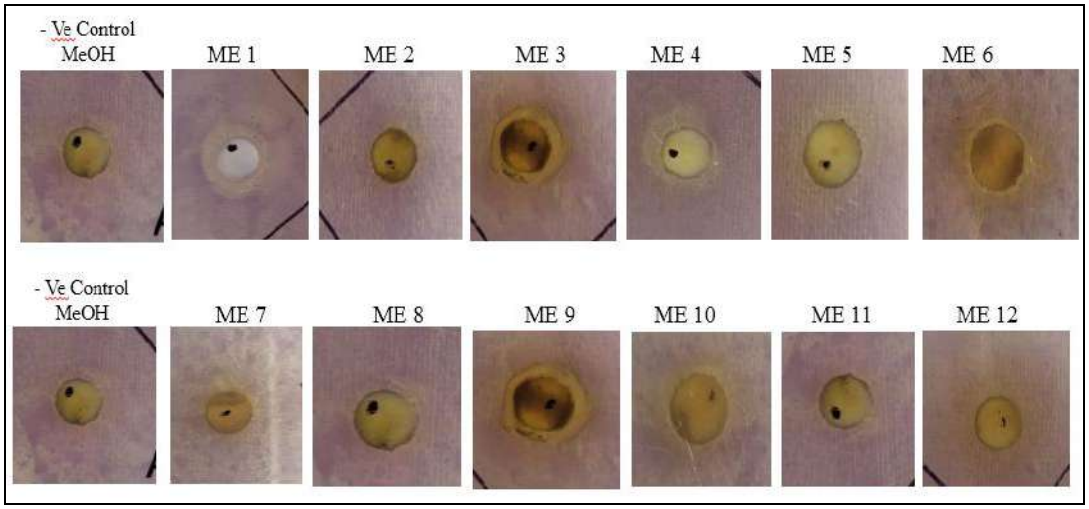


FIG. 5: RESULT OF QUORUM SENSING INHIBITION ASSAY USING *CHROMOBACTERIUM VIOLACEUM* MTCC 2656. BY METHANOLIC EXTRACT OF DIFFERENT TEA PRODUCT

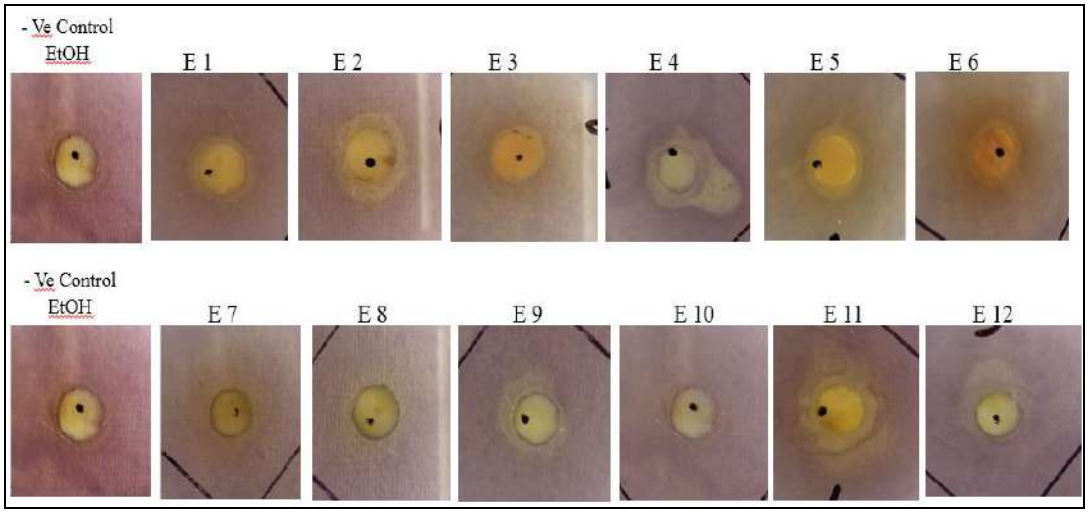


FIG. 6: RESULT OF QUORUM SENSING INHIBITION ASSAY USING *CHROMOBACTERIUM VIOLACEUM* MTCC 2656. BY ETHANOLIC EXTRACT OF DIFFERENT TEA PRODUCT

DISCUSSION: Green tea is one of the most popular beverages worldwide due to its health-promoting properties, which reflect the presence of antioxidants and also antimicrobial substances that are active against various Gram-positive and Gram-negative bacteria [12-16]. Both activities are mainly due to polyphenols, the most abundant of which is the catechins, particularly epigallocatechin gallate (EGCG), representing 50–80% of the total catechin content [17]. A deeper understanding of Bacterial cell-cell communication promises to shed light on the complexities of the host-microbe relationship and may lead to novel therapeutic applications. Many species of bacteria use quorum sensing to coordinate gene expression according to the density of the local population. Hence in the present study anti-quorum sensing activities of the twelve organic tea of various brands has been studied for their inhibition of Quorum sensing, controlled phenotype Swarming and biofilm formation of *Pseudomonas aeruginosa* and pigment production *Chromobacterium violaceum MTCC* 2656. The tea extract effectively inhibited Quorum sensing and controlled phenotypes of both tested organisms. This study's findings support other investigations that demonstrated anti-QS activity in certain Tea extracts. Further works are required to find active QSI ingredients of tea extracts and to clarify the mechanism of their action as a Quorum sensing inhibitor. A few tea extract showed negative result may be due to insufficient active ingredient concentration in that extract for inhibition of respective Quorum sensing controlled Phenotypes.

CONCLUSION: It is concluded that anti-QS is as important as antibacterial activity as it will unlikely cause resistance problems as it does not pose selection pressure. Anti-swarming, Biofilm, and QS are major virulence factors of most pathogenic microorganisms. The bioassay of the 12-studied tea extracts revealed significant Quorum sensing controlled bacterial phenotype inhibition activities. Further research is needed to investigate the molecular mechanism and active ingredient in each tea extract. Biofilm-associated bacterial infections frequently caused by *P. aeruginosa* are found in most diseases. The effectiveness of many antibacterial drugs has been lost due to the evolution of pathogenic resistance. Therefore alternative ways of reducing biofilms are essential. The anti-QS compounds present in green tea products help enhance the susceptibility of the bacteria and thus eradicate biofilms. Green tea may therefore offer a new source of antimicrobial compounds that can be used to reduce our reliance on antibiotics by inhibiting bacterial virulence without selecting for resistant bacterial strains [18-20].

ACKNOWLEDGEMENT: We thank Dr. B. A. Mehere, Principal of Dr. Ambedkar College, Deeksha Bhoomi, for providing a Laboratory facility, and I am also thankful to non-teaching staff members Avinash Chauhan, Leena Kamble, and Vishwanath Bhaisare.

CONFLICTS OF INTEREST: All authors declared no conflicts of interest.

REFERENCES:

1. Vivas R, Barbosa AA, Dolabela SS and Jain S: Multidrug-resistant bacteria and alternative methods to control them: an overview. Microbial Drug Resistance 2019; 25(6): 890-908.
2. Pote M and Hirapure P: Antimicrobial potential of Acacia nilotica extracts on few dental pathogens. Int J Pharm Sci Res 2014; 5: 4759.
3. Botelho J, Grosso F and Peixe L: Antibiotic resistance in Pseudomonas aeruginosa–Mechanisms, epidemiology and evolution. Drug Resistance Updates 2019; 44: 100640.
4. Kalia VC, Patel SK, Kang YC & Lee JK: Quorum sensing inhibitors as antipathogens: biotechnological applications. Biotechnology Advances 2019; 37(1): 68-90.
5. Mukherjee S & Bassler BL: Bacterial quorum sensing in complex and dynamically changing environments. Nature Reviews Microbiology 2019; 17(6): 371-382.
6. Haque S, Ahmad F, Dar SA, Jawed A, Mandal RK, Wahid M & Akhter N: Developments in strategies for Quorum Sensing virulence factor inhibition to combat bacterial drug resistance. Microbial Pathogenesis 2018; 121: 293-302.
7. Saeki EK, Kobayashi RK and Nakazato G: Quorum sensing system: Target to control the spread of bacterial infections. Microbial Pathogenesis 2020; 142: 104068..
8. Haramati R, Dor S, Gurevich D, Levy D, Freund D, Rytwo G, Sharon I and Afriat-Jurnou L: Mining marine metagenomes revealed a quorum-quenching lactonase with improved biochemical properties that inhibits the food spoilage bacteria Pseudomonas fluorescens. Applied and Environmental Microbiology 2021 Dec 15: AEM-01680.
9. Balappanavar AY: Tea and Oral Health. In Tea-Chemistry and Pharmacology 2020 Apr 29. Intech Open.
10. Moradi F and Hadi N: Quorum-quenching activity of some Iranian medicinal plants. New Microbes and New Infections 2021; 42: 100882.
11. Chen X, Zhang L, Zhang M, Liu H, Lu P and Lin K: Quorum sensing inhibitors: a patent review (2014–2018). Expert Opinion on Therapeutic Patents 2018; 28(12): 849-65.
12. Suryawanshi V, Yadav A, Mohite S and Magdum CS: Toxicological Assessment using Brine Shrimp Lethality Assay and Antimicrobial activity of Capparis Grandis.

Journal of University of Shanghai for Science and Technology 2020; 22(11): 746-59.
13. Hirapure P and Pote M: Antimicrobial activity of Nyctanthes arbor tristislinn on few clinical isolates. IJPRBS 2014; 3(3): 80-5..
14. Hemeg HA, Moussa IM, Ibrahim S, Dawoud TM, Alhaji JH, Mubarak AS, Kabli SA, Alsubki RA, Tawfik AM and Marouf SA: Antimicrobial effect of different herbal plant extracts against different microbial population. Saudi Journal of Biological Sciences 2020; 27(12): 3221-7.
15. Maarisit W and Lawani M: Chemical investigation and antimicrobial activity of medicinal plant *Toddalia asiatica* Lam. Indonesian J of Chemistry 2020; 20(5): 1025-31.
16. Nengroo ZR, Rauf AB, Danish MO and Dar MS: Evaluation of fatty acid composition and antimicrobial activity of eight medicinal plants from Kashmir. Orient J Chem 2020; 36: 44-53.
17. Jang M, Park YI, Cha YE, Park R, Namkoong S, Lee JI and Park J: Tea polyphenols EGCG and theaflavin inhibit the activity of SARS-CoV-2 3CL-protease *in-vitro*. Evidence-Based Complementary and Alternative Medicine 2020; 2020.
18. Zhang W and Jiang W: Antioxidant and antibacterial chitosan film with tea polyphenols-mediated green synthesis silver nanoparticle *via* a novel one-pot method. International Journal of Biological Macromolecules 2020; 155: 1252-61.
19. Ren Y, Wang FY, Chen ZJ, Lan RT, Huang RH, Fu WQ, Gul RM, Wang J, Xu JZ and Li ZM: Antibacterial and anti-inflammatory ultrahigh molecular weight polyethylene/tea polyphenol blends for artificial joint applications. Journal of Materials Chemistry B 2020; 8(45): 10428-38.
20. Mion S, Carriot N, Lopez J, Plener L, Ortalo-Magné A, Chabrière E, Culioli G and Daudé D: Disrupting quorum sensing alters social interactions in *Chromobacterium violaceum*. NPJ Biofilms and Microbiomes 2021; 7(1): 1-6.

How to cite this article:
Hirapure PV, Paranjape SA, Bind TV, Bawankar KK and Upadhye VJ: Investigation of anti-swarming, anti-biofilm and anti-quorum sensing potential of some organic Tea of different brands from India. Int J Pharm Sci & Res 2022; 13(11): 4620-27. doi: 10.13040/IJPSR.0975-8232.13(11). 4620-27.

All © 2022 are reserved by International Journal of Pharmaceutical Sciences and Research. This Journal licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.

This article can be downloaded to **Android OS** based mobile. Scan QR Code using Code/Bar Scanner from your mobile. (Scanners are available on Google Playstore)

ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/365626950

INVESTIGATION OF ANTI-SWARMING, ANTI-BIOFILM AND ANTI-QUORUM SENSING POTENTIAL OF SOME ORGANIC TEA OF DIFFERENT BRANDS FROM INDIA

Experiment Findings · January 2022

DOI: 10.13040/IJPSR.0975-8232.13(11).4620-27

CITATIONS
0

READS
11

5 authors, including:

Pradip Hirapure
Rashtrasant Tukadoji Maharaj Nagpur University
22 PUBLICATIONS **13** CITATIONS
SEE PROFILE

Tejashree Vinod Bind
Dr Ambedkar College, Nagpur
1 PUBLICATION **0** CITATIONS
SEE PROFILE

Kanchan Krishnakumar Bawankar
Dr. Reddy's Laboratories
1 PUBLICATION **0** CITATIONS
SEE PROFILE

Vijay jagdish Upadhye
parul university
67 PUBLICATIONS **163** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

molecular charecterization of plant biodiversity based on chloroplast specific marker Genes View project

COVID REVIEW ARTICLE View project

All content following this page was uploaded by Pradip Hirapure on 21 November 2022.

The user has requested enhancement of the downloaded file.

IJPSR (2022), Volume 13, Issue 11 **(Research Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 24 March 2022; received in revised form, 12 May 2022; accepted, 24 May 2022; published 01 November 2022

INVESTIGATION OF ANTI-SWARMING, ANTI-BIOFILM AND ANTI-QUORUM SENSING POTENTIAL OF SOME ORGANIC TEA OF DIFFERENT BRANDS FROM INDIA

P. V. Hirapure [*1], S. A. Paranjape [1], T. V. Bind [1], K. K. Bawankar [1] and V. J. Upadhye [2]

Department of Biochemistry and Biotechnology [1], Dr. Ambedkar College Deekshabhoomi, Nagpur - 440010, Maharashtra, India.
Department of Microbiology [2], Parul Institute of Applied Sciences (PIAS), Parul University, Vadodara - 391760, Gujarat, India.

Keywords:

Anti-quorum sensing, Biofilm disruption, Anti-swarming, Tea extract, Bacterial communication

Correspondence to Author:
Pradip Hirapure

Assistant Professor,
Department of Biochemistry and Biotechnology, Dr. Ambedkar College Deekshabhoomi, Nagpur - 440010, Maharashtra, India.

E-mail: pradiphirapure@gmail.com

ABSTRACT: The emergency to find a solution to multidrug resistance of bacteria due to the abuse of antibiotics leads to the search for new antibacterial pathways. Quorum sensing (QS), or bacterial cell to cell communication, is a cell-density-dependent bacterial response. It is mediated by hormone-like compounds called autoinducers (AIs). QS-dependent regulation of gene expression controls various phenotypes, including bioluminescence, biofilm formation, drug resistance, virulence factors expression, and motility. Therefore, the inhibition of QS is considered a new promising target of antimicrobial pathways as anti-virulence compounds that can repress the gene expression of QS. Green tea is one of the most commonly consumed teas in the world. Green tea extract is also a great source of compounds like polyphenols, amino acids, enzymes, pigments, and carbohydrates. Hence, green tea has recently received considerable attention as a new source of safe and effective QS inhibitory substances. In the present study, methanolic and ethanolic various tea extracted were prepared and tested to inhibit quorum sensing mediated bacterial virulence factors such as anti-swarming, and antibiofilm potential against organism P*seudomonas aeruginosa*. Quorum sensing inhibition against *Chromobacterium violaceum MTCC* 2656 has been carried out. The study's outcome shows that most of the methanolic and ethanolic extracts of various tea products show significantly Anti-quorum sensing Potential up to 83% swarming inhibition with P*seudomonas aeruginosa*, inhibition *violaceum pingment* and biofilm disruption were also quite high in most of the Tea extract of ethanol and methanol.

INTRODUCTION: The problem of multidrug-resistant bacteria is becoming a worldwide concern nowadays. This pathogenic organism became resistant to a large range of antibiotics that possess a problem with treating various diseases [1]. Antibacterial drugs are the foremost effective of all medicines. Their success is reflected by their continuous use and thus the decreased morbidity and mortality from bacterial infections over the past 50 years.

However, the continued emergence and spread of multidrug-resistant bacteria have predicted that we are re-entering the predominant era [2]. The event of antibiotic resistance is the key reason for the development of pathogenicity. The microorganism dwelling within the biofilm often develops antibiotic resistance against common disinfectants and antiseptics that are regularly used [3]. So to beat the rapid spread of multidrug resistance, the event

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.13(11).4620-27

This article can be accessed online on www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.13(11).4620-27

of recent antimicrobial or antipathogenic agents that influence new microbial targets has become an extremely pressing priority.

Because of the proven fact that quorum sensing is involved in microbial pathogenesis, research efforts have recently focused on developing antipathogenic agents to manage bacterial diseases by inhibiting quorum sensing [4].

Quorum sensing is the ability to detect and reply to cell population density by gene regulation and intracellular communication between bacteria using bacterial products. This population density-dependent mechanism is mediated through small signaling molecules called autoinducers by which bacteria regulate gene expression in gram-negative bacteria; the autoinducers are AHLs that are acyl-homoserine lactone [5].

Quorum sensing enables bacteria to limit the expression of specific genes to high cell densities at which the resulting phenotypes are visiting be most beneficial. QS-dependent regulation of gene expression controls many phenotypes, including bioluminescence, biofilm formation, drug resistance, virulence factors expression, and motility.

Therefore, the inhibition of QS is considered a fresh, promising target of antimicrobial pathways as anti-virulence compounds that could repress the gene expression essential for basic metabolism in vitro, rather than the microorganisms themselves [6].

Quorum sensing might be a good drug target because, unlike antibiotics and biocides that kill bacteria, interfering with signaling system or cell to cell communication relies on the principle that when one bacterium releases autoinducers into the environment, their concentration is just too low to detect, hence when sufficient bacteria present concentration of autoinducers reach threshold level that permits the bacteria to sense critical cell population and to activate target genes [7].

In Gram-negative bacteria, the foremost common autoinducers are N-acyl-homoserine lactones (AHLs), a signalling molecule in higher concentrations that can bind to and activate a transcriptional activator or R protein which successively induces the expression of target genes. Whereas Gram-positive bacteria usually utilize peptides as autoinducers [8].

In recent years, Green tea is becoming increasingly popular worldwide, partly because of many documented evidence about its beneficial effects on health.

Tea contains numerous components, including catechins, caffeine, amino acids, carbohydrates, proteins, chlorophyll, volatile compounds, fluoride, minerals, and other undefined compounds. Several biological properties are associated with tea polyphenols (TP); tea extract can modulate the Quorum sensing [9].

We hypothesize that a variety of its antimicrobial properties is additionally contributed by the QSI phytochemicals present in it.

Therefore, within the current study, we aimed to research the anti-quorum sensing and anti-biofilm potentials of herb polyphenol extract against *Chromobacterium violaceum* CV026 and *Pseudomonas aeruginosa* at sub-inhibitory concentration.

Furthermore, the influence of tea extract on *P. aeruginosa* quorum-sensing- regulated virulence factors production, motility, and biofilm formation were also assayed [10].

MATERIALS AND METHODS:

Chemicals, Bacterial Strains and Culture Medium: All the chemicals and media were used for carrying out this study purchased from High-media Pvt.Ltd and Sigma Aldrich. *Chromobacterium violaceum MTCC* 2656, a pathogenic strain, was procured from MTCC Chandīgarh, India.

Pseudomonas aeruginosa with a trait of swarming motility isolated from soil collected from the campus of Dr. Ambedkar College Deekshabhoomi Nagpur and isolates were maintained on Nutrient Agar medium slant at 2-8°C.

Tea Samples Collection: Organic tea and various brands of tea were purchased from nearby local markets, twelve tea samples were purchased from local market of Nagpur city. India. Which are listed in **Table 1**. The tested tea samples are listed below.

TABLE 1: THE TESTED TEA SAMPLES AND STOCK AND WORKING CONCENTRATION OF TEA EXTRACT

S. no.	Name of extract	Stock Concentration of methanol Extract mg/ml	Stock Concentration of ethanol Extract mg/ml	Concentration of Working methanol & ethanol extract mg/ul
1	Lipton	700	650	1.0
2	Himalaya wellness tea	630	600	1.0
3	Organic India	890	720	1.0
4	24 Mantra Organic Green Tea	820	870	1.0
5	LaPlant Green Tea	670	630	1.0
6	Twinings Green Tea	540	590	1.0
7	Tetley	810	760	1.0
8	Taaza	760	700	1.0
9	Tulsi Green Tea	680	570	1.0
10	TajMahal Green Tea	530	780	1.0
11	Tata tea	520	610	1.0
12	The Indian Tea	660	530	1.0

Preparation of Tea Extract: A modification of previously described procedures (Raaman, 2006), was used to prepare the Methanolic and ethanolic extract of the tea Product. The dried Tea materials (2 gm) were mixed with 20 ml 70% (v/v) ethanol and 20 ml Methanol separately for 8 h in a Soxhlet extractor. The extract was then allowed to evaporate in an oven at 37°C for at least three days. Some of the extracts were dried using IR Concentrator. The dried extract was stored in a refrigerator until used (extracts were tested within 2 weeks of extraction).

Preparation of Stock Solutions: Stock solutions of crude ethanol and methanol extracts were prepared, filter-sterilized (0.25 µm), and stored at 4°C. **Table 1**. Shows the concentration of each stock solutions concentrations working solution.

Swarming Inhibition Assay: Swarming Inhibition assay was conducted with a nutrient medium containing 0.8% agar. Swarm plates were allowed to dry in the incubator before being used. Prepared Swarm plates were then divided into four regions by using a marker and inoculated with the overnight grown bacterial culture of *Pseudomonas aeruginosa* in Nutrient broth. 0.5 µl of culture inoculated over 1µl of tea extract and allowed to absorb sample drop in the medium. These plates were then incubated for 48 h at 37°C. Inhibition in the swarming motility was determined by measuring the diameters of the swarm zones compared to the negative control.

Quorum Sensing Inhibition Assay using *Chromobacterium violacein* CV026: A paper disc diffusion assay was performed to test for Quorum sensing inhibition using. *Chromobacterium violaceum MTCC* 2656. 100 microliter of the. *Chromobacterium violaceum MTCC* 2656 overnight culture grown was spread on agar plates and allowed it to dry. Paper discs were dipped into the extracts and placed on the culture-grown plates. The plates were incubated at 37°C for 24 hrs; then, plates were observed for any pigment inhibition zones and examined for violacein production. Quorum sensing inhibition was detected by a colourless, opaque, but viable halo around the disc. Methanol and ethanol were also used as a negative control [10].

Biofilm Inhibition Assay using Tube Method: In this assay 100 µL of bacterial culture *Pseudomonas aeruginosa* were transferred to glass test tubes containing 5 mL Nutrient Broth and 150 µl of tea extract, and tubes were incubated at 37°C for 24 h. Three controlled tubes were also prepared, one containing culture media only and the other two of ethanol and methanol as a negative control. The media was then removed, and the tubes were washed with distilled water. The tubes are stained with crystal violet and rinsed twice to discharge the extra stain and air-dried. The occurrence of the blue ring above on the wall at the bottom of the tube indicates biofilm production. Two control tubes of ethanol and methanol were also taken for comparison[11].

RESULTS:

Anti-swarming Assay: Ethanol and methanol extract of various Tea extracts were tested for the ability to inhibit swarming in *Pseudomonas aerogenosa*.

The result of this assay was interpreted in a way that is the reduction in the diameter of the swarm zones as compared to control. Data represented in **Table 2** shows no significant variations in ethanolic and methanolic extract, but the Highest Swarming inhibition was found in methanolic and ethanolic extract of Lipton. The size of swarm zones of *Pseudomonas aerogenosa* was significantly reduced in the presence of these extracts as compared to control. In some extracts pattern of motility was found to be different. All the Tea brands significantly effective as an Anti-swarming Agent for the tested organism *Pseudomonas aerogenosa*

TABLE 2: RESULT OF ANTI-SWARMING POTENTIAL OF VARIOUS TEA EXTRACTS

S. no.	Tea Extracts	Diameter of Swarm zone in cm	
		Methanol (% of Swarming inhibition)	Ethanol (% of Swarming inhibition)
	Negative control	1.6	1.8
1	Lipton	0.3 (81.25%)	0.3 (83.33 %)
2	Himalaya wellness tea	0.4 (75%)	0.4(77.77 %)
3	Organic India	0.3 (81.25%)	0.6 (66.66 %)
4	24 Mantra Organic Green Tea	0.5 (68.75)	0.5 (72.22%)
5	LaPlant Green Tea	0.6 (62.5 %)	0.4(77.77%)
6	Twinings Green Tea	0.3 (81.25 %)	0.4(77.77%)
7	Tetley	0.5 (68.75 %)	0.5 (72.22%)
8	Taaza	0.9 (43.75)	1.3 (27.77%)
9	Tulsi Green Tea	0.5 (68.75%)	0.4(77.77%)
10	TajMahal Green Tea	0.5 (68.75%)	0.4(77.77%)
11	Tata tea	0.4 (75%)	0.5 (72.22%)
12	The Indian Tea	0.4 (75%)	0.5 (72.22%)
		The values of swarm zones presented as Mean	

Anti-quorum Sensing Bioassay using *Chromobacterium violaceum MTCC* 2656: The pigment production is one of the phenomena controlled by quorum sensing regulatory mechanism in *Chromobacterium violaceum MTCC* 2656. The paper disc diffusion assay was performed for pigment inhibition in which various Tea extracts tested for only the pigment inhibition and no growth inhibition. The area of colorless turbid zone indicates that the extract is allowing inhibition of the quorum sensing mechanism in the organism. Data of Pigment Production inhibition in *Chromobacterium violaceum MTCC* 2656 presented in **Table 3.**

TABLE 3: PIGMENT PRODUCTION INHIBITION IN *CHROMOBACTERIUM VIOLACEUM* MTCC 2656

S. no.	Sample	Methanol Extract	Ethanol extract
1	Lipton	+++	++
2	Himalaya wellness tea	-ve	+++
3	Organic India	+++	+
4	24 Mantra Organic Green Tea	+++	+++
5	LaPlant Green Tea	+	++
6	Twinings Green Tea	++	+
7	Tetley	-ve	-ve
8	Taaza	-ve	-ve
9	Tulsi Green Tea	+++	+++
10	TajMahal Green Tea	+	+
11	Tata tea	-ve	+++
12	The Indian Tea	++	+++

+++ High, ++ Moderate, + Least

Biofilm Disruption Assay by Tube Method: *P. aeruginosa* shows strong biofilm formation; the different Tea extracts were screened for their biofilm disruption Potential against *P. aeruginosa*. The crystal violates staining method is easily and widely used to measure biofilms' formation and inhibition in a tube. The results of this assay are presented in **Table 4**. All most all the methanol and ethanol extract were showed significant Biofilm reduction as compared to negative control except for ethanol and methanol extract of Taza

TABLE 4: RESULT OF BIOFILM DISRUPTION ASSAY BY TUBE METHOD

S. no.	Sample	Methanol Extract	Ethanol extract
1	Lipton	+++	++
2	Himalaya wellness tea	++	+++
3	Organic India	+++	++
4	24 Mantra Organic Green Tea	+++	++
5	LaPlant Green Tea	+++	++
6	Twinings Green Tea	++	+
7	Tetley	+	+
8	Taaza	-ve	-ve
9	Tulsi Green Tea	++	+++
10	TajMahal Green Tea	+++	+++
11	Tata tea	+	+
12	The Indian Tea	++	+++

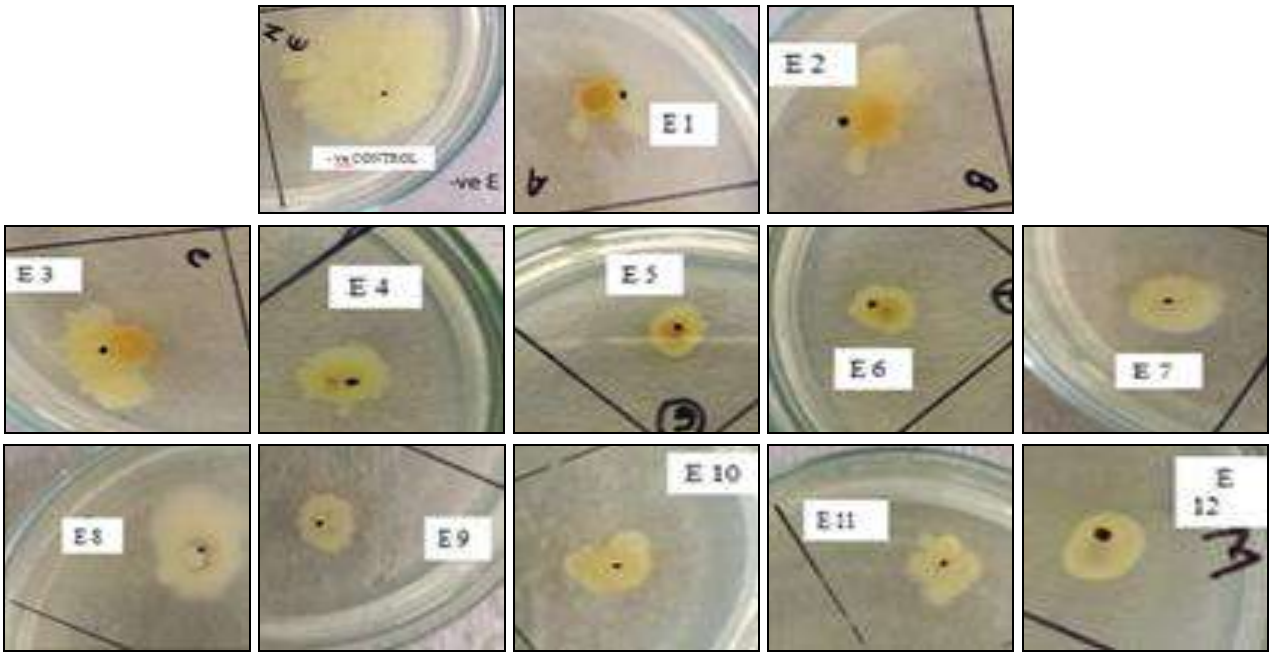


FIG. 1: THE PHOTOGRAPH OF SWARMING INHIBITION ASSAY BY ETHANOLIC TEA EXTRACTS USING *PSEUDOMONAS AERUGINOSA*

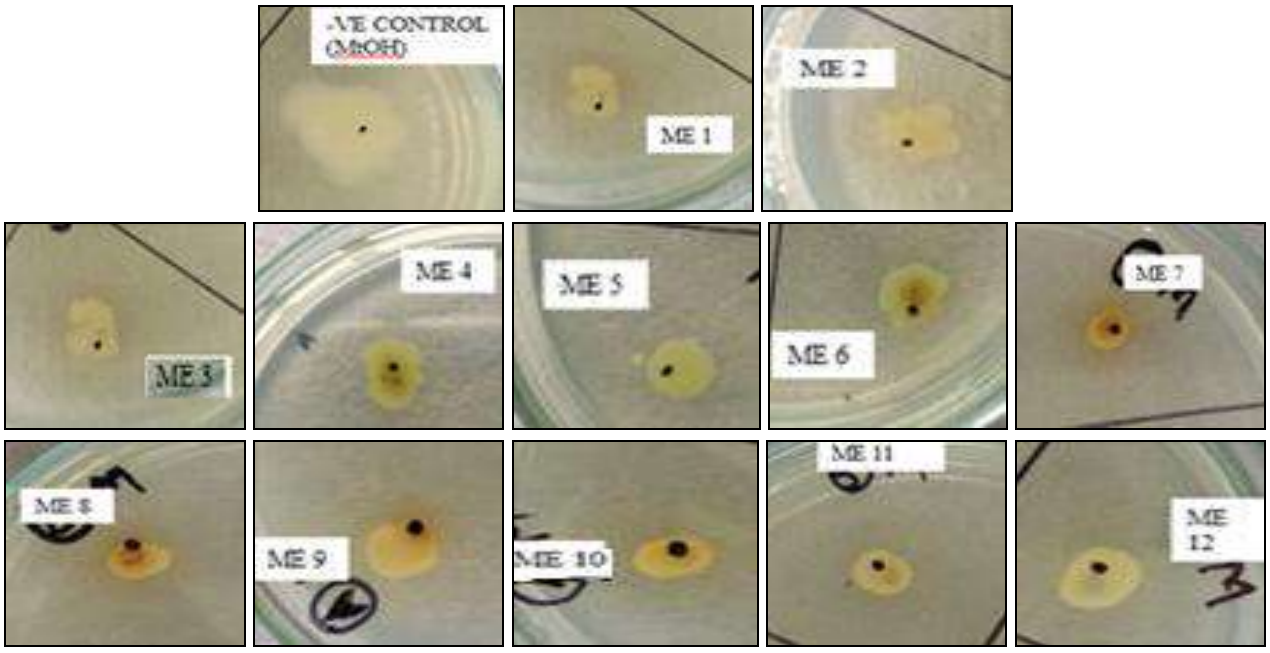


FIG. 2: THE PHOTOGRAPH OF SWARMING INHIBITION ASSAY BY MTHANOLIC TEA EXTRACTS USING *PSEUDOMONAS AERUGINOSA*

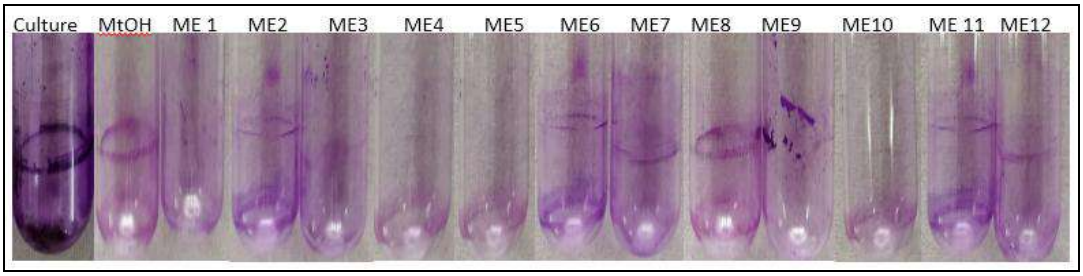


FIG. 3: RESULT OF BIOFILM DISRUPTION ASSAY USING *PSEUDOMONAS AERUGINOSA* BY METHANOLIC EXTRACT OF DIFFERENT TEA

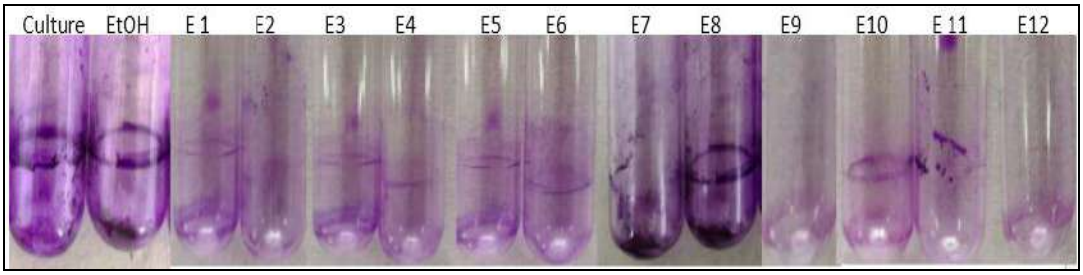


FIG. 4: RESULT OF BIOFILM DISRUPTION ASSAY USING *PSEUDOMONAS AERUGINOSA* BY ETHANOLIC EXTRACT OF DIFFERENT TEA

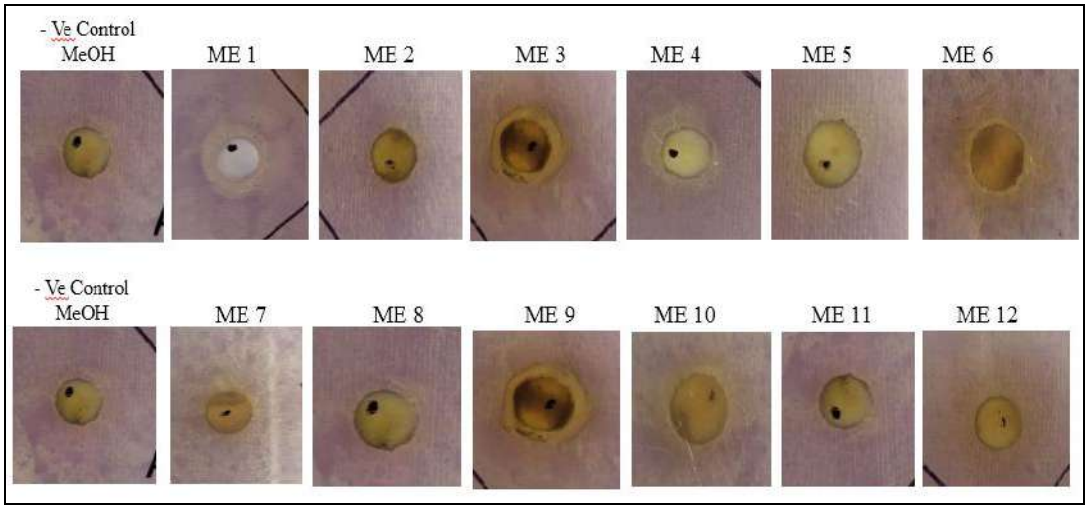


FIG. 5: RESULT OF QUORUM SENSING INHIBITION ASSAY USING *CHROMOBACTERIUM VIOLACEUM* MTCC 2656. BY METHANOLIC EXTRACT OF DIFFERENT TEA PRODUCT

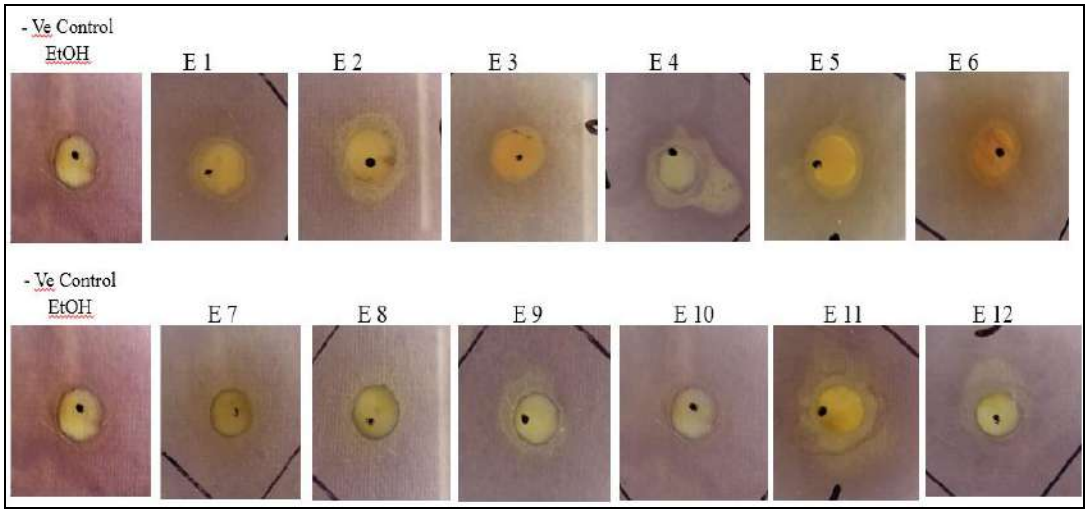


FIG. 6: RESULT OF QUORUM SENSING INHIBITION ASSAY USING *CHROMOBACTERIUM VIOLACEUM* MTCC 2656. BY ETHANOLIC EXTRACT OF DIFFERENT TEA PRODUCT

DISCUSSION: Green tea is one of the most popular beverages worldwide due to its health-promoting properties, which reflect the presence of antioxidants and also antimicrobial substances that are active against various Gram-positive and Gram-negative bacteria [12-16]. Both activities are mainly due to polyphenols, the most abundant of which is the catechins, particularly epigallocatechin gallate (EGCG), representing 50–80% of the total catechin content [17]. A deeper understanding of Bacterial cell-cell communication promises to shed light on the complexities of the host-microbe relationship and may lead to novel therapeutic applications. Many species of bacteria use quorum sensing to coordinate gene expression according to the density of the local population. Hence in the present study anti-quorum sensing activities of the twelve organic tea of various brands has been studied for their inhibition of Quorum sensing, controlled phenotype Swarming and biofilm formation of *Pseudomonas aeruginosa* and pigment production *Chromobacterium violaceum MTCC* 2656. The tea extract effectively inhibited Quorum sensing and controlled phenotypes of both tested organisms. This study's findings support other investigations that demonstrated anti-QS activity in certain Tea extracts. Further works are required to find active QSI ingredients of tea extracts and to clarify the mechanism of their action as a Quorum sensing inhibitor. A few tea extract showed negative result may be due to insufficient active ingredient concentration in that extract for inhibition of respective Quorum sensing controlled Phenotypes.

CONCLUSION: It is concluded that anti-QS is as important as antibacterial activity as it will unlikely cause resistance problems as it does not pose selection pressure. Anti-swarming, Biofilm, and QS are major virulence factors of most pathogenic microorganisms. The bioassay of the 12-studied tea extracts revealed significant Quorum sensing controlled bacterial phenotype inhibition activities. Further research is needed to investigate the molecular mechanism and active ingredient in each tea extract. Biofilm-associated bacterial infections frequently caused by *P. aeruginosa* are found in most diseases. The effectiveness of many antibacterial drugs has been lost due to the evolution of pathogenic resistance. Therefore alternative ways of reducing biofilms are essential. The anti-QS compounds present in green tea products help enhance the susceptibility of the bacteria and thus eradicate biofilms. Green tea may therefore offer a new source of antimicrobial compounds that can be used to reduce our reliance on antibiotics by inhibiting bacterial virulence without selecting for resistant bacterial strains [18-20].

ACKNOWLEDGEMENT: We thank Dr. B. A. Mehere, Principal of Dr. Ambedkar College, Deeksha Bhoomi, for providing a Laboratory facility, and I am also thankful to non-teaching staff members Avinash Chauhan, Leena Kamble, and Vishwanath Bhaisare.

CONFLICTS OF INTEREST: All authors declared no conflicts of interest.

REFERENCES:

1. Vivas R, Barbosa AA, Dolabela SS and Jain S: Multidrug-resistant bacteria and alternative methods to control them: an overview. Microbial Drug Resistance 2019; 25(6): 890-908.
2. Pote M and Hirapure P: Antimicrobial potential of Acacia nilotica extracts on few dental pathogens. Int J Pharm Sci Res 2014; 5: 4759.
3. Botelho J, Grosso F and Peixe L: Antibiotic resistance in Pseudomonas aeruginosa–Mechanisms, epidemiology and evolution. Drug Resistance Updates 2019; 44: 100640.
4. Kalia VC, Patel SK, Kang YC & Lee JK: Quorum sensing inhibitors as antipathogens: biotechnological applications. Biotechnology Advances 2019; 37(1): 68-90.
5. Mukherjee S & Bassler BL: Bacterial quorum sensing in complex and dynamically changing environments. Nature Reviews Microbiology 2019; 17(6): 371-382.
6. Haque S, Ahmad F, Dar SA, Jawed A, Mandal RK, Wahid M & Akhter N: Developments in strategies for Quorum Sensing virulence factor inhibition to combat bacterial drug resistance. Microbial Pathogenesis 2018; 121: 293-302.
7. Saeki EK, Kobayashi RK and Nakazato G: Quorum sensing system: Target to control the spread of bacterial infections. Microbial Pathogenesis 2020; 142: 104068..
8. Haramati R, Dor S, Gurevich D, Levy D, Freund D, Rytwo G, Sharon I and Afriat-Jurnou L: Mining marine metagenomes revealed a quorum-quenching lactonase with improved biochemical properties that inhibits the food spoilage bacteria Pseudomonas fluorescens. Applied and Environmental Microbiology 2021 Dec 15: AEM-01680.
9. Balappanavar AY: Tea and Oral Health. In Tea-Chemistry and Pharmacology 2020 Apr 29. Intech Open.
10. Moradi F and Hadi N: Quorum-quenching activity of some Iranian medicinal plants. New Microbes and New Infections 2021; 42: 100882.
11. Chen X, Zhang L, Zhang M, Liu H, Lu P and Lin K: Quorum sensing inhibitors: a patent review (2014–2018). Expert Opinion on Therapeutic Patents 2018; 28(12): 849-65.
12. Suryawanshi V, Yadav A, Mohite S and Magdum CS: Toxicological Assessment using Brine Shrimp Lethality Assay and Antimicrobial activity of Capparis Grandis.

Journal of University of Shanghai for Science and Technology 2020; 22(11): 746-59.
13. Hirapure P and Pote M: Antimicrobial activity of Nyctanthes arbor tristislinn on few clinical isolates. IJPRBS 2014; 3(3): 80-5..
14. Hemeg HA, Moussa IM, Ibrahim S, Dawoud TM, Alhaji JH, Mubarak AS, Kabli SA, Alsubki RA, Tawfik AM and Marouf SA: Antimicrobial effect of different herbal plant extracts against different microbial population. Saudi Journal of Biological Sciences 2020; 27(12): 3221-7.
15. Maarisit W and Lawani M: Chemical investigation and antimicrobial activity of medicinal plant *Toddalia asiatica* Lam. Indonesian J of Chemistry 2020; 20(5): 1025-31.
16. Nengroo ZR, Rauf AB, Danish MO and Dar MS: Evaluation of fatty acid composition and antimicrobial activity of eight medicinal plants from Kashmir. Orient J Chem 2020; 36: 44-53.
17. Jang M, Park YI, Cha YE, Park R, Namkoong S, Lee JI and Park J: Tea polyphenols EGCG and theaflavin inhibit the activity of SARS-CoV-2 3CL-protease *in-vitro*. Evidence-Based Complementary and Alternative Medicine 2020; 2020.
18. Zhang W and Jiang W: Antioxidant and antibacterial chitosan film with tea polyphenols-mediated green synthesis silver nanoparticle *via* a novel one-pot method. International Journal of Biological Macromolecules 2020; 155: 1252-61.
19. Ren Y, Wang FY, Chen ZJ, Lan RT, Huang RH, Fu WQ, Gul RM, Wang J, Xu JZ and Li ZM: Antibacterial and anti-inflammatory ultrahigh molecular weight polyethylene/tea polyphenol blends for artificial joint applications. Journal of Materials Chemistry B 2020; 8(45): 10428-38.
20. Mion S, Carriot N, Lopez J, Plener L, Ortalo-Magné A, Chabrière E, Culioli G and Daudé D: Disrupting quorum sensing alters social interactions in *Chromobacterium violaceum*. NPJ Biofilms and Microbiomes 2021; 7(1): 1-6.

How to cite this article:
Hirapure PV, Paranjape SA, Bind TV, Bawankar KK and Upadhye VJ: Investigation of anti-swarming, anti-biofilm and anti-quorum sensing potential of some organic Tea of different brands from India. Int J Pharm Sci & Res 2022; 13(11): 4620-27. doi: 10.13040/IJPSR.0975-8232.13(11). 4620-27.

All © 2022 are reserved by International Journal of Pharmaceutical Sciences and Research. This Journal licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License.

This article can be downloaded to **Android OS** based mobile. Scan QR Code using Code/Bar Scanner from your mobile. (Scanners are available on Google Playstore)

View publication stats

Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454

Vol. 20 | No.4 | pp. 1817-1823 | 2021

Original Research Paper

https://doi.org/10.46488/NEPT.2021.v20i04.048

Open Access Journal

Evaluation of Cytotoxicity and Genotoxicity of Water from Nag River, Nagpur, India

P. V. Hirapure*†, S. A. Paranjape*, V. S. Sarodaya*, B. A. Mehere* and V. J. Upadhye**

*Department of Biochemistry and Biotechnology, Dr. Ambedkar College, Deekshabhoomi, Nagpur, India

**Department of Microbiology, Parul Institute of Applied Sciences (PIAS), Parul University, Vadodara, Gujarat, India

†Corresponding author: P. V. Hirapure; pradiphirapure@gmail.com, dr.vijaysemilo@gmail.com

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 23-01-2021
Revised: 29-03-2021
Accepted: 14-04-2021

Key Words:
Nag river
Cytotoxicity
Genotoxicity
Allium cepa.L.
Water pollution
Mutagenesis

ABSTRACT

The pollution of the river by man-made sewage and waste disposal is not only harmful to animals and plants in it but also for animals higher in the food chain including those close to the food chain. Water is the most vital natural substance, as it plays a role in nearly every aspect of human life. Therefore, there is a great need to ensure that the water used by humans should not contain hazardous substances. Water quality is directly linked to biological life. The Nag River flows from the Lava village of north Ambazari Lake and flows into the center of Nagpur city. As a result of rapid and unstoppable development, significant changes have taken place in the water quality of the Nag River. Because the Nag River's water is frequently used for irrigation, it should be tested for cytotoxicity and genotoxicity. Since the rate of cancer and genetic disorders has recently increased in the Nagpur region, the Nag River's water could be a source of carcinogens in the food chain, affecting the population. This study was conducted to analyze the impact of water collected from various points of the Nag River using *Allium cepa* as a model organism. The results of this study showed that all water samples from the Nag River cause a cytotoxic effect (20-23%) and genotoxic effects (23-28%) in *Allium cepa* cells. Therefore, before the use of Nag River water, it must be treated to diminish its harmful effect.

INTRODUCTION

Nagpur is the third biggest city in Maharashtra after Mumbai and Pune and it is one of India's quickest developing cosmopolitan cities. It is the winter capital of the province of Maharashtra and the second greenest city in India. Nagpur is home to a number of natural and man-made lakes, the largest of which being Ambazari Lake. This lake is where Nagpur's waterway begins. India has a vast and changing topography, which includes a large number of water bodies. Lakes and streams are now widely used for domestic purposes (Patil et al. 2017). Nagpur is fed by the Nag river, which gives the city its name. Originating from the Ambazari lake, the Nag river takes a winding path for approximately 16 km through the city before it joins another stream called Pili Nadi, which originates at another lake. This stream then merges into the Kanhan river on the outskirts of the city. Because Nagpur has experienced fast urbanization and migration to the city in the last five to six decades, there is increased use of water for domestic purposes, as well as, industrial production has increased, causing a sudden surge in sewage quantity (a meager grimy stream of water (Kalyani et al. 2017). Because of the value and importance of freshwater resources, they must be closely monitored biologically to meet water quality standards (Puri et al. 2010). An enormous amount of wastewater from the Nagpur metropolitan region and numerous enterprises surrounding the urban areas is dumped into streams, such as the Nag river and its tributaries, contaminating both ground and surface water (Manzar et al. 2010). Because this river runs through a city with a population of around 50 lakh people, it is quite dirty. The Nag river was once a lifeline of the city. But today, the river's rich history has got buried in deep silt beneath the millions of litres of sewage flowing in it (Anparthi 2013). The Ambazari Lake which was the prime source of water to Nagpur city is filled with waste and sewage (which gives it an unnatural dark gray color and a foul smell), and despite receiving rainwater during monsoon it is not fit for consumption. Since such contaminated waste affects all metabolic and physiological activities, it is necessary to analyze the physiochemical attributes of water and propose measures to reduce contamination. All said and done, the sewage-water-flooded soils had higher pH, natural carbon, and $CaCO_3$. Surface skylines of soils (flooded/non-flooded) had higher groupings of DTPA-extractable Fe, Mn, Cu, and Zn, which decreased with depth. When compared to non-flooded soils, sewage-water-flooded soils are associated with moderately higher concentrations of DTPA-Fe, Mn, Cu, Zn, Pb, Cr, and Album (Tayawade et al. 2010).

Exposure to organic and inorganic chemicals over a long period of time can cause ecological health impairment of aquatic ecosystems causing considerable effects on aquatic biota including bioaccumulation of chemicals in organisms and biomagnification in higher trophic levels. Further, these can result in cytotoxic and genotoxic effects in the organisms (Daniels et al. 1989, Kannangara & Pathiratne 2015). Therefore, many ecotoxicological studies focus on the assessment of physical and chemical environmental parameters and biological responses of organisms. However, recent ecotoxicological studies are paying more attention to using bioassays to assess the mutagenic and genotoxic effects of aquatic pollution (Kannangara & Pathiratne 2015). These mutagenic and genotoxic studies have focused on assessing genotoxicity and mutagenic effects of fish species (Alimba et al. 2015, Carrasco et al. 1990) [12, 14], microorganisms (Buschini et al. 2001, Guan et al. 2017), mammals (Chiu et al. 2009, Kim et al. 2010), and higher plants (Iqbal et al. 2019) in relation to variation of chemical parameters in aquatic ecosystems

However, compared to other organisms *Allium cepa* is considered an efficient bioindicator in genotoxicity testing, because of the rapid root growth rate and reduced number of large chromosomes. *A. cepa* assay is commonly utilized as a short-term and cost-effective indicator of toxicity in monitoring water pollution in many parts of the world. This bioassay can provide valuable information on the presence of genotoxic and/or mutagenic compounds in surface waters and sediments of aquatic ecosystems. However, in Nagpur, a few tests have been carried out to analyze the physiochemical parameters of Bother stream water at various locations (Patil 2017, Manzar 2010, Tayawade et al. 2010) yet till today nobody evaluated the cytotoxicity and genotoxicity of the Bother Waterway Water. Therefore, the current study will use an *A. cepa* bioassay to assess the cytogenotoxic effects of water collected from several locations along the Bother Stream of the Nag River in Nagpur. By proving the ability of such substances to cause chromosomal changes in *A. cepa* root cells, the testing would provide important information concerning the presence of cytogenotoxic or potentially mutagenic substances in surface waters of the Bother stream.

MATERIALS AND METHODS

All the experimental work was completed at the Department of Biochemistry and Biotechnology, Dr. Ambedkar School, Deekshabhoomi, Nagpur during the period of October 2019 to Jun 2020. All the chemicals utilized in this investigation were bought from Hi-media Pvt. Ltd and (The basic purple onion, *A. cepa*) bulbs (2.5-2.8 cm in diameter) used in this study were purchased from a local market in Nagpur, Maharashtra (India).

Sample collection: The collection of water samples of Nag River which is spread over Nagpur city. Five different locations were randomly selected to collect the water sample which is given in Table 1**.** Water samples were collected in clean glass bottles and GPS values of that site were noted down.

Allium cepa Test

A commercial variety of common onions (*Allium cepa*) was used for the determination of different toxicity end points of meristematic cells. Equal sized healthy onion bulbs were chosen and the outer scales of bulbs were removed by gently scraping to make the apices of root primodia exposed. Scarped onion bulbs were germinated in glass test tubes containing distilled water for 24 hours in the dark. The *Allium cepa* bioassay in accordance with Grant (1982) with some modifications was conducted using water samples collected from the study sites. After 24 hours, onion bulbs were exposed to the exposure media (70 mL, Nag River sample taken from each site) in the glass tubes at the time of processing. For each exposure media 10 onion bulbs were tested. Bulbs with exposure media were kept in dark to avoid the direct sunlight.

After 48 hours of exposure, root lengths of randomly selected five onion bulbs from each exposure media were measured in millimeters. Root tips (5-6 from each onion bulb) of 1-2 mm length were processed for microscopic studies of toxicity end points. Root tips were fixed in ethanol: glacial acetic acid (3:1, v/v) solution for overnight at 4°C. Root tips were transferred into 70% alcohol and stored at 4°C until the time of processing.

Table 1: River Water was collected from five different locations of Nag River, Nagpur.

Samples ID	Water collected from different area	GPS Location
Sample 1	Rashimbagh Darsa Road	21°08’19.9”N 79°06’31.3”E
Sample 2	Gangabai Ghat Road	21°08’26.2”N 79°07’13.0”E
Sample 3	Near Airtel express	21°08’30.0”N 79°07’32.5”E
Sample 4	Near RajatSankul apartment	21°08’14.3”N 79°05’43.0”E
Sample 5	Rashimbagh road (Plant growing side)	21°08’18.4”N 79°06’21.0”E

When processing the root tips, they were hydrolyzed in hydrochloric acid (1N) solution for 5 minutes at 60°C and washed with distilled water. Root tips were then placed in watch glasses containing acetocarmine for 30 minutes to allow the stain to penetrate to the primordial cells. After staining, root tips were placed on glass slides and a slight pressure was applied on the cover slip to squash the tip cells over the slide. Prepared slides for each exposure medium were observed under the light microscope at 400x magnification to score mitotic stages, occurrence of micronuclei, and nuclear abnormalities in the interphase cells (Fiskesjo 1985, 1988).

Mitotic index was calculated as the number of dividing meristematic cells into 100 total meristematic cells by counting 1000 meristematic cells in each slide

Mitotic index = Number of dividing meristemetic cells / total meristemetic cells (500) × 100

RESULTS AND DISCUSSION

Effect of water samples on cell division process, cytological and chromosomal characteristics were assessed by *A. cepa* test and results given in Tables 2, 3 and 4, and Figs. 1 and 2.

Table: 2. Effect of water sample collected from different sites of Nag river on cell division.

	No. of dividing cells	Prophase	Pro-metaphase	Metaphase	Anaphase	Telophase	MI in %
Control	163±3.05	78±1.02	24±2.08	21±1.52	29±2.51	11±1.15	32.6
Sample 1	50±2.05	20±1.03	6±0.33	8±2.52	9±1.15	7±0.57	10
Sample 2	48±1.05	18±1.52	8±0.12	7±1.52	10±2.51	5±1.15	9.6
Sample 3	43±1.06	17±0.50	6±0.60	6±0.57	8±1.15	6±0.72	8.6
Sample 4	49±1.52	19±0.8	7±1.01	8±1.15	9±1.15	6±2.51	9.8
Sample 5	40±2.51	17±1.01	5±0.91	7±0.57	6±0.57	5±0.72	8.0

Data are presented as mean ± standard deviation (SD), MI – mitotic index

Table 3: Chromosomal aberrations in *Allium cepa* root tip cells exposed to the Nag river water samples.

	Bridges	Breaks	lagging	Stickiness	Abnormal spiralisation	Multipolarity	Abnormal Kinetics	Total No. of Aberrant cells (%)
Control	00±00	00±00	01±0.57	01±0.02	00±00	01±0.57	01±0.57	04 (0.8)
Sample 1	09±0.57	17±2.52	00±00	78±2.52	13±0.57	11±2.52	13±1	141 (28.00)
Sample 2	07±1.15	11±1.15	02±0.57	67±1.51	12±2.15	09±0.57	12±2.51	120 (24)
Sample 3	09±2.15	10±1.52	01±0.02	71±0.57	9±1.15	07±1.52	11±2	118 (23.6)
Sample 4	09±0.57	09±1.15	00±00	74±2.52	16±1.52	13±2.51	15±1.52	136 (26.2)
Sample 5	10±0.51	12±2.08	03±0.57	64±3.15	14±2.52	09±1.15	12±2.51	124 (24.8)

Data are presented as mean ± standard deviation (SD)

Table: 4: Cytotoxic effects of different collected Nag River water on root tips of *Allium cepa*.

	Cells without nucleus	Morphological alterations	Plasmolysed cells	BNC	MNC	Total no. of aberrant cells (%)
Control	00±00	01±0.57	01±0.5	01±0.57	00±00	03 (0.6)
Sample 1	07±0.57	20±2.52	34±2.52	07±1.51	50±3.02	118 (23.06)
Sample 2	08±1.15	15±3.08	40±1.52	04±1.52	44±2.52	110(22.00)
Sample 3	07±0.57	24±2.15	30±2.52	06±0.57	40±2.52	107(21.4)
Sample 4	07±1.52	22±1.52	25±2.15	04±1.15	37±0.57	100 (20.00)
Sample 5	08±1.00	19±1.02	29±3.08	07±1.52	49±1.15	112 (22.4)

Data are presented as mean ± standard deviation (SD); BNC-nucleated cells, MNC- micronucleated cells.

The mitotic index of the *A. cepa* root tip cells in the present study ranged from 8% to 10 % in Nag River water samples which were low compared to control (32%) (Fig. 3). A mitotic index of less than 22% is considered fatal to organisms (Antonise-Wiez 1990) As a result, the mitotic indices measured in this study are frequently regarded

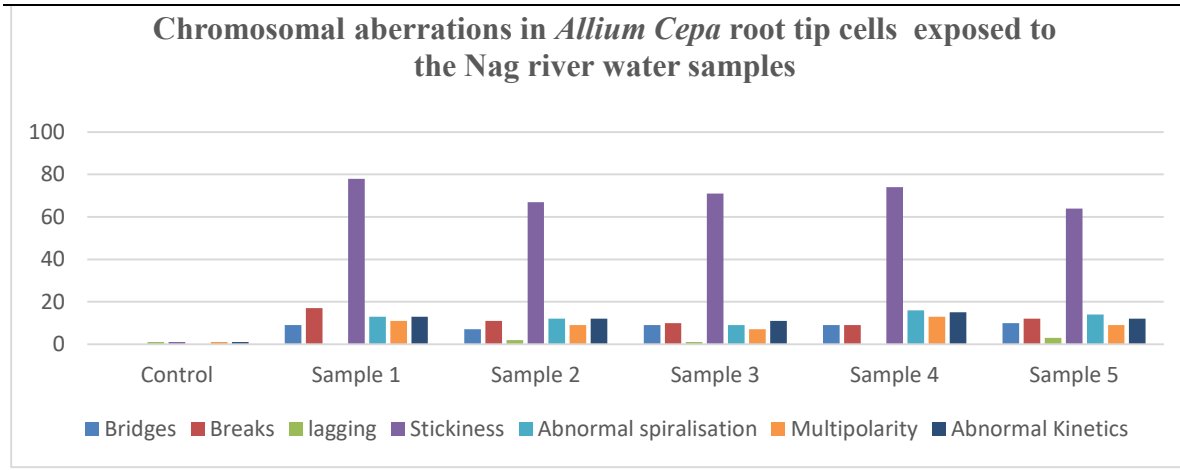


Fig. 1: Chromosomal aberrations in *Allium cepa* root tip cells exposed to the Nag river water samples.

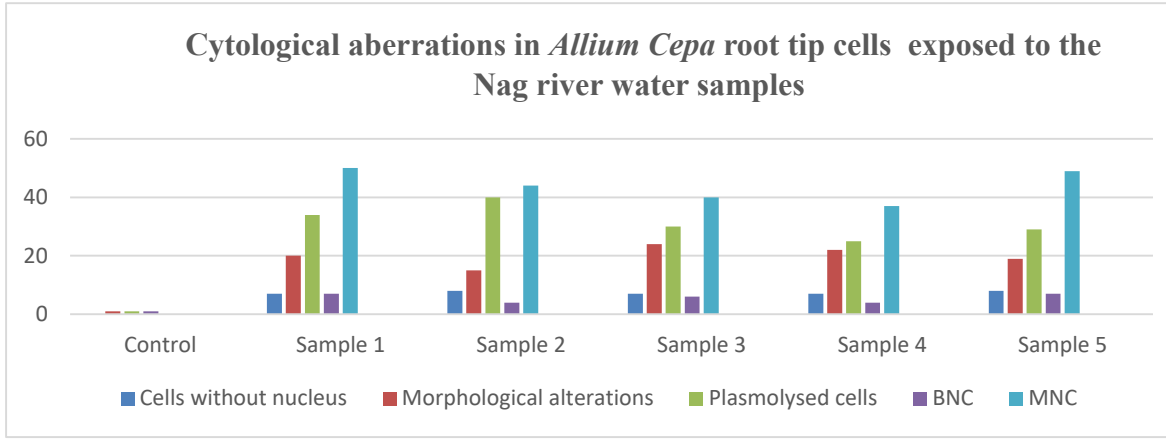


Fig. 2: Cytological aberrations in *Allium cepa* root tip cells exposed to the Nag river water samples.

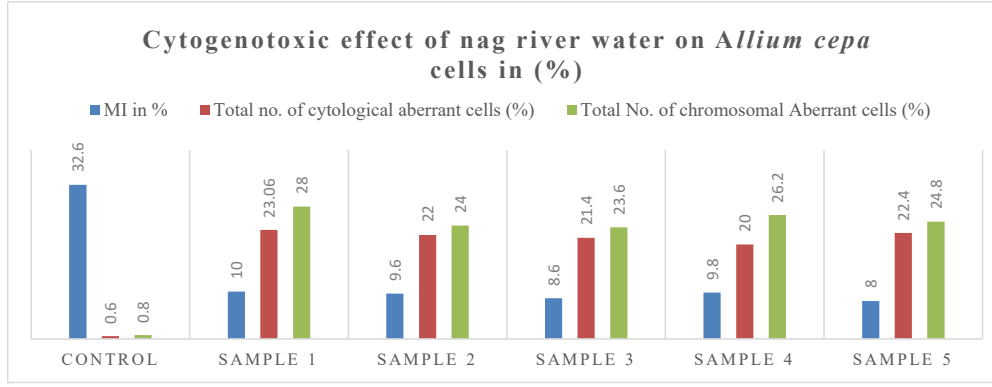


Fig. 3: Cytogenotoxic effect of nag river water on A*llium cepa* cells in (%).

as harmful and indicate high cytotoxic effects within the environment.

The presence of chromosomal abnormalities in *A. cepa* root tip cells indicates that genotoxic compounds may be present in the exposed medium (Kannangara & Pathiratne 2015, Boumaza et al. 2016).

After exposure to the Nag river water sample, chromosomal abnormalities in *A. cepa* root tip cells were observed. Anaphase bridges, breaks, chromosomal lagging and stickiness, aberrant spiraliation of chromosomes, multipolarity, and polyploidy were all observed, as shown in Fig. 4.

After treatment with Nag river water, cytological abnormalities were identified during the cell cycle. In all water samples except the control, anomalies such as cells without nucleus, bi-nucleated cells, and morphological alterations were observed. Fig. 5 shows a few examples of cytological changes.

Studies have proven that compounds such as poly aromatic hydrocarbons, copper, arsenic, and other industrial effluents have been shown to have cytotoxic and genotoxic effects in *A. cepa* root tip cells (Kannangara & Pathiratne 2015, Samuel et al. 2010, Da Costa et al. 2012, Olorunfemi 2011)

The *A. cepa* assay is a vital in-vivo assay in which the roots develop in direct contact with the substance of interest, allowing for the prediction of possible DNA damage in humans (Nefic et al. 2013). The test used in this study allows for the evaluation of several genetic endpoints that arise as a result of exposure to various water samples collected from the Nag River in Nagpur, Maharashtra. All 5 samples caused significant inhibition of MI in *Allium cepa* meristem cells and induced chromosomal aberrations, nuclear abnormalities and micro nucleated cells (MNCs).

The mitotic index decreased in all five experimental water samples when compared to the control. The cytotoxic and

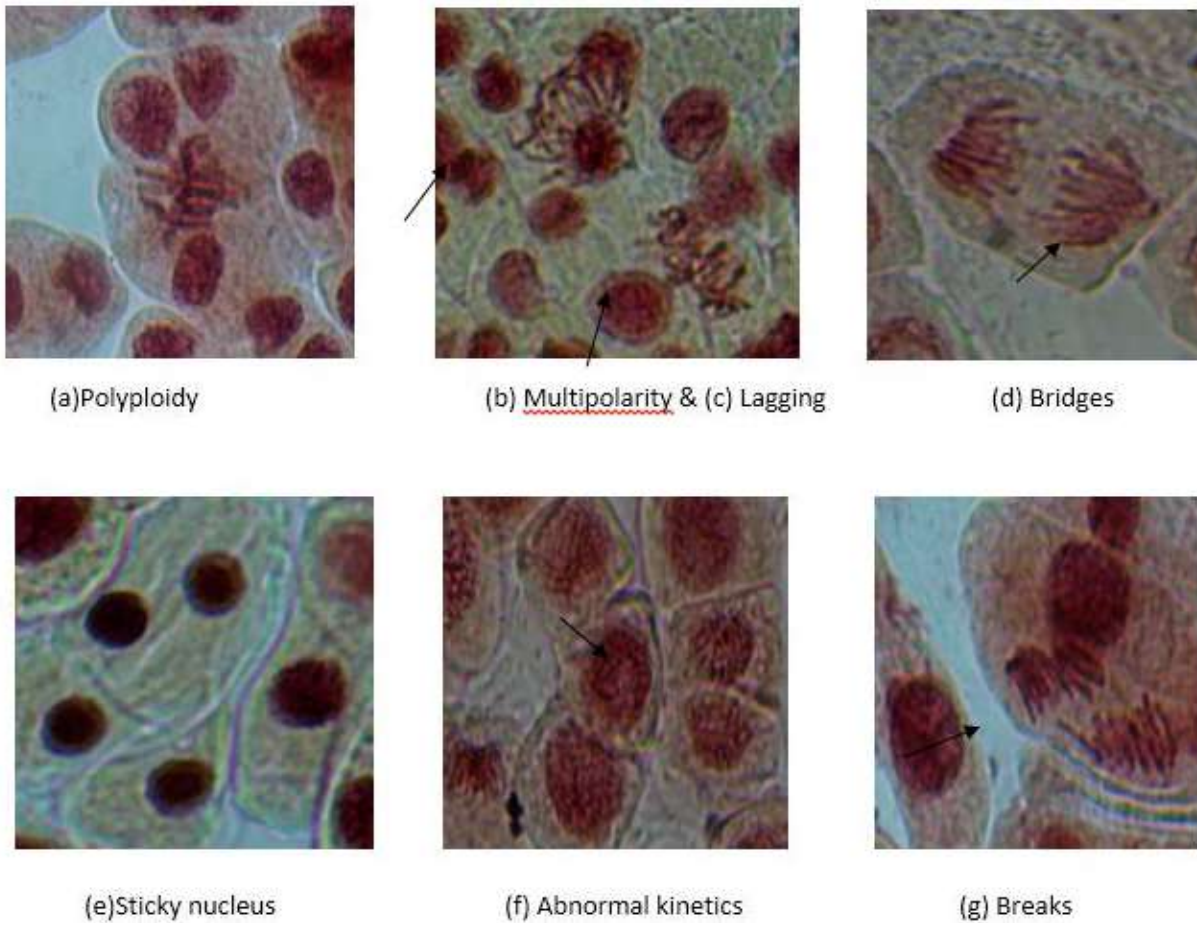


Fig. 4: Photomicrographs of CAs induced by Nag River water in root cells of *Allium cepa.*

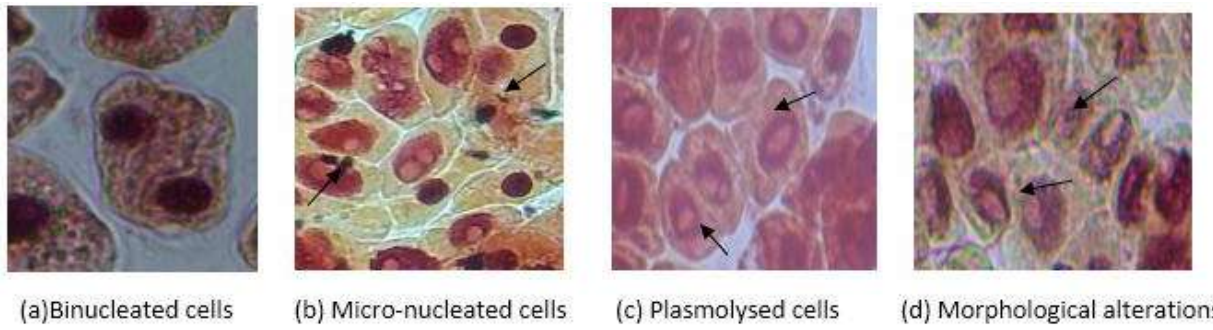


Fig. 5: Cytological aberrations in *Allium cepa* meristem cells exposed to Nag River water

genotoxic potential of Nag river water samples is determined by changes in MI of *Allium cepa* cells. The sample with the most chromosomal abnormalities was no. 1. (28%). The examination of various chromosomal abnormalities types at various stages of the cell cycle allows for a more thorough investigation of the impacts of the Nag river water sample. Breakages may occur and subsequent inhibition of repair mechanisms may lead to base mismatch, mutation and CAs such as fragmented chromosomes and DNA breaks (Nefic et al 2013).

All water samples tested from different points along the Nag River had bridges, breaks, lags, multi-polar anaphase chromosomes, and aberrant spiralization. The findings revealed that all Nag river water samples were capable of inhibiting normal cell division and causing deadly chromosomal abnormalities. Stickiness is due to inter-chromosomal linkages of sub-chromatid strands coupled with excessive formation of nucleoproteins and inappropriate protein-protein interaction (Nefic et al. 2013).

Cytological aberrations are characterized by BNC, plasmolyzed cells, and micronucleus formation as a result of exposure to Nag river Water samples. Also, we observed alterations in the shape and size of cells in all collected Nag river water samples.

CONCLUSION

Domestic as well as industrial activities are important sources of pollution during the flow of these rivers. Domestic sources as compared to industrial sources exceed. substantially in terms of organic load addition into the River. The predominant source is untreated sewage discharged by Nagpur Municipal Corporation into Nag and Pili Rivers.

The findings of this study revealed that the water of the Nag River is highly cytotoxic and genotoxic, making it unsafe for drinking and irrigation. No one should grow any vegetables or crops near the Nag River because toxic substances could enter the food chain and cause diseases due to the phenomenon of biomagnification and bioaccumulation. It's critical to identify the composition and speciation of those cytogenotoxic compounds in the tropical climate, as well as to provide cleanup or treatment options to address this environmental and public health risk. Furthermore, continual water quality monitoring and management are critical for maintaining the ecosystem's ecological health.

ACKNOWLEDGMENTS

The authors wish to acknowledge the Principal of Dr. Ambedkar College, Deekshabhoomi, Nagpur (India), for providing the laboratory facilities to conduct this research and Mr. Avinash Chavhan's laboratory assistant for the kind support.

REFERENCES

Alimba, C.G., Ajayi, E.O., Hassan, T., Sowunmi, A.A. and Bakare, A.A. 2015. Cytogenotoxicity of abattoir effluent in Clariasgariepinus (Burchell, 1822) using the micronucleus test. Chinese J.Biol., 2015: 56-71

Anparthi, A. 2013. Nag river looks like a sewage drain. Times of India, Times News Network, Mumbai, India.

Antonise-Wiez, D. 1990. Analysis of the cell cycle in the root meristem of *Allium cepa* under the influence of ledakrin. Folia Histochem. Cytobiol., 28(1-2): 79-95.

Boumaza, A., Lalaoui, K., Khallef, M., Sbayou, H., Talbi, H. and Hilali, A. 2016. Assessment of cytotoxic and genotoxic effects of Clodinafop-propargyl commercial formulation on *Allium cepa* L. J. Mater. Environ. Sci., 7(4): 1245-1251.

Buschini, A., Cassoni, F., Anceschi, E., Pasini, L., Poli, P. and Rossi, C. 2001. Urban airborne particulate: Genotoxicity evaluation of different size fractions by mutagenesis tests on microorganisms and comet assay. Chemosphere, 44(8): 1723-1736.

Carrasco, K.R., Tilbury, K.L. and Myers, M.S.1990. Assessment of the piscine micronucleus test as an in situ biological indicators of chemical contaminant effects. Can. J. Fish. Aquat. Sci., 47(11): 2123-2136.

Chiu, W. A., Okino, M. S. and Evans, M. V. 2009. Characterizing uncertainty and population variability in the toxicokinetics of trichloroethylene and metabolites in mice, rats, and humans using an updated database, physiologically based pharmacokinetic (PBPK) model, and Bayesian approach. Toxicol. Appl. Pharmacol., 241(1): 36-60.

Daniels, S.A., Munawar, M. and Mayfield, C.I. 1989. An improved elutriation technique for the bioassessment of sediment contaminants. Hydrobiologia, 188(1): 619-631.

Da Costa, T. C., de Brito, K. C. T., Rocha, J. A. V., Leal, K. A., Rodrigues, M. L. K., Minella, J. P. G., ... & Vargas, V. M. F. 2012. Runoff of genotoxic compounds in river basin sediment under the influence of contaminated soils. Ecotoxicol. Environ Safety, 75: 63-72.

Fiskesjo, G. 1985. The Allium test is a standard in environmental monitoring. Hereditas, 102(1): 99-112.

Fiskesjo, G. 1988. The Allium test: An alternative in environmental studies: The relative toxicity of metal ions. Mutat. Res/Fund. Mol. Mech. Mutagen., 197(2): 243-260.

Grant, W.F. 1982. Chromosome aberration assays in Allium: A report of the US Environmental Protection Agency gene-tox program. Mutat Res-Rev. Gene. Toxicol., 99(3), 273-291.

Guan, Y., Wang, X., Wong, M., Sun, G., An, T., Guo, J. and Zhang, G. 2017. Evaluation of genotoxic and mutagenic activity of organic extracts from drinking water sources. PloS One, 12(1): e0170454.

Iqbal, M., Abbas, M., Nisar, J., Nazir, A. and Qamar, A. 2019. Bioassays based on higher plants as excellent dosimeters for ecotoxicity monitoring: A review. Chem Int., 5(1), 1-80.

Kalyani, M. 2017. Nag river's rich history drown in silt. Articulations, 2017: 3-9

Kim, Y. J., Yang, S. I. and Ryu, J. C. 2010. Cytotoxicity and genotoxicity of nano-silver in mammalian cell lines. Mol. Cell. Toxicol. 6(2): 119-125.

Kannangara, D.N.M. and Pathiratne, A. 2015. Toxicity assessment of industrial wastewaters reaching DanduganOya, Sri Lanka using a plant-based bioassay. J. Natl. Sci. Found Srilanka, 43(2): 153-163

Manzar, A. 2010. Report of Government of India Ministry of Water Resources. Central Groundwater Board, India

Nefic, H., Musanovic, J., Metovic, A. and Kurteshi, K. 2013. Chromosomal and nuclear alterations in root tip cells of *Allium cepa* L. induced by alprazolam. Med Arch., 67(6): 388.

Olorunfemi D.I. 2011. Cytotoxic and genotoxic effects of Cassava effluents using the *Allium cepa* bioassay. Res. J. Mutagen, 1(1), 1-9

Patil, A.M. 2017. Assessment of Water Quality Parameters of Nag River Flowing through Nagpur, Maharashtra. Monitoring Central Organization, Central Water Commission Nagpur, India

Puri, P.J., Yenkie, M.K.N., Battalwar, D.G., Gandhare, N.V. and Dhanorkar, D B. 2010. Study and interpretation of physico-chemical characteristics of lake water quality in Nagpur city (India). Rasayan J. Chem., 3(4): 800-810.

Samuel, O.B., Osuala, F.I. and Odeigah, P. G.2010. Cytogenotoxicity evaluation of two industrial effluents using *Allium cepa* assay. Afr. J. Environ. Sci. Tech., 4(1): 123-140.

Tayawade, S.S. and Prasad, J. 2008. Characterization of sewage-water-irrigated and non-irrigated soils in nag river ecosystem of Nagpur, Maharashtra. J. Indian Soc. Soil Sci., 56(3): 247-253.

ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/351249126

Extremophiles as a source of valuable Biomolecules

Article *in* Research Journal of Biotechnology · May 2021

CITATIONS
0

READS
217

2 authors:

Pradip Hirapure
Rashtrasant Tukadoji Maharaj Nagpur University
22 PUBLICATIONS **13** CITATIONS
SEE PROFILE

Arti S. Shanware
Rashtrasant Tukadoji Maharaj Nagpur University Nagpur Maharashtra India
84 PUBLICATIONS **1,949** CITATIONS
SEE PROFILE

Some of the authors of this publication are also working on these related projects:

oil biosynthesis View project

molecular charecterization of plant biodiversity based on chloroplast specific marker Genes View project

All content following this page was uploaded by Pradip Hirapure on 01 May 2021.

The user has requested enhancement of the downloaded file.

Review Paper:

Extremophiles: Potential Sources of Valuable Biomolecules

Hirapure Pradip* and Shanware Arti
Rajiv Gandhi Biotechnology Centre, Laxminarayan Institute of Technology Campus, Rashtrasant Tukudoji Maharaj Nagpur University, Nagpur, INDIA
*pradiphirapure@gmail.com

Abstract

Extremophiles are a large group of organisms with the ability to thrive under extreme environmental conditions such as high and low temperatures, high salt levels, radiation and high antibiotic concentrations. Extremophilic microorganisms have established a diversity of molecular strategies in order to survive in extreme conditions and hence they are able to produces new and novel biomolecules. They have been the center of attention due to the remarkable benefits to the human society.

The knowledge of various novel biomolecules isolated from extremophiles and their application is essential for chemists, biochemists, chemical/biochemical/ bioprocess engineers, genetic engineers, biotechnologists, molecular biologists as well as computational biologists. This study discusses the classification of extremophiles, their survival mechanism and applications of various biomolecules isolated from extremophiles.

Keywords: Extremophiles, Microorganisms, Valuable Biomolecules, Thermopiles, Halophiles.

Introduction

The term extremophile was coined over a quarter of a century ago by MacElroy in 1974. The word has been interpreted in a number of ways and perhaps has become associated with those microorganisms that inhabit environments unsuitable to mammals. Conditions that are 'extreme' to one organism may be essential for another's survival, so the concept of extremophily is a relative one. Extremophiles span all three domains of life: bacteria, archaea and eukaryotes[11].

The extremophilic microorganisms live in extreme conditions and also adopt in ranges of environmental variables such as temperature (55°C to 121°C and -2°C to 20°C), pressure (>500 atmospheres), alkalinity or acidity pH (pH > , pH < 4), salinity (2-5 M NaCl or KCl), geological scale/barriers, radiation (UVR resistance >600 J/m), chemical extremes of heavy metals (arsenic, cadmium, copper and zinc), lack of nutrients (e.g. water, ice, air, rock, or soil), osmotic barriers, or polyextremity[15,33,42].

They are characterized by efficient growth and enzymes products that led them to be potential candidate in industrial productions as detergents, brewing, cosmetics, dairy products, bakery, textiles, medicine, agriculture, biofuel production and as degradation materials.[17,44]

Farlow was the pioneer, first extremophile species isolated from salted fish described as a salt-loving organisms (halophilic)[17]. In 1936, up to 34% salt concentration resistance strains have been isolated from the Dead-sea by Eleazari Volcani[45]. Volcani is considered as historical leader due to his efforts since he got the starting point in extremophilic field and focused in halophilic microbes.

During that decade, hyperthermophilic and thermophilic microbes were isolated at 60 to 80°C. Furthermore, in 1969, *Thermus aquaticus* thermophilic bacterium was isolated by Thomas Brock from Yellowstone National Park hot spring in the United States[7]. After one year, *Sulfolobus acidocaldarius* was the first hyperthermophile isolated able to survive in low pH (1-5) and up to 85°C[8]. Accordingly, this was a great discovery for biologists because it changed all the previous concepts that used to state that there are no organisms which can resist higher than 80°C[31].

These discoveries were fully focused on the diversity of microbiology. Extremophiles are important not only because of what they can teach us about the fundamentals of biochemical and structural biodiversity but also, because of their enormous potential as sources of enzymes and other biomolecules with applications in biotechnology, veterinary, agriculture, industry and medicine for the benefit of human. Their unusual properties make them key targets for exploitation by biotech companies around the world.

Classification of Extremophiles

Extremophile organisms are classified as living organisms able to survive and proliferate in environments with extreme physical (temperature, pressure, radiation) and geochemical parameters (salinity, pH, redox potential). Polyextremophile microorganisms are those that can survive in more than one of these extreme conditions. The vast majority of extremophile organisms belong to the prokaryotes and are therefore, microorganisms belonging to the Archaea and Bacteria domains. Extremophile microorganisms are classified according to the extreme environments in which they grow and the major types are summarized in table 1.

Different structural and metabolic characteristics are acquired by these organisms so that they can survive in these environments.

Survival and defensive strategies of Extremophiles: It is vital for extremophiles to cope with their environments making them viable to withstand under harsh environmental conditions. Extremophiles are known to adopt to the changes in their environment and surroundings that enable them to stabilize the changes in their homeostasis. The adaptability of extremophiles arrives from alteration of varying genes and proteins. Extremophiles produce extremolytes which help them to maintain their homeostasis such as ectoine mediated mechanism, which is produced by halophiles and organisms alike.

Evolutionary diversity, increased catalytic activity, amino acid accumulation, aggregation resistance strategies, resistance to cell death, activation of the nuclear factor, the use of heat shock proteins and cellular compartmentalization, are all vital tools that extremophiles take on in order to conserve their genes[35]. Table 2 provides an overview of the survival and defensive strategies of selected extremophiles.

Extremophiles and Biomolecules

Extremophiles are able to produce various novel biomolecules because of their unusual behaviors in extreme conditions. It is difficult to overstate the success or impact the DNA polymerases from the thermophiles *Thermus aquaticus*, *Pyrococcus furiosus* and *Thermococcus litoralis*, otherwise known as Taq, Pfu and Vent[29,32,43] respectively have had in biotechnology.

Table 1
Extremophile microorganisms and their environments[22]

Extremophile Microorganism	Favorable Environment to Growth
Acidophile	Optimum pH for growth—Below 3
Alkaliphile	Optimum pH for growth—Above 10
Halophile	Requires at least 1M salt for growth
Hyperthermophile	Optimum growth at temperatures above 80 °C
Thermophile	Grows at temperatures between 60 °C and 85 °C
Eurypsychrophile (psychrotolerant)	Grows at temperatures above 25 °C, but also grow below 15 °C
Stenopsychrophile (psychrophile)	Grows at temperatures between 10 °C and 20 °C
Piezophile	Grows under high pressure—Above 400 atm (40 MPa)
Endolithic	Grows inside rocks
Hipolithic	Grows on rocks and cold deserts
Oligotrophs	Able to grow in environments of scarce nutrients
Radioresistant	Tolerance to high doses of radiation
Metallotolerant	Tolerance to high levels of heavy metals
Toxitolerant	Tolerates high concentrations of toxic agents (eg. Organic solvents)
Xerophile	Grows in low water availability, resistant to desiccation

Table 2
Survival and defensive strategies in major extremophiles to thrive under extreme environmental conditions.

Extremophiles	Survival and defensive strategies
Thermophiles	Stabilization of enzymes from stress and freeze drying; protection of oxidative protein damage[27]
Acidophiles/ alkaliphiles	Maintaining a circumneutral intracellular pH; constant pumping of protons in and out of cytoplasm; acidic polymers of the cell membrane; passive regulation of the cytoplasmic pools of polyamines and low membrane permeability[3,9,21]
Halophiles	Protection of skin immune cells from UV radiation; enzyme stabilization against heating, freezing anddrying; protection of the skin barrier against water loss and drying out; block of UV-A induced ceramide release in human keratinocytes[10,34,41]
Geophiles	Mucoidal layer enveloping cell colonies; biofilm formation as stress response to extreme environmental conditions[2,4,26]
Psychrophiles	Translation of cold-evolved enzymes; increased flexibility in the portions of protein structure; presence of cold shock proteins and nucleic acid binding proteins; reduction in the packing of acyl chains in the cell membranes[6,12,18.,28]
Barophiles	Homeoviscous adaptation, tight packing of their lipid membranes; and increased levels of unsaturated fatty acids; polyunsaturated fatty acids maintain the membrane fluidity; robust DNA repair systems; highly conserved pressure regulated operons; presence of heat shock proteins[28,36]

Without a doubt, the automated version of the PCR would not have been possible without these enzymes. Nowadays biodiesel can be produced with the help of extremophiles. Previously the production of hydrogen traditionally relies on a chemical/catalyst process[14]; however, larger-scale microorganism-based systems using the thermophiles *Caldicellulosiruptor saccharolyticus* and *Thermotoga elfii* have been developed recently[16]. In contrast to the other products, methane has always been produced using a consortium of microorganisms, which include methanogens (extremophiles that are the only known biologic producers of methane)[5].

Psychrophilic/mesophilic protease was generated that proved to improve the performance of detergent during cold water washing[24]. Lipases are a billion-dollar industry[25] and very attractive for use in industrial settings because of their broad range of substrates, high degree of specificity and stability[19]. Although their applications in laundry detergents (i.e. low temperatures and alkaline conditions) and organic synthesis (i.e. low water activity) require lipases to be active under extreme conditions, most lipases used are mesophilic. Many mesophilic lipases, which typically come from organisms like *Bacillus* and *Aspergillus* species, are active at high temperatures.

As a result, extremophilic lipases are often overlooked; however, lipases from thermophilic *Bacillus* species have been shown to be more efficient than currently used enzymes[23]. Many industrial processes involved in hydrolyzing starch require high temperatures (95°C for one step and 60°C for the other) and high pH, polyextremophilic (thermophilic and alkaliphilic) enzymes would be ideal. Currently, α-amylase from *Bacillus acidicola*[37], glucoamylases from *Picrophilus*[38] and a pullulanase from *Thermococcus kodakarensis*[20] show great promise in replacing their mesophilic counterparts.

However, amylases have also been isolated from halophiles such as *Halomonas meridian* and *Natronococcus amylolyticus* that could be useful in the process of producing high-fructose corn syrup, which is produced by hydrolyzing corn starch[39]. Surprisingly, recently extremophiles, are good producers of a host of antibiotics, antifungals and antitumor molecules[30]. Diketopiperazines (also known as cyclic dipeptides) have been shown to affect blood-clotting functions as well as having antimicrobial, antifungal, antiviral and antitumor properties.

They are found in halophiles like *Naloterrigena hispanica* and *Natronococcus occultus*[13] and have been shown to activate and inhibit quorum-sensing pathways[1]. Finally, a very interesting extremophile contribution to the field of medicine comes in the form of an alternative vaccine delivery system[40]. Some extremophiles and biomolecules produced by them are mentioned in the fig. 1.

Conclusion

Due to the complex properties of extremophiles and extremolytes, research in this field will continue to expand. New extremozymes from extremophiles are being identified and developed relatively slowly, since pharmaceutical industries are driven by economic gains from their innovations. However, increased investment for research into the characteristics of the various proteins and substances from extremophiles can help in the process of sustainable development.

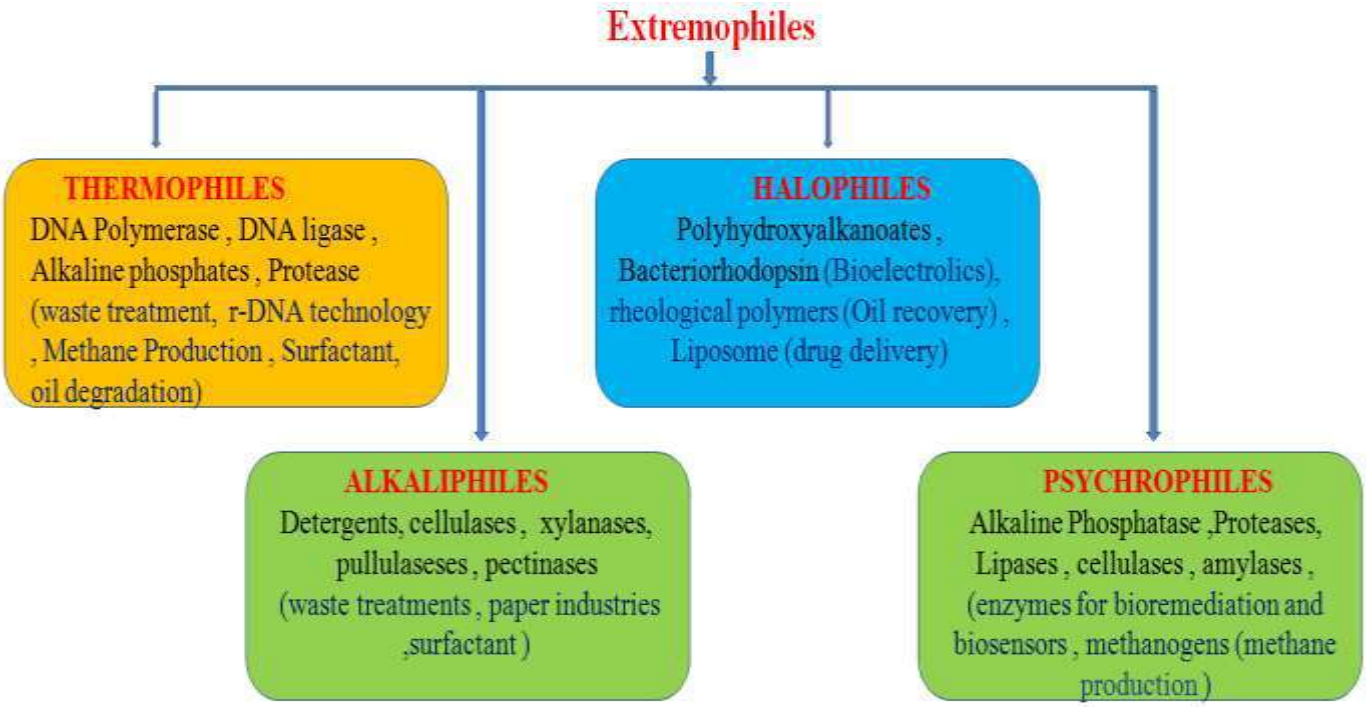


Fig. 1: Biotechnological applications of Biomolecules isolated from Extremophiles

Therefore, there is a need for collaborative efforts to study extremophiles to resolve various challenges in the field of agriculture, medical, renewable energy production, pharmaceutical, bioremediation, biomonitoring etc. Extremophiles have untapped potential and future research must investigate types of extremophiles that have not been previously studied for their possible new and novel application for the benefit of human society.

References

1. Abed R.M. et al, Quorum-sensing inhibitory compounds from extremophilic microorganisms isolated from a hypersaline cyanobacterial mat, *J Ind Microbiol Biotechnol*, **40(7)**, 759–72 **(2013)**

2. Arena A. et al, An expolysaccharide produced by Geobacillus thermodenitrificans strain B3-72: antiviral activityon immunocompetent cells, *Immunol Lett*, **123**, 132–137 **(2009)**

3. Baker-Austin C. and Dopson M., Life in acid: pH homeostasis in acidophiles, *Trends Microbiol.*, **15(4)**, 165-71 **(2007)**

4. Barbara N., Giancula A. and Annrita P., Bacterial polymers produced by extremophiles; biosynthesis, characterization and applications of expolysaccharides, In Singh O.V., eds., Extremophiles- Sustainable resources and biotechnological implications, Wiley, Hoboken **(2013)**

5. Barnard D., Casanueva A. and Tuffin M., Extremophiles in biofuel synthesis, *Environ Technol.*, **31(8–9)**, 871–88 **(2010)**

6. Berger F. et al, Cold shock and cold acclimation proteins in the psychrotrophic bacterium Arthrobacter globiformis SI55, *J Bacteriol*, **178**, 2999–3007 **(1996)**

7. Brock T.D. and F.H., Thermus aquaticus gen. n. and sp. n., a nonsporulating extreme thermophile, *J. Bacteriol*, **98**, 289–297 **(1969)**

8. Brock T.D., B.K.M., Belly R.T. and Weiss R.L., Sulfolobus: a new genus of sulfur-oxidizing bacteria living at low pH and high temperature, *Arch Mikrobiol*, **84**, 54–68 **(1972)**

9. Bordenstein S., Microbial life in alkaline environments, http://www.serc.carleton.edu/, Accessed 20 April 2019 **(2008)**

10. Buommino E. et al, Ectoine from halophilic microorganisms induces the expression of hsp70 and hsp70B' in human keratinocytes modulating the proinflammatory response, *Cell Stress Chaperones*, **10**, 197–203 **(2005)**

11. Cavicchioli R., Amils D. and McGenity T., Life and applications of extremophiles, *Environ. Microbiol*., **13**, 1903- 1907 **(2011)**

12. Chakravorty D. and Patra S., Attaining extremophiles and extremolytes: methodologies and limitations, In Singh O.V., eds., Extremophiles—Sustainable resources and biotechnological implications, Wiley, Hoboken, 29–74 **(2013)**

13. Charlesworth J.C. and Burns B.P., Untapped Resources: Biotechnological Potential of Peptides and Secondary Metabolites in Archaea, *Archaea*, **2015**, 1-7 **(2015)**

14. Das D. and Veziroglu T.N., Hydrogen production by biological processes. A survey of literature, *Int J Hydrogen Energy*, **26(1)**, 13–28 **(2001)**

15. Deppe U., Richnow H.H., Michaelis W. and Antranikian G., Degradation of crude oil by an arctic microbial consortium, *Extremophiles*, **9**, 461-470 **(2005)**

16. De Vrije T. et al, Pretreatment of Miscanthus for hydrogen production by Thermotoga elfii, *Int J Hydrogen Energy*, **27(11–12)**, 1381–90 **(2002)**

17. Farlow W.G., on the nature of the peculiar reddening of salted codfish during the summer season, U.S. Commission of Fish and Fisheries, 969–974 **(1880)**

18. Feller G. and Gerdey C., Psychrophilic enzymes: hot topics in cold adaptation, *Nature*, **1**, 200–208 **(2003)**

19. Hasan F., Shah A.A. and Hameed A., Industrial applications of microbial lipases, *Enzyme Microb Technol*., **39(2)**, 235–51 **(2006)**

20. Han T. et al, Biochemical characterization of a recombinant pullulanase from Thermococcus kodakarensis KOD1, *Lett Appl Microbiol.*, **57(4)**, 336–43 **(2013)**

21. Horikoshi K., Alkaliphiles: some applications of their products for biotechnology, *Microbiol Mol Biol Rev*, **63**, 735–750 **(1999)**

22. Horikoshi K. and Bull A.T., Prologue: Definition, categories, distribution, origin and evolution, pioneering studies andemerging fields of extremophiles In Extremophiles Handbook, Horikoshi K., Antranikaian G., Bull A.T., Robb F.T. and Stetter K.O., Eds., Springer, Tokyo, Japan, 4–15 **(2011)**

23. Imamura S. and Kitaura S., Purification and characterization of a monoacylglycerol lipase from the moderately thermophilic Bacillus sp. H-257, *J Biochem*, **127(3)**, 419–25 **(2000)**

24. Joshi S. and Satyanarayana T., Biotechnology of cold-active proteases, *Biology (Basel)*, **2(2)**, 755–83 **(2013)**

25. Jaeger K.E., Dijkstra B.W. and Reetz M.T., Bacterial biocatalysts: molecular biology, three-dimensional structures and biotechnological applications of lipases, *Annu Rev Microbiol*., **53**, 315–51 **(1999)**

26. Kambourova M. et al, Production and characterization of a microbial glucan, synthesized by Geobacillus tepidamans V264 isolated from Bulgarian hot spring, *Carbohydr Poly*, **77**, 338–343 **(2009)**

27. Kumar R. et al, Extremophiles: sustainable resource of natural compound-Extremolytes, In Singh O.V. and Harvey S.P., eds., Sustainable biotechnology: sources of renewable energy, Springer Press, UK, 279–294 **(2010)**

28. Lauro F.M. and Bartlett D.H., Prokaryotic lifestyles in deep sea habitats, *Extremophiles*, **12**, 15–25 **(2007)**

29. Lundberg K.S. et al, High-fidelity amplification using a thermostable DNA polymerase isolated from Pyrococcus furiosus, *Gene*, **108(1)**, 1–6 **(1991)**

30. Littlechild J.A., Archaeal Enzymes and Applications in Industrial Biocatalysts, *Archaea*, **2015**, 1-10 **(2015)**

31. Madigan M.T., Brock Biology of Microorganisms, 10th edition, New Jersey, Prentice-Hall, Inc. **(2002)**

32. Mattila P. et al, Fidelity of DNA synthesis by the Thermococcus litoralis DNA polymerase--an extremely heat stable enzyme with proofreading activity, *Nucleic Acids Res*., **19(18)**, 4967–73 **(1991)**

33. Navarro-González R., Iniguez E., De La Rosa J. and McKay C.R., Characterization of organics, microorganisms, desert soil and Mars-like soils by thermal volatilization coupled to mass spectrometry and their implications for the search for organics on Mars by Phoenix and future space missions, *Astrobiology*, **9**, 703-711 **(2009)**

34. Ortenberg R., Rozenblatt-Rosen O. and Mevarech M., The extremely halophilic archaeon Haloferax volcanii has two very different dihydrofolate reductases, *Mol Microbiol*, **35**, 1493–1505 **(2000)**

35. Prasanti Babu, Chandel Anuj K. and Singh Om V., Extremophiles and Their Applications in Medical Processes, Springer **(2015)**

36. Rothschild L.J. and Mancinelli R.L., Life in extreme environments, *Nature*, **409**, 1092–1101 **(2001)**

37. Sharma A. and Satyanarayana T., Cloning and expression of acid stable, high maltose-forming,Ca^{2+}- independent α-amylase from an acidophile Bacillus acidicola and its applicability in starch hydrolysis, *Extremophiles*, **16(3)**, 515–22 **(2012)**

38. Serour E. and Antranikian G., Novel thermoactive glucoamylases from the thermoacidophilic Archaea Thermoplasma acidophilum, Picrophilus torridus and Picrophilus oshimae, *Antonie Van Leeuwenhoek*, **81(1–4)**, 73–83 **(2002)**

39. Schiraldi C., Giuliano M. and De Rosa M., Perspectives on biotechnological applications of archaea, *Archaea*, **1(2)**, 75–86 **(2002)**

40. Stuart E.S., Morshed F. and Sremac M., Antigen presentation using novel particulate organelles from halophilic archaea, *J Biotechnol.*, **88(2)**, 119–28 **(2001)**

41. Singh O.V. and Gabani P., Extremophiles: radiation resistance microbial reserves and therapeuticimplications, *J Appl Microbiol*, **110,** 851–861 **(2011)**

42. Seitz K.H., Studdert C., Sanchez J. and De Castro R., Intracellular proteolytic activity of the haloalkaliphilic archaeon Natronococcus occultus. Effect of starvation, *J. Basic Microbiol*., **7**, 313-322 **(1997)**

43. Tindall K.R. and Kunkel T.A., Fidelity of DNA synthesis by the Thermus aquaticus DNA polymerase, *Biochemistry*, **27(16)**, 6008–13 **(1988)**

44. Waznah Moayad and Genhan Zha, Extremophile Current Challenges and New Gate of Knowledge by Nanoparticles Pathways, *IOSR-JPBS*, **12(1)**, 10-17 **(2017)**

45. Wilkansky B., Life in the Dead Sea, *Nature*, **138**, 467 **(1936)**

46. Woese C.R., Phylogenetic structure of the prokaryotic domain: the primary kingdoms, Proc. Natl. Acad. Sci. USA, 5088–5090 **(1977)**.

(Received 06th May 2020, accepted 09th July 2020)

View publication stats

ScienSage

Journal of Advanced Scientific Research

Available online through http://www.sciensage.info

ISSN
0976-9595
Review Article

A REVIEW ON ECO-FRIENDLY APPROACH FOR GREEN SYNTHESIS OF ZINC OXIDE NANOPARTICLES USING PLANT LEAF EXTRACTS

Nandkishor G. Telkapalliwar*[1], Gulzar H. Shaikh[2]

[1]*Department of Chemistry, Dr. Ambedkar College, Deekshabhoomi, Nagpur, Maharashtra, India*

[2]*Department of Physics, Dr. Ambedkar College, Deekshabhoomi, Nagpur, Maharashtra, India*

**Corresponding author: telkapalliwar80@gmail.com*

ABSTRACT

Nanotechnology is concerned with the development and applications of nanoscale materials. Nanoparticles have a high surface area to volume ratio and thus have very unique properties due to their nanoscale dimension. Due to the abundance of zinc and the relatively simple conversion of its oxide to nanostructures, ZnO-based nanomaterials are of great use for many leading applications since the beginning of nanoscience. Zinc oxide nanoparticles (ZnO NPs) have gained a lot of attention because of their wide bandwidth and strong exciton binding energy, and possess antibacterial, antifungal, anti-diabetic, anti-inflammatory, wound healing, antioxidant, and optical properties. Because of its versatility, eco-friendliness, and comprehensive biological activity, plant-mediated green synthesis of nano-metal oxide particles is gaining a lot of traction as a viable alternative to not only physical but also chemical processes, avoiding the use of harmful chemicals and harsh environments. This review article is a study of the green synthesis of Zinc oxide nanoparticles (ZnO NPs) using different plant leaf extract.

Keywords: Zinc oxide, Nanomaterials, Green Synthesis, Leaf Extracts.

1. INTRODUCTION

Nanotechnology has emerged over the past decade as a technology that has revolutionized every area of applied science. One of the avenues of nanotechnology associated with nanoscale materials with very small particle sizes ranging from 1 to 100 nm is the nanoparticles (Nano-particles) sector. Due to their extremely small size and high surface area to volume ratio, nanoparticles exhibit distinctive properties, which have been attributed to major variations in properties compared to their bulk counterparts [1]. In this respect, by offering novel solutions, nanoparticles have been introduced into different industries.

Including titanium dioxide (TiO_2), indium (III) oxide (In_2O_3), zinc oxide (ZnO), tin (IV) oxide (SnO_2) and silicon dioxide (SiO_2), there are different forms of metal oxides, where ZnO is one of the most abundantly developed metal oxides after SiO_2 and TiO_2 [2]. ZnO is an inorganic material with unusual properties such as semiconductor, broad radiation absorption, piezo-electricity, pyroelectricity, and high catalytic activity [3]. Furthermore, ZnO has been classified by the US Food and Drug Administration (FDA 21CFR182.8991) [4] as 'Generally Accepted as Safe' (GRAS) because of its non-toxic properties [5]. As a result, it is safe to use on both humans and animals. Zinc oxide nanoparticles have gotten a lot of coverage in recent years. This is due to the fact that they have the smallest particles, which increases their chemical reactivity. Due to this, ZnO Nanoparticles have a broader range of applications in electronics, optics, biomedicine, and agriculture [6]. In living organisms, zinc is an essential nutrient [7]. Evidence has shown that there is a great potential for ZnO nano-particles in biological applications, especially as anti-microbial agents [8]. Furthermore, numerous studies have been published on the efficacy of ZnO nanoparticles in inhibiting the growth of a large variety of pathogens [9], indicating that they may eventually replace antibiotics. Besides, zinc is a major trace mineral that plays a vital role in many physiological functions [10].

1.1. Synthetic methods for nanoparticles

For nanoparticle synthesis, two methods have been suggested: bottom-up and top-down. Milling or attrition of large macroscopic particles is used in the top-down method. It involves initially synthesizing large-scale patterns and then reducing them by plastic deformation to the nanoscale level. For large-scale production of

nanoparticles, this technique cannot be used because it is an expensive and slow process [11]. The most popular technique employing the function of the top-down approach for nanomaterial synthesis is Interferometric Litho-graphic (IL) [12]. This process involves the synthesis of nanoparticles by self-assembly from already miniaturised atomic components. It requires creation through physical and chemical means. This method is comparatively inexpensive [13]. It is based on the principle of kinetic and thermodynamic equilibrium. MBE is used in the kinetic approach (molecular beam epitaxy).

1.2. Other different techniques and methods used in nanoparticle synthesis

The physical method includes the attraction of nanoscale particles and the creation of large, stable, well-defined nanostructures by physical forces. Nanoparticle synthesis using the colloidal dispersion method is an example. Basic techniques such as vapour condensation, amorphous crystallisation, physical fragmentation and many others are also included [14]. Physical, chemical and green methods are used to make nanoparticles [15-17]. The physical method necessitates the use of expensive machines, high temperatures and pressures [18], and a wide area for system setup. The chemical method requires the use of harmful chemicals that can be dangerous to the environment as well as the person handling them. According to the literature, some of the toxic chemicals used in physical and chemical methods can resurface in the Nanoparticles produced, posing a risk in the field of medical application [19]. As a result, we needed a process for nanoparticle synthesis that was both environmentally friendly and cost-effective. In processes such as pulsed laser deposition, MBE (molecular beam epitaxy), thermal evaporation, etc., the physical process includes the use of high vacuum [20] and chemical methods include chemical microemulsion, wet chemicals, spray pyrolysis, electrodeposition [20], chemical and direct precipitation, and combustion aided by microwaves [21]. In both physical and chemical methods, additional capping and stabilising agents are needed [22].

1.3. Green synthesis approach

Biosynthesis of nanoparticles is a method of synthesising nanoparticles for biomedical applications using micro-organisms and plants parts. This approach is an approach which is environmentally sustainable, cost-effective, biocompatible, healthy and green [23]. Green synthesis requires plant synthesis, bacteria, fungi, algae, etc. They allow the production of ZnO Nanoparticles on a large scale without the presence of additional impurities [24]. Biomimetic-synthesized nanoparticles demonstrate more catalytic activity and limit the use of costly and toxic chemicals.

These natural strains and plant extract secrete certain phytochemicals that act as both reducing agent and capping or stabilising agent; for example, in the presence of ZnO blue (MB) pollutant dye, synthesis of ZnO nanoflowers of uniform size from cell soluble proteins of *B. licheniformis* demonstrated increased photocatalytic activity and photostability clearly shown by 83 percent degradation of methylene blue (MB) pollutant dye in the presence of ZnO nanoflowers, self-degradation of MB was null (observed through the control value), and degradation was found to be 74 percent after three repeated cycles of the experiment at different time intervals, demonstrating photostability of ZnO nano-flowers developed [25].

The fungal strain *Aspergillus fumigatus* TFR-8 was used to synthesise oblate spherical and hexagonal shaped ZnO Nanoparticles with sizes ranging from 1.2 to 6.8 nm. These Nanoparticles showed stability for 90 days, which was verified by measuring the hydrodynamic diameter of nanoparticles using a particle size analyzer, which showed agglomeration formation of nanoparticles only after 90 days, indicating high stability. ZnO 36 nm synthesised nanoparticles from seaweed *Sargassum myriocystum* (microalgae) collected from the Gulf of Mannar showed no visible changes, even after 6 months, clearly demonstrating the stability of the shaped nanoparticles. It has been confirmed from FTIR outcome studies that fucoidan soluble pigments secreted from microalgae were responsible for reducing and stabilising the nanoparticles. For the synthesis of nanoparticles, plant components such as roots, leaves, stems, seeds, fruits have also been used as their extract is rich in phytochemicals that act as both a reduction and stabilisation agent [27]. ZnO synthesized nanoparticles from *Trifolium pratense* flower extract showed similar peaks in the UV-Vis spectrophotometer after 24, 48, 72, 96 and 120 hours of formation of nanoparticles indicating stability of the formed nanoparticles [28].

1.4. Zinc oxide nanoparticles and their applications

ZnO is a semiconducting metal oxide of n-type. Because of its wide range of applicability in the field of electronics, optics, and biomedical systems, zinc oxide

NP has attracted interest in the past two to three years [29]. Several forms of inorganic metal oxides, such as TiO_2, CuO, and ZnO, have been synthesised and have remained in recent studies. ZnO Nanoparticles are the most interesting of these metal oxides because they are inexpensive to make, safe, and easy to prepare [30].

Due to its wide bandgap (3.37 eV) and high exciton binding energy (60meV), ZnO nanoparticles exhibit tremendous semiconducting properties, such as high catalytic activity, optic, UV filtering properties, anti-inflammatory, wound healing [31]. It has been commonly used in cosmetics, such as sunscreen lotions, due to its UV filtering properties [32]. It has a broad range of therapeutic uses, such as drug delivery, anti-cancer, anti-diabetic, antibacterial, antifungal and agricultural properties [33]. While ZnO is used for the delivery of targeted drugs, it still has a cytotoxicity limit that has yet to be resolved [34].

According to research, ZnO Nanoparticles have a much greater antibacterial activity at low concentrations of gramme negative and gramme positive bacteria than chemically synthesised ZnO Nanoparticles [35]. They've also been used in the manufacture of rubber, paint, the removal of sulphur and arsenic from water, the properties of protein adsorption, and dental applications. The piezoelectric and pyroelectric properties of ZnO nanoparticles have been discovered [36]. They are used for aquatic weed disposal that is resistant to all sorts of eradication techniques such as human, chemical and mechanical means [37]. Different morphologies of ZnO nanoparticles have been published, including nanoflake, nanoflower, nanobelt, nanorod, and nanowire [38].

2. SYNTHESIS OF ZINC OXIDE NANOMATERIALS BY GREEN APPROACH

Due to the growing popularity of green methods, numerous works have been carried out using various sources such as bacteria, fungi, algae, plants and others to synthesise ZnO nanoparticles. The literature review on the synthesis of zinc oxide nanomaterials by a green approach using various plant leaf extracts is carried out in this paper. To summarise the useful work done by the researchers in this area, a list of table1 was put up.

Umamaheswar A. et al. [39] synthesised zinc oxide nanoparticles (ZnO NPs) from *Raphanus sativus var. Longipinnatus* leaves extract and investigated their anticancer activity. UV-vis, FTIR, particle size analysis, SEM, XRD and its anticancer activity using A549 cell lines were examined by synthesised ZnO NPs. The UV-vis and particle size of nanoscale ZnO NPs are stated as 66.43 nm. The FTIR studies indicated that different functional groups were present. The partial crystal spherical form and wurtzite crystal character were verified by SEM and XRD images. The findings of cytotoxicity highlighted the improved cytotoxic effect of the synthesised ZnO NPs.

Zinc oxide nanoparticles (ZnO NPs) were synthesised by Dhandapani KV, et al. [40] using *Melia azedarach* leaf extract with zinc nitrate as the initiating source. The Ultra Violet-Visible (UV-Vis) Spectroscopy absorption peak at 372 nm in synthesised nanoparticles is one of the distinguishing features of ZnO NPs. The role of aliphatic amines, alkyl halides, and carboxylic acids in the synthesis and stability of ZnO NPs is indicated by the Fourier Transform Infrared (FTIR) spectrum. The nanocrystal nature of the synthesised zinc oxide particles was confirmed by an X-Ray Diffraction (XRD) spectrum. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM) images revealed hexagonal and spherical forms ranging in size from 33 to 96 nm of synthesised zinc oxide nanoparticles. The Energy Dispersive X-Ray Study (EDAX) reported that the existence of zinc content in synthesised nanoparticles of zinc oxide has been confirmed and notes that the biosynthesis process of nanoparticles has been carried out accordingly. Biosynthesized ZnO NPs with powerful biological activities in terms of anti-oxidant and antibacterial potential that could be used in many biological applications.

The green synthesis of zinc oxide nanoparticles using ethanolic extract *Typha latifolia* was reported by Kumar BP, et al. [41]. L leaf without the use of dangerous chemicals Using XRD, SEM, UV, EDAX and FTIR measurements, the acquired properties of ZnO nanoparticles, such as crystallite size, morphology, bandgap, elemental composition, were studied. The existence of ZnO is indicated by peaks of between 400 and 600 cm-1. The highly magnified SEM images of the synthesised nanoparticles by the process of biosynthesis clearly display the creation of the structure of nanoflowers. ZnO nanoparticles were used in the photo-degradation experiments. The photo-degradation efficiency of ZnO nanoparticles was found to be significantly higher than that of bulk ZnO.

Vijayakumar S, et al. [42] used *Atalantia monophylla* leaf extract to successfully synthesise Zinc Oxide nanoparticles for the first time. This study found that the green, eco-friendly and cost-effective approach is ideally suited for the synthesis of potent anti-microbial hexagonal ZnO nanoparticles using *A. monophylla* leaf

extract. The UV-vis absorption peak of these nanoparticles was found to be 352 nm. XRD, FTIR, SEM with EDAX, and TEM were used to classify the ZnO nanoparticles. In the destruction of pathogenic microorganisms, biosynthesized ZnO nanoparticles outperformed traditional antibiotics and plant extracts. Thus, nanoparticles of this form of bio-doped oxide can productively minimise infections caused by micro-organisms. It is stated that, because of its non-toxic and inexpensive material that is suitable for environmental and health-related applications, green synthesis has a strong social relevance.

The synthesis of zinc oxide nanoparticles (ZnO-NPs) using *Ocimum basilicum L. var. purpurascens* Benth.-LAMIACEAE leaf extract and zinc nitrate was reported by Abdul Salam H, et al. [43]. Using leaf extract of Ocimum basilicum L. var. purpurascens Benth., green synthesis of hexagonal (wurtzite) shaped ZnO-NPs of about 50 nm was achieved, thus bringing to light yet another application of the plant, in addition to its normal utilities. The approach stands out mainly because it is eco-friendly and shuts down the demerits of traditional methods of physics and chemistry. In different industries, these particles are anticipated to have broad applications.

Green tea leaves (*Camellia sinensis*) were chosen by Dhanemozhi AC, et al. [44] for the green synthesis of Zinc oxide nanoparticles (ZnO NPs). The formation of nanoparticles was detected by visualising colour changes and was confirmed by the spectrophotometers Scanning Electron Microscope (SEM), UV-Vis and Fourier Transform InfraRed (FT-IR). The absorption spectra were observed using the UV-Vis spectrum, which showed a blue shift absorption peak at 338 nm. Well described peaks occurring at 2 positions corresponding to the hexagonal wurtzite structure of ZnO nanoparticles were revealed by the XRD pattern. The mean size of the nanoparticles measured using XRD data was 54.84 nm, with an energy gap of 3.40eV in the band. The study found that the higher percentage of antioxidant-potential phenolic compounds acting as a reduction agent on metal oxides and substantially present in amino acids, proteins and lipids helped to regulate the growth of nanoparticles. The obtained CV curve reveals excellent capacitance behaviour, low equivalent series resistance (ESR), and thus rapid electrolyte ion diffusion into the composite. This indicates that the best-suited material for supercapacitor applications is the as-prepared ZnO materials.

Sangeetha G, et al. [45] has developed a simple, rapid biological technique to synthesise nanoparticles of zinc oxide with tunable optical properties guided by particle size using varying concentrations of solution extracted from *Aloe vera* leaf broth. There is a distinct poly-dispersity of the zinc oxide nanoparticle and the particle size varies from 25 to 45 nm with an average size of 35 nm. The maximum nanoparticles have a particle size of 30 nm with a separate cap that may be due to the presence of flavonoids, proteins and other functional groups in the aloe vera leaf broth and are likely to be responsible for the formation of nanoparticles of zinc oxide. In biomedical fields and in the cosmetic industry, the eco-friendly, highly efficient zinc oxide nanoparticles produced from Aloe vera leaf broth are expected to have more extensive applications.

The synthesis of zinc oxide nanoparticles (ZnO NPs) using *Azadirachta indica* leaf aqueous extract and its antimicrobial activities have been identified in Elumalai K, et al. [46]. UV-visible spectroscopy, photo-luminescence (PL), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscope (SEM) analysis, energy dispersive X-ray (EDAX) analysis, field emission scanning electron microscopy (FESEM) and atomic force microscope (AFM) analysis were used to classify the nanoparticles. Researchers also investigated the antimicrobial activity of synthesised green ZnO NPs in this report. The findings showed an increase in the concentration of ZnO NPs (50, 100, 200 μg/ml) and the increase in antimicrobial activity was also attributed to an increase in the concentration of H2O2 on the surface of ZnO. Green synthesised ZnO NPs, on the other hand, is more potent than bare ZnO and A. indica leaf. Finally, the analysis concluded that the zinc oxide nanoparticles displayed interesting antimicrobial activity with micromolar concentrations of both gram-positive and gram-negative bacteria and yeast.

The researchers Darvishi E, et al. [47] used *Juglans regia L.* leaf extract to synthesise zinc oxide (ZnO) nanoparticles. Different concentrations of walnut leaf extract and zinc acetate was reported to have been used, and ZnO NPs with different structures and sizes were produced. Particles showed circular, irregular surface morphology and flower shape. The antimicrobial activity of ZnO nanoparticles has also been studied against resistant strains of Escherichia coli, Pseudomonas aeruginosa and Acinetobacter baumannii. The properties of zinc oxide nanoparticles synthesised using both green and chemical methods were compared. More than a chemical, the antimicrobial effect of ZnO nanoparticles synthesised by the green method was greater. The

cytotoxicity assay showed that the cytotoxicity of the green-synthesized ZnO nanoparticles was lower than that of the chemical ZnO. This research has shown that green-synthesized nanoparticles of ZnO have many advantages over chemicals. Chemical ZnO nanoparticles are smaller, have more solubility, have more antibacterial activities, and are less cytotoxic.

In research paper, Ramesh P, et al. [48] identified the synthesis and antibacterial activity of biocompatible zinc oxide nanoparticles (ZnO Nps) from zinc acetate employing an eco-friendly green process using *Cassia auriculata* leaf extract. ZnO Nps synthesised is spherical and ranged in size from 20 to 30 nm. Antibacterial activity of green synthesised ZnO Nps against bacterial pathogens was found to be very high. As a result, the environmentally friendly and high-efficiency zinc oxide nanoparticles produced with *C. auriculata* leaf extract are expected to see more widespread use in the food packaging industry to avoid bacterial contamination.

The biodegradation of zinc nitrate hexahydrate using crude leaf extract from *Gulmohar*, by combustion method at 400°C to form ZnO nanostructures, was studied by Begum JPS, et al. [49]. The synthesised nanoparticles for the formation of polydisperse ZnO NPs have been characterised and confirmed. Using bavistin as a positive control, the antibacterial operation of pure wurtzite ZnO NPs was carried out by the Resazurin plate assay method followed by antifungal evaluation using the food poisoning technique. For the quantitative evaluation of MTT and apoptosis assay, the anticancer potential was evaluated using the HeLa cell line. The antibacterial activity of ZnO NPs on *Escherichia coli* and *Staphylococcus aureus* was within the 0.25e0.0025 mg/ml range and the antifungal effect was within the 100e700 mg/ml range on Fusarium oxysporum and Phomposis azadirachtae. On 24 hours after exposure, the MTT assay and apoptosis study on the HeLa cell line pinpointed optimum cell uptake and toxicity. This biogenic method-based ZnO NPs synthesis paves the way for substantial microbicidal potential against a variety of plant and animal pathogenic microorganisms, as well as a superior cytotoxic effect against HeLa cell lines. As a result, they are promising nano-antibiotics for medicinal use.

The co-precipitation method was used by Park JK, et al. [50] to synthesise *Gynostemma pentaphyllum* zinc oxide nanoparticles (GP-ZnO-NPs) from Gynostemma plant extract using a green chemistry protocol. The decolourization efficiency of GP-ZnO-NPs was evaluated by extracting the toxic Malachite Green (MG) dye under UV illumination. X-ray powder diffraction (XRD) study has confirmed the hexagonal wurtzite structure with a mean size of 35.41 nm. The FE-TEM analysis showed the hexagonal form of the nanoparticles, and the percentage of Zn & oxygen in the nanostructures was analysed by electron diffraction analysis (EDX). The functional group responsible for forming Gp-ZnO-NPs was revealed in the Fourier-transform infrared spectroscopy (FT-IR) study. The study of X-ray photoelectron spectroscopy (XPS) revealed the chemical compositions (Zn, C & O) and the elemental state of the nanostructure. To investigate the photocatalytic behaviour of Malachite Green dye under UV illumination, the newly synthesised nanocatalyst was added. Within 180 minutes of observation, the photocatalyst (GP-ZnO-NPs) decoloured 89 percent (10 mg/L) toxic MG dye. The hexagonal nanoparticle arrangement provides a larger active site for interacting with the poisonous dye molecules, allowing the reaction to proceed more rapidly. The GP-ZnO-NPs are highly recommended by this study as a greener nanocatalyst for removing toxic dye for a safer climate.

Agarwal H, et al. [51] researched the fabrication of nano-sized ZnO particles using zinc oxide as a precursor molecule and *Cinnamomum Tamala* leaf extract as a reducing and capping agent. The hexagonal wurtzite phase was confirmed by XRD analysis on the nanoparticles, which had a particle size of 26.57 nm. The nanoparticles' moderate stability was confirmed by zeta potential analysis, and SEM analysis showed that they were spherical and hexagonal. On selected bacterial organisms, the antibacterial properties of the nano-particle against *Staphylococcus aureus* were investigated using the broth dilution process, protein leakage analysis, membrane stability analysis, and growth curve analysis. The results showed a time- and concentration-dependent reduction in bacterial growth due to membrane damage due to leakage of intracellular proteins and cellular material. This method of producing ZnO NPs from *Cinnamomum Tamala* is simple, environmentally friendly, cost-effective, and convenient, and it is expected to find applications in bioremediation, drug delivery, catalysis, and other medical fields.

Zinc oxide nanoparticles (ZnO-NPs) have been synthesised by Ekennia A, et al. [52] using a simple, low-cost and safe process involving aqueous leaf extracts of *Alchornea laxiflora* and zinc precursor salt. In the degradation of the Congo red dye, ZnO-NPs were assessed for their ability as tyrosinase inhibitors and as catalysts. Within the range of 276456 nm, the UV-vis spectra showed characteristic surface Plasmon bands. The range of the bandgap energies of the ZnO-NPs was 2.50-

3.67 ev. Particles obtained with 1 mL and 2 mL of plant extracts had average sizes of 29 nm and 38 nm, respectively, according to SEM results. The elemental compositions of the nanoparticles with pronounced zinc and oxygen were demonstrated in the EDX map. The ZnO nanoparticles had an IC_{50} of 66.28 g/mL and showed good photocatalytic efficiency of 87 percent degradation of Congo red (CR) dye molecules in 60 minutes. They also had good antityrosinase performance. Overall, biogenic ZnO nanoparticles are promising materials for dual applications as photocatalysts and tyrosinase inhibitors in the degradation of Congo red dye.

Varadavenkatesan T, et al. [53] announces a green synthesis of zinc oxide nanoparticles (ZnONPs) using *Cyanometra ramiflora* leaf extracts and zinc acetate precursor. The extract's phyto-components helped reduce and shape nanoparticles. The formation of ZnONPs was confirmed by a sharp absorption limit at 360 nm in the UV-Vis results. The nanoflower morphology was revealed in the SEM image and EDS showed clear signals for zinc and oxygen components. The XRD spectrum indicated a crystalline structure of 13.33 nm hexagonal wurtzite. BET research confirmed a substantial broad surface area of $16.27 m^2/g$ with mesopores. The presence of the characteristic zinc and oxygen bonding vibrations at 557 cm^{-1}, 511 cm^{-1} and 433 cm^{-1} was substantiated by FTIR. Using the pollutant dye, Rhodamine B, the photocatalytic function of ZnONPs was examined. Under sunlight irradiation, a remarkable degradation efficiency of 98 percent within 200 min was achieved and a degradation constant of 0.017 min^{-1} was obtained. ZnONPs synthesised using a cheap and abundant source can therefore play a promising role in the degradation of toxic dyes present in wastewater, the leaf extract of C. ramiflora.

The green, eco-friendly synthesis of zinc oxide nanoparticles (ZnO NPs) using *Cucurbita pepo* leaf extract was reported by Hu D' et al. [54]. TEM images verified that NPs with an average size of 8 nm were developing. The crystalline nature of prepared ZnO NPs was demonstrated by XRD. This shows that, in a concentration-dependent manner, the ZnO NPs induced cytotoxicity that affected the proliferation of MG63 osteoblast-like cells. Fluorescein diacetate hydrolysis (FDA) staining confirmed the ZnO NPs-induced reduction in cell proliferation. The FDA staining results indicated a decrease in fluorescence intensity as the concentration of ZnO NPs increased. When compared to ZnO NPs treated samples, the untreated control displayed the highest fluorescence. The fluorescence of samples incubated with 80ppm ZnO NPs was substantially reduced. In conclusion, these cell test results indicated that the ZnO NPs produced are an essential substitute for the formation of osteoporotic and bone tissue.

Fahimmnisha B, et al. [55] used *Aloe socotrina* (As) leaf extract to synthesise ZnO NPs and classify them by UV, FTIR, XRD, SEM, and TEM. The overall absorption was found to be about 315 nm using UV spectroscopy. The structure of ZnO NPs ranging in size from 15 to 50 nm was determined by TEM images, while their crystallinity was revealed by XRD spectra. Extensive experiments were carried out to understand the antibacterial activity of NPs, including agar well diffusion, minimum inhibitory concentration, growth kinetics, intracellular uptake, reactive oxygen species (ROS) production, and antibiofilm activity. The *A. socotrina* capped ZnO NPs (As-ZnO NPs) showed substantial activity against biofilms produced by four bacterial pathogens, which may make it difficult to treat drug-resistant bacterial diseases caused by these biofilms.

Rad SS, et al. [56] produced a simple and environmentally friendly synthesis of zinc oxide nanoparticles (ZnO NPs) using *Mentha pulegium L.* leaf extract. The XRD data showed that the nanoparticles and EDX measurements were crystalline in nature, suggesting a high zinc content of 56.26 percent and 43.74 percent oxygen. The existence of functional groups in both leaf extract and ZnO NPs was confirmed by FT-IR. The size and morphology of the particles were determined using FE-SEM and TEM, and the UV visible absorbance spectrum of ZnO NPs showed an absorbance band at 370 nm. On Escherichia coli and Staphylococcus aureus, the antibacterial properties of synthesised ZnO nanoparticles were investigated. The reported findings indicate that aqueous extracts of *Mentha pulegium* (L.) are efficient reducing agents with important antimicrobial potential for the green synthesis of ZnO NPs.

Zinc oxide nanoparticles (ZnONps) were synthesised by Singh A, et al. [57] using *Azadirachta Indica* leaf extract. Various analytical techniques, including UV-Visible spectroscopy, FTIR, XRD, SEM, FESEM and EDAX, were then characterised by ZnONps. ZnONps interaction experiments with Calf-Thymus DNA (CT-DNA) have been further investigated using UV-Visible, UV-thermal, fluorescence, spectroscopy of circular dichroism, and electrophoresis of agarose gel. In absorption spectra, ZnONps showed a sharp peak of about 368 nm, confirming their synthesis. SEM and FESEM were used to investigate the surface morphology

of ZnONps, and the size was found to be in the 20-40 nm range. After analysing all of the results, the interaction of CT-DNA with ZnONps indicated that DNA was stabilised. These physicochemical studies may provide additional knowledge for biosensing and biomedical applications.

Pai S, et al. [58] used an aqueous extract of *Peltophorum pterocarpum* leaves to investigate the synthesis of zinc oxide nanoparticles (ZnO NPs) by reducing zinc acetate. Zinc acetate was reduced to ZnONPs by the phenolic compounds present in the leaf extract. The synthesis process was visually monitored, and the formation of ZnO NPs was confirmed by a high absorption peak at 365 nm in the UV-vis spectrum. 3.39 eV was measured as the bandgap capacity. The FE-SEM picture revealed isolated flower-shaped ZnO NPs, and the EDS spectrum revealed characteristic zinc and oxygen peaks. In the XRD spectrum, the hexagonal wurtzite structure was confirmed, and the crystallite size was determined to be 11.64 nm. Moreover, the values of the lattice parameters were consistent with the normal values for ZnO NPs. The mesoporous structure (pore diameter = 10.77 nm) with a relatively high surface area (13.56 m^2 /g) was confirmed by BET analysis. A TGA curve in which only 12 percent weight loss was observed demonstrated the thermal stability of the ZnO NPs. The degradation of methylene blue (MB) dye under sunlight irradiation demonstrated the photocatalytic ability of ZnO NPs. 95 percent of the dye could be degraded within 120 min. The study stated that synthesised ZnO NPs can be used for the degradation of dyes from wastewater as photocatalysts.

Ahmad W, et al. [59] proposed using *Euphorbia hirta* leaves extract to synthesise ZnO nanoparticles in a greenway. The leaf extract was used for the synthesis of ZnO nanoparticles from zinc nitrate as a biological reduction agent. Using various analytical and spectroscopic instruments, such as UV visible spectroscopy, Fourier transform infrared spectroscopy (FT-IR), X-ray diffraction (XRD) and scanning electron microscopy (SEM) study, the prepared nanoparticles were characterised. Along with the synthesis and characterization of ZnO nanoparticles, this research uses the disc diffusion approach to test the antimicrobial activity of bio synthesised nanoparticles against clinical and normal strains of *Streptococcus mutans, Streptococcus aureus, Clostridium absonum, Escherichia coli, Arthogrophis cuboida, Aspergillius fumigates,* and *Aspergillius nigar*. Therefore, it is stated that synthesised ZnO NPs may be a potential candidate for various applications related to medicine and biology.

Yedurkar S, et al. [60] focuses on the green synthesis of nanoparticles of zinc oxide by zinc acetate and the use of bio-components of *Euphorbia milii* leaves extract. The zinc oxide nanoparticles prepared were spherical and XRD, FTIR, EDX, DLS, UV-Vis absorption and SEM techniques were used to classify them. The SEM images revealed that the majority of the nanoparticles are spherical and have a diameter of 90-110 nm. The characteristic absorption of zinc oxide bonds is shown by FTIR at 536 cm^{-1}, confirming the formation of zinc oxide nanoparticles. X-ray diffraction confirms the formation at ambient conditions of a hexagonal wurtzite phase, which is the most stable type of zinc oxide. The particle size was 110nm and the polydispersity index was 0.2, suggesting a uniform distribution of nanoparticles in size. 24.64 mV was considered to be the zeta potential. The high value confirms the stability of nanoparticles with zinc oxide. The authors reported that there are many benefits to the green chemistry approach to the synthesis of zinc oxide nanoparticles, such as the ease with which the process can be escalated, economic feasibility, etc. The use in bactericidal wound healing and other medical and electronic applications of such eco-friendly nanoparticles allows this process potentially exciting for large-scale synthesis of other inorganic materials.

The leaves extract of a medicinally essential plant, watercress (*Nasturtium officinale*), was obtained by an ultrasound-facilitated method and used by Bayrami A. et al. [61] for the preparation of ZnO nanoparticles utilizing a joint ultrasound-microwave-assisted technique. SEM, TEM, XRD, EDX, BET, FTIR, TGA, and UV-Vis DRS analyses were used to determine the characteristics of extract enriched nanoparticles (Ext/ZnO) and to compare them with those of ZnO prepared in the absence of extract (ZnO). Several differences between ZnO and Ext/ZnO verified the relation of extract over nanoparticles due to the presence of carbon and carbon bonds, changes in morphology, size, bandgap energy, and weight-decay percentage. To treat alloxan-diabetic Wister rats, Ext/ZnO, watercress leaf extract, ZnO, and insulin therapies were administered and their healing efficacy outcomes were compared to each other. Serum levels of the main diabetic indices, such as insulin, fasting blood glucose and lipid profiles (total triglycerides, total cholesterol and high-density lipoprotein cholesterol) have been calculated for balanced, diabetic and rehabilitated rats with the therapeutic agents tested. The watercress extract-enriched ZnO nanoparticles worked the best and stopped diabetic rats from developing diabetes.

Moreover, the activity of *Staphylococcus aureus* and *Escherichia* coli bacteria was satisfactorily inhibited by both ZnO samples. According to the findings, *Nasturtium officinale* leaf extract will significantly enhance the anti-diabetic and antibacterial activities of ZnO nanoparticles.

Chinnasamy C, et al. [62] applied a green approach using *Costusigneus leaf* extract for the synthesis of zinc oxide nanoparticles. The Costusigneus leaves serve as both a reduction and capping agent and assist in the synthesis of nanoparticles of zinc oxide. By selecting different levels in each parameter using the Design of Experiments L9 orthogonal array, the parameters that affect the yield of the synthesis process are defined and optimised. The results of the characterization support the development of ZnO nanoparticles and the particle size is found to be 31 nm with a spherical shape. Characterization findings from XRD, FTIR, EDX and UV-Vis spectroscopy demonstrated the formation of ZnO nanoparticles.

Santhoshkumar J, et al. [63] synthesised zinc oxide nanoparticles (ZnO NPs) from *Passiflora caerulea* fresh leaf extract and zinc acetate. UV-visible spectroscopy, XRD, FTIR, SEM, EDAX, AFM have characterised the ZnO NPs produced. The size of the particle is found to be 37.67 nm and in cubical form. The study reveals that the green synthesis of multifunctional ZnO NPs using P. caerulea is an inexpensive, eco-friendly and simple process. As compared to plant extract, the synthesised nanoparticles displayed a very strong zone of inhibition against the pathogenic culture.

Sohail MF, et al. [64] was designed to develop, along with multiple biomedical applications, green synthesised zinc oxide nanoparticles (ZnO-NPs) as possible nano-antibiotics against drug-resistant microbes. The developed ZnO-NPs with an average size of 19.57 nm were characterised for zeta potential, crystalline structure using X-ray diffraction, surface morphology using scanning electron microscopy, and FTIR analysis using *Azadirachta indicia* leaf extract when compared to a standard comparison, the ZnO-NPs demonstrated much superior antioxidant and enzyme inhibition activity, with a significantly lower IC50 value. Besides, ZnO-NPs demonstrated substantially greater antibacterial activity against pneumococcal strains resistant to levofloxacin with an IC_{50} value of 0.014 μM compared to 2.048 mM for levofloxacin. Slight changes in liver function tests, especially renal functional tests, were observed in an in vivo acute toxicity study in mice when compared to the control group. No major improvements were shown by full blood analysis. Also, the treatment group's histopathology of vital organs indicated no anatomical changes in major organs. Overall, the results indicated that ZnO-NPs based on the current green synthesised *Azadirachta indicia* leaf could be produced as a therapeutic agent with antioxidant, enzyme inhibition and good antibacterial potential for safe administration against antibiotic-resistant bacteria.

Nano-zinc oxide (nano-ZnO) particles were successfully prepared by an eco-friendly method using plant *Barleria gibsoni* (B. gibsoni) aqueous leaf extract, according to Shao F, et al. [65]. The *B. gibsoni* water leaf extract is responsible for reducing not only the source but also the protective agent. XRD studies showed the hexagonal (wurtzite) structure of the shaped nano-ZnO particles. The TEM analysis confirmed the range between 30 and 80 nm of nanoparticles, which is followed by DLS analysis. When bacterial pathogens were used to test the antibacterial properties of synthesised nano-ZnO particles, the findings were positive. Another tropical antimicrobial formulation for the healing of burn infections serves as an effective and superior nano-ZnO gel. Furthermore, in rats, the nano-ZnO gel had a remarkable wound healing ability.

Green synthesised zinc oxide nanoparticles from methanolic leaf extract of *Glycosmis pentaphylla* were reported by Vijayakumar S, et al. [66]. UV-VIS spectroscopy, fluorescence spectrometer, FT-IR, XRD, SEM with EDAX, and TEM were used to classify the synthesised nanoparticles. The UV-VIS spectrum and photoluminescence spectrum of synthesised nanoparticles were characterised by peaks at 351 and 410 nm, respectively. The functional group of the nanoparticles was discovered using FT-IR analysis. The XRD data revealed the crystalline nature of the nanoparticles and 20.70 percent of the highly pure zinc oxide metal was shown by EDAX measurements. SEM and TEM were used to investigate the morphological characterization of synthesised zinc oxide nanoparticles, which ranged in size from 32 to 36 nm. The antimicrobial activity of the synthesised zinc oxide nanoparticles against pathogenic species was intriguing. Furthermore, this is the first study on leaf mediated synthesis of *Glycosmis pentaphylla* nanoparticles of zinc oxide (ZnO).

Letsholathebe D, et al. [67] has been synthesized zinc oxide (ZnO) using *Moringa Oleifera* leaf extract by hydrothermal method. The XRD patterns of ZnO nanoparticles synthesised were investigated. The wurtzite process is confirmed by the high diffraction peaks found in the sample. The enlargement of diffraction peaks from various polycrystalline aggregates at different crystal sizes. The average particle size was calculated using the

Scherrer equation from the full width at the half maximum (FWHM) of the diffraction peaks. The average particle size of zinc oxide nanoparticles was found to be 25 nm. The UV-vis absorption spectrum shows substantial absorption in the 200-450 nm range (visible light region).

Sharmila G, et al. [68] synthesised zinc oxide nanoparticles (ZnO NPs) using the green method of *Tecoma castanifolia* leaf extract. UV-Vis spectroscopy, TEM, EDAX, XRD and FTIR have been characterised by ZnO NPs. GC-MS studied the phytochemical constituents of *T. castanifolia* leaf extract. UV-Vis absorption revealed a 370-400 nm SPR band, confirming the formation of ZnO NPs. TEM analysis reveals a spherical form with a size of 70-75 nm and the hexagonal step of the wurtzite structure was revealed by XRD results. GC-MS detected the presence of bioactive phytochemical constituents in the methanolic extracts of T. castanifolia. For both Gram-positive and Gram-negative bacteria, excellent antibacterial activity was observed. The antioxidant activity of ZnO nanoparticles was found to increase as the concentration of the nanoparticles increased. Anticancer behaviour with an IC50 value of 65µg/mL with stronger cytotoxic effects of ZnO NPs on A549 cell line proliferation. The study reported that the pharmacologically active compounds present in the green synthesised nanoparticles of ZnO pave the way for their successful use in the delivery systems of biomedical and nano-drugs.

Umavathi S, et al. [69] used *Parthenium hysterophorus* leaf extract to synthesise zinc oxide (ZnO) nanoparticles using green approaches. With a bandgap value of 3.26 eV, the optical property of synthesised ZnO nanoparticles showed UV-vis absorption at 380 nm. The structural analysis of X-ray diffraction reveals the development of ZnO nanoparticles with hexagonal stage structures. Surface morphologies of ZnO nanoparticles are exposed by SEM and TEM analysis, and the majority of them are spherical with a size range of 10 nm. Good antimicrobial activity against both bacterial and fungal strains has been shown in ZnO nanoparticles. *Sesamum indicum's* seed germination and vegetative growth have been significantly enhanced.

As an environmentally friendly approach, Vijayakumar S, et al. [70] reported green synthesis of ZnO nanoparticles using *Acalypha fruticosa* leaf extracts. UV-Visible spectroscopy with a maximum absorbance of 310 nm was used to classify ZnO nanoparticles. The crystalline structure was demonstrated by XRD analysis and the purity of the ZnO nanoparticle was verified by EDAX analysis. The size of the nanoparticles in the range of 50-60 nm was revealed by FE-SEM analysis, and SAED pattern analysed the crystalline nature of the nanoparticles. Also, the green ZnO synthesised nanoparticle has proven to be an excellent antimicrobial agent against pathogenic species.

For the production of zinc oxide nanoparticles, Soni N, et al. [71] used the aqueous leaf extract of *Ficus religiosa* (Peepal). The synthesised nanoparticles were tested against Anopheles stephensi larvae as larvicides. The synthesised nanoparticles were further tested against *Escherichia coli* (gramme negative) and *Staphylococcus aureus* (gramme positive) bacteria as antibacterial agents. The research report revealed that rapid biological synthesis of ZnO NPs using F. religiosa aqueous leaf extract would be an efficient potential larvicide for mosquito control as well as eco-friendly antimicrobial agents.

Zinc oxide nanoparticles have been synthesised by Mirgane NA, et al. [72] from leaves of *Abelmoschus esculentus Linn* using the environmentally friendly green route at room temperature. Various phytochemicals include ladyfinger extract leaves or those used in *Abelmoschus esculentus* (L) for the reduction and stabilisation of ZnONP synthesis agents. The stabilisation of ZnONPs by phytochemicals is stronger, as demonstrated by Fourier-transform infrared spectroscopy. Plant-assisted nanoparticles of zinc oxide display a good 3.37Ev bandgap and have good photocatalytic activity in the UV zone. Plant-assisted ZnO nanoparticles are used under UV light for splitting or cutting or degrading dye. Methylene Blue and Methyl Orange were used as dyes.

Anbuvannan M, et al. [73] identified a simple combination reaction involving zinc nitrate and *Anisochilus carnosus* leaf extract to produce ZnO nanoparticles. The prepared ZnO NPs are crystalline and have a hexagonal wurtzite composition, according to the structural analysis. Besides, the photocatalytic output under UV radiation of the ZnO measured against the methylene blue (MB) dye has substantial photo-degradation. Excellent results were seen in the antibacterial activities of the prepared products analysed against some selected human pathogens.

The zinc oxide nanoparticles derived from *Malus pumila* (apple) and *Juglen regia* (walnut) plant leaves are an appealing area of study, according to Mirza AU, et al. [74], because of their widespread use, low cost, and environmentally friendly approach. The extract's biomaterials are responsible for the capping and

stabilising action. The form, morphology, and particle size are verified using XRD, SEM, and TEM. DLS, on the other hand, confirms the scale of zinc oxide nanoparticles. The compositional analysis of zinc oxide nanoparticles is demonstrated using EDX. The DPPH radical assay measured the scavenging activity and the free radical potential of *Malus pumila* and its mediated zinc oxide nanoparticle is found to be greater than *Juglen regia* and its synthesised nanoparticles of zinc oxide and their activity increases as extract concentration increases. Against both gram-positive and gram-negative bacteria, the plant extracts and nanoparticles are effective antibacterial agents. For cosmetic, biomedical, and pharmaceutical applications, biosynthesized zinc oxide nanoparticles are also useful.

Rajiv P, et al. [75] used a low-cost, environmentally friendly, and easy method to synthesise and characterise zinc oxide nanoparticles from *Parthenium hysterophorus L.* leaf extract. Using different concentrations of 50 percent and 25 percent parthenium leaf extracts, highly stable spherical and hexagonal zinc oxide nanoparticles were synthesised. For nanoparticle conversion, both concentrations of the leaf extract serve as a reducing and capping agent. Analysis of SEM, TEM and EDAX showed that the nanoparticle sizes of spherical and hexagonal zinc oxide were 27±5 nm and 84±2 nm, respectively, and the chemical composition of zinc oxide was present. In 25 lg/ml of 27±5 nm zinc oxide nanoparticles against *Aspergillus flavus* and *Aspergillus niger*, different sized zinc oxide nanoparticles were synthesised and the size-dependent antifungal activity against plant fungal pathogens was studied and the highest inhibition zone was observed. Nanoparticles of Parthenium hysterophorus L. mediated zinc oxide were synthesised and proved to be good antifungal agents and pleasant to the environment.

Zare M, et al. [76] developed a simple synthetic route and growth mechanism for phytochemically stabilised zinc oxide (ZnO) nanoparticles using *Thymus vulgaris* (Thyme) leaf extract using a hydrothermal process. The existence of flavonoids, phenols and saponins in thyme leaf extract has acted as both reducing and stabilising agents that play a critical role in the development of nanoparticles of ZnO. The obtained ZnO nanoparticles have an irregular shape and a size of 50-60 nm. The DPPH assay showed prominent activity (< 75 percent) for higher concentrations (10 mg/ml) of tested ZnO nanoparticles with *in vitro* antioxidant activity. The antimicrobial activity of ZnO nanoparticles against a range of foodborne pathogens showed that the antimicrobial activity of the tested gram-negative bacteria is greater than the antimicrobial activity of the tested Gram-positive bacteria. Results of this study show that phytochemicals containing thyme leaf extract have decreasing properties for the manufacture of ZnO nanosize and the ZnO nanoparticles obtained could be used effectively for biological applications and food science.

Using fresh *Cassia alata* leaf extract, Happy A, et al. [77] investigated the antibacterial activity of green synthesised zinc oxide nanoparticles (ZnO NPs). The successful synthesis of spherical nanoparticles with an average size range of 60-80 nm is validated by the study results. In terms of size and purity, SEM and EDAX data support the results obtained by the XRD pattern. The antibacterial activity of ZnO NPs against *Escherichia coli (E. coli)* was dose-dependent, with an IC_{50} value of about 20 g/mL. In the presence of nanoparticles, growth kinetics research was conducted which demonstrated the bacteriostatic effect of ZnO NPs. For its antibacterial activity, the study recommends the potential use of ZnO NPs in industries such as agricultural, pharmaceutical, food, and cosmetic industries.

Kavya JB, et al. [78] used aqueous leaf extract of *Sida rhombifolia Linn* for biofabrication of ZnO-NPs. The biofabricated ZnO-NPs showed a peak of absorption at 307 nm and a 3.51 eV bandgap energy with a mean size of ~30 nm. The XRD analysis showed stiff narrow peaks, suggesting that the particles were free of impurities, and this was confirmed by the EDS analysis. With a MIC of 0.25 mg mL^{-1} against E. coli, the biofabricated ZnO-NPs exhibited substantial antibacterial activity, compared to 0.5 mg mL^{-1} against *B. subtilis* and *S. typhi*. The study of the live and dead cells of the nanoparticles indicated that the antibacterial activity was due to the damage of the test pathogens to the cell walls. Also, with an IC_{50} of 974.5 μg mL^{-1} and 548.4 μg mL^{-1}, respectively, the nanoparticles also offered important antioxidant and genotoxic properties.

Patil BN, et al. [79] conducted research to synthesise zinc oxide nanoparticles from *Limonia acidissima L.* leaf extract and evaluate their efficacy against *Mycobacterium tuberculosis* development. T A atomic force microscope, X-ray diffraction, and a high-resolution transmission electron microscope were used to validate the shape and scale. The microplate alamar blue assay technique was used to see how these nanoparticles affected M. tuberculosis growth. An absorbance peak at 374 nm confirms the formation of zinc oxide nanoparticles, which are spherical in shape and range in size from 12 nm to 53 nm, according to the UV-visible results. At 12.5

mg/mL, these nanoparticles inhibit M. tuberculosis development. Since it is inexpensive and pollution-free, phytosynthesis of zinc oxide nanoparticles is a green, environmentally friendly technology.

Cui P, et al. [80] reprted a novel concept for the manufacture of zinc oxide nanoparticles (ZnO-NPs) by using an environmentally friendly approach to the extract of *Cinnamon zeylanicum* leaf. The results of the Dynamic Light Scattering (DLS) method and TEM analysis demonstrated the formation of spherical shaped ZnO-NPs with an average size of 20 nm. The capping of ZnO NPs with polyphenols from *Cinnamon zeylanicum* extract was revealed by FTIR and Zeta potential results. Furthermore, the activity of local anaesthesia was tested in frog models, and it was discovered that ZnO NPs is responsible for the important activity of local anaesthesia.

Vidya C, et al. [81] used a green method to make zinc oxide (ZnO) nanoparticles from *Artocarpus Heterophyllus* leaf extract. As stabilising agents, the phytochemicals present in the leaf act. The SEM images revealed agglomerated structures that were porous and sponge-like. TEM analysis showed that the ZnO nanoparticles were formed to have a structure of hexagonal wurtzite and particles ranging from 15-25 nm. The green synthesised ZnO nanoparticles displayed outstanding efficiency of photodegradation (> 80%, 0.24 g/L, 1h) against Rose Bengal dye, a major water pollutant released by the textile industry. The results of the characterization verified that ZnO nanoparticles can be synthesised efficiently using *Artocarpus Heterophyllus* leaf extract as a stabiliser and the results of the photodegradation demonstrated the efficacy of green synthesised ZnO nanoparticles to degrade Rose Bengal dye.

Nava OJ, et al. [82] deals with the low-cost, non-toxic green synthesis of nanoparticles of zinc oxide prepared with various quantities of *Camellia Sinensis* leaf extract. At 618 cm^{-1}, the Zinc Oxide nanoparticles presented the desired Zn-O bond, demonstrated growth in a strictly hexagonal Wurtzite crystal structure, and displayed distinct size and shape homogeneity depending on the quantity of extract used. The photocatalytic activity of the Zinc Oxide nanoparticles obtained has been studied. At a 1:1 molar ratio of methylene blue to zinc oxide nanoparticles under UV light, photocatalytic degradation studies were performed. The results showed a faster rate of decomposition than commercially available Zinc Oxide nanoparticles.

Elumalai K, et al. [83] researched the production of zinc oxide nanoparticles (ZnO NPs) from *Murraya koenigii* leaf extract, using zinc nitrate as a precursor. The crystalline structure was shown by X-ray diffraction (XRD) analysis, and atomic force microscopy (AFM) showed the morphology of the ZnO NPs to be spherical with an average size of 12 nm. The results showed that synthesised ZnO NPs is moderately stable and hexagonal, with a spherical form of less than 100 nm maximum particle size.

Raja A, et al. [84] reported an environmentally friendly green synthesis of Zinc Oxide Nanoparticles (ZnO NPs) using aqueous *Tabernaemontana divaricata* green leaf extract. The existence of a pure hexagonal wurtzite crystalline structure of ZnO is confirmed by XRD pattern analysis, with an average crystallite size of 36.82 nm. The TEM images show the formation of ZnO NPs with sizes varying from 20-50 nm in spherical form. The FTIR study indicates that through the interactions of steroids, terpenoids, flavonoids, phenyl propanoids, phenolic acids and enzymes found in the leaf extract, the ZnO NPs obtained have been stabilised. Compared to the normal pharmaceutical formula, the ZnO NPs demonstrate greater antibacterial activity against *S.aureus* and *E.coli* and less antibacterial activity against *S. Paratyphi*. In 90 minutes with ZnO NPs, almost complete degradation of methylene blue dye occurred. The results show that for bacterial decontamination and industrial dye wastewater treatment, the prepared catalyst will be applicable.

3. CONCLUSION

The synthesis of nanoparticles using traditional physical and chemical methods has some disadvantages, such as critical temperature and pressure conditions, costly and toxic materials, long reaction reflux times, toxic by-products, and so on. In recent years, green nanoparticle synthesis has increased in popularity and has become one of the most popular methods. Green synthesis procedures have many benefits, including simplicity, low cost, good nanoparticle stability, reduced time consumption, non-toxic byproducts, and large-scale synthesis. The review's goal was to provide information on the synthesis of zinc oxide nanoparticles using various plant extracts, as well as their applications in various fields. Several studies have shown that zinc oxide nanoparticles (ZnO NPs) can be produced using a green synthesis method involving a variety of plant leaf extracts. Furthermore, the studies cited here show that these substrates, regardless of their source, act as reducing and stabilising agents or chelating agents. It's worth noting that, in addition to the variations in composition found in biological extracts, variables

including temperature, reaction time, pH, and concentrations have a major effect on the final properties of the synthesised nanoparticles. The concentrations of biological extract and zinc source, as well as the pH of the solution, play a major role in the final properties of ZnO NPs obtained using the green path, according to the literature cited. While evaluating the green synthesis of nanoparticles remains difficult due to the complexity of biological substrates, further research into the mechanism of formation of the biological synthesis of ZnO NPs is required to gain a better understanding of the chemical processes and reactions that occur during the synthesis. It appears that by naming the described mechanism, it will be possible to monitor and optimise the green synthesis process, which is crucial for large-scale ZnO NP development. As a consequence, the rapidly advancing understanding of green synthesis outlined herein indicates that ZnO NPs have tremendous potential for industrial production using biological extracts close to expectations.

Table 1: Green synthesis of zinc oxide nanoparticles reported by different researchers

Plant leaf extract	Zinc source material	*Characterization techniques used	Average size /range (nm)	Shape	Reference
Raphanus sativus var. Longipinnatus leaf extract	Zinc acetate	SEM, TEM, XRD, FTIR, UV-visible	66.43	spherical	[39]
Melia azedarach leaf extract	Zinc nitrate	SEM, TEM, XRD, FTIR, EDAX, UV-visible	33 - 96	hexagonal and spherical	[40]
Typha latifolia.L leaf extract	Zinc chloride	SEM, TEM, XRD, FTIR, EDAX, UV-visible	--	hexagonal wurzite	[41]
Atalantia monophylla leaf extract	Zinc acetate	SEM, TEM, XRD, FTIR, EDAX, FS, UV-visible	30	hexagonal wurtzite	[42]
Ocimum basilicum L. var. purpurascens Benth.-lamiaceae leaf extract	Zinc nitrate	XRD, TEM, EDX	50	hexagonal wurtzite	[43]
Green tea leaf (*Camellia sinensis*) extract	Zinc acetate	SEM, XRD, FTIR, UV-Vis, EIS	54.84	hexagonal wurtzite	[44]
Aloe barbadensis miller leaf extract	Zinc nitrate	SEM, TEM, XRD, FTIR, UV-Vis	25 to 40	spherical	[45]
Azadirachta indica (L.) leaf extract	Zinc nitrate	SEM, XRD, EDAX, FTIR, UV-Vis, PL, FESEM	18	spherical and hexagonal wurtzite	[46]
Juglans regia L. leaf extract	Zinc acetate	XRD, FTIR, UV-Vis, FESEM	--	spherical	[47]
Cassia auriculata leaf extract	Zinc acetate	XRD, EDAX, FTIR, UV-Vis, FESEM, PL	20-30	hexagonal	[48]
Delonix regia leaf extract (Gul Mohar)	Zinc nitrate	SEM, TEM, XRD, FTIR, UV-Vis	20	hexagonal	[49]
Gynostemma pentaphyllum leaf extract	Zinc nitrate	TEM, EDAX, XRD, FTIR, PS	35.41	hexagonal wurtzite	[50]
Cinnamomum Tamala leaf extract	Zinc nitrate	SEM, EDAX, XRD, FTIR, UV-Vis, ZPA	26.57	hexagonal wurtzite	[51]
Alchornea laxiflora leaf extract	Zinc chloride	SEM, EDAX, XRD, FTIR, UV-Vis,	29-38	hexagonal	[52]
Cyanometra ramiflora leaf extract	zinc acetate	SEM, EDAX, XRD, FTIR, UV-Vis, BET	13.33	hexagonal wurtzite	[53]
Cucurbita pepo leaf extract	Zinc acetate	TEM, XRD, FTIR, UV-Vis	8	hexagonal wurtzite	[54]
Aloe socotrina leaf extract	Zinc acetate	SEM, TEM, EDAX, XRD, FTIR, UV-Vis	15 to 50	hexagonal wurtzite	[55]
Mentha pulegium (L.) leaf extract	Zinc nitrate	FESEM, TEM, EDAX, XRD, FTIR, UV-Vis	44.94 n	quasi spherical	[56]
Azadirachta Indica (Neem)	Zinc acetate	SEM, FESEM, EDAX,	20-40	hexagonal	[57]

leaf extract		XRD, FTIR, UV-Vis		wurtzite	
Peltophorum pterocarpum leaf extract	zinc acetate	SEM, FESEM, EDAX, XRD, FTIR, UV-Vis, BET	11.64	hexagonal wurtzite	[58]
Euphorbia hirta leaf extract	Zinc nitrate	SEM, XRD, FTIR, UV-Vis,	20 to 25	hexagonal	[59]
Euphorbia milii leaf extract	Zinc acetate	SEM, EDAX, XRD, FTIR, UV-Vis, DLS, ZPA	90-110	hexagonal wurtzite	[60]
Nasturtium officinale (watercress) leaf extract	Zinc nitrate	SEM, TEM, XRD, EDX, BET, FTIR, TGA, UV-Vis	14-19	hexagonal wurtzite	[61]
Costusigneus leaf extract	Zinc nitrate	SEM, EDAX, XRD, FTIR, UV-Vis	100	spherical	[62]
Passiflora caerulea fresh leaf extract	Zinc acetate	SEM, EDAX, XRD, FTIR, UV-Vis, AFM	37.67	cubic	[63]
Azadirachta indica leaf extract	Zinc sulphate	SEM, XRD, FTIR,	19.57	non-spherical	[64]
Barleria gibsoni leaf extract	Zinc nitrate	TEM, XRD, FTIR, UV-Vis, PL, TGA, DLS	30 -80	hexagonal wurtzite	[65]
Glycosmis pentaphylla leaf extract	Zinc acetate	SEM, TEM, EDAX, XRD, UV-Vis	32 to 36	hexagonal wurtzite	[66]
Moringa Oleifera leaf extract	Zinc nitrate	XRD, FTIR, UV-Vis, PL	25	hexagonal wurtzite	[67]
Tecoma castanifolia leaf extract	Zinc nitrate	SEM,TEM, EDAX, XRD, FTIR, UV-Vis,	70-75	spherical and hexagonal	[68]
Parthenium hysterophorus leaf extract	Zinc nitrate	SEM,TEM, XRD, FTIR, UV-Vis,	5 and 20	spherical and hexagonal	[69]
Acalypha fruticosa leaf extract	Zinc Acetate	SEM,TEM, XRD, FTIR, UV-Vis,	50- 60	hexagonal wurtzite	[70]
Ficus religiosa leaf extract	Zinc nitrate	SEM,TEM, XRD, EDAX, UV-Vis	70.29 to 84.93	spherical and hexagonal	[71]
Abelmoschus esculentus Linn leaf extract	Zinc acetate	SEM,TEM, XRD, EDAX, UV-Vis	20 to 45	spherical	[72]
Anisochilus carnosus leaf extract	Zinc nitrate	FESEM,TEM, XRD, EDAX, FTIR UV-Vis, PL	30 to 40	quasi-spherical	[73]
Malus pumila leaf extract	Zinc acetate	SEM,TEM, XRD, FTIR, EDAX, UV-Vis, DLS	12	spherical	[74]
Juglen regia leaf extract	Zinc acetate	SEM,TEM, XRD, FTIR, EDAX, UV-Vis, DLS	16	spherical	[74]
Parthenium hysterophorus L. leaf extract (25% extract)	Zinc nitrate	SEM,TEM, XRD, FTIR, EDAX, UV-Vis	22- 35	spherical and hexagona	[75]
Parthenium hysterophorus L. leaf extract (50% extract)	Zinc nitrate	SEM,TEM, XRD, FTIR, EDAX, UV-Vis	75-90	spherical and hexagonal	[75]
Thymus vulgaris leaf extract (1 ml extract)	Zinc nitrate	TEM, XRD, FTIR, EDAX, UV-Vis, DLS	46.74	hexagonal wurtzite	[76]
Thymus vulgaris leaf extract (0.5 ml extract)	Zinc nitrate	TEM, XRD, FTIR, EDAX, UV-Vis, DLS	132.54	hexagonal wurtzite	[76]
Cassia alata leaf extract	Zinc acetate	SEM, XRD, FTIR, EDAX, UV-Vis, AFM	60-80	spherical	[77]
Sida rhombifolia Linn leaf extract	Zinc nitrate	SEM, XRD, FTIR, EDAX, UV-Vis,	30	hexagonal wurtzite	[78]
Limonia acidissima L. leaf extract	Zinc nitrate	TEM, XRD, FTIR, EDAX, UV-Vis, AFM	12 to 53	spherical	[79]
Cinnamon zeylanicum leaf	Zinc nitrate	SEM, TEM, XRD,	20	hexagonal	[80]

extract		EDAX, FTIR, ZPA, DLS			
Artocarpus Heterophyllus leaf extract	Zinc nitrate	SEM, TEM, XRD, EDAX, FTIR	15-25	hexagonal wurtzite	[81]
Camellia Sinensis leaf extract	Zinc Nitrate	TEM, XRD, FTIR	9.04 - 17.47	hexagonal wurtzite	[82]
Murraya koenigii leaf extract	Zinc nitrate	FESEM, TEM, XRD, EDAX, FTIR, UV-Vis, AFM	22	hexagonal wurtzite	[83]
Tabernaemontana divaricata leaf extract	Zinc nitrate	SEM, TEM, XRD, FTIR, UV-Vis, TGA	36.82	hexagonal wurtzite	[84]

**Abbreviations' used*

*UV-Visible spectroscopy (UV-Vis); Fourier transform infrared (FTIR); X-Ray diffraction (XRD); Scanning electron microscopy (SEM); Transmission electron microscopy (TEM); Fluorescence spectrometer (FS); Electrochemical impedance spectroscopy (EIS); Photo-luminescence (PL); Field emission scanning electron microscopy (FESEM); Zeta Potential analysis (ZPA); Dynamic light scattering analysis (DLS); Thermo-gravimetric analysis (TGA); Brunauer-Emmett-Teller (*BET*) and Atomic force microscopy (AFM).*

4. REFERENCES

1. Singh RP, Shukla VK, Yadav RS, Sharma PK, Singh PK, Pandey AC. *Adv. Mater. Lett.,* 2011; **2(4)**:313-317.
2. Piccinno F, Gottschalk F, Seeger S, Nowack B. *J. Nanopart. Res.,* 2012; **14**:1109.
3. Sharma D, Sharma S, Kaith BS, Rajput J, Kaur M. *Appl. Surf. Sci.,* 2011; **257(22)**:9661-9672.
4. Agarwal H, Kumar SV, Rajeshkumar S. *Resource-Efficient Technologies*, 2017; **3**:406-413.
5. Pulit-Prociak J, Chwastowski J, Kucharski A, Banach M. *Appl. Surf. Sci.,* 2016; **385**:543-553.
6. Anbuvannan M, Ramesh M, Viruthagiri G, Shanmugam N, Kannadasan N. *Spectrochim. Acta A Mol Biomol. Spectrosc.,* 2015; 143:304-308.
7. Swain PS, Rao SBN, Rajendran D, Dominic G, Selvaraju S. *Anim Nutr.*, 2016; **2**:134-141.
8. Jamdagni P, Khatri P, Rana JS. *J. King Saud. Univ. - Sci.,* 2018; **30**:168-175.
9. Moghaddam AB, Moniri M, Azizi S, Rahim RA, Ariff AB, Saad WZ, et al. *Molecules*, 2017; **22**:1-18.
10. Sahoo A, Swain R, Mishra SK. *Int. J. Adv. Res.,* 2014; **2:**828-837.
11. Arasu T. *J. Biosci. Res.,* 2010; **1**:259-270.
12. Vitor G, Palma TC, Vieira B, Lourenço JP, Barros RJ, Costa MC. *Miner. Eng.,* 2015; **75**:85-93.
13. Imtiaz M, Shahzad T, Shahid M, Ismail IMI, Mustafa G, Almeelbi T. *J. Hazard. Mater.,* 2017; **324**:298-305.
14. Vidya C , Hiremath S, Chandraprabha MN, Antonyraj MAL, Gopala IV, et al.. *Int J Curr Eng Technol.,* 2013; **1**:118-120.
15. Afifi M, Almaghrabi OA, Kadasa NM. *Biomed. Res. Int.,* 2015; **2015**:153573.
16. Chen J, Liu X, Wang C, Yin SS, Li XL, Hu WJ, et al. *J. Haz ard. Mater.,* 2015; **297**:173-182.
17. Vitosh BML, Warncke DD, Lucas RE. *Ext. Bull.,* 1994; **E-486:**18-31.
18. Chandrasekaran R, Gnanasekar S, Seetharaman P, Keppanan R, Arocki- aswamy W, Sivaperumal S. *J. Mol. Liq.*, 2016; **219**:232-238.
19. Dhandapani P, Siddarth AS, Kamalasekaran S, Maruthamuthu S, Rajagopal G. *Carbohydr. Polym.,* 2014; **103**:448-455.
20. Mitra S, Patra P, Pradhan S, Debnath N, Dey KK, Sarkar S, et al. *J. Colloid. Interface Sci.,* 2015; **444**:97-108.
21. Yuvakkumar R, Suresh J, Saravanakumar B, Joseph Nathanael A, Hong SI, Rajendran V. *Spectrochim. Acta A Mol. Biomol. Spectrosc.*, 2015; **137**:250-258.
22. Kumari B, Sharma S, Singh N, Verma A, Satsangi VR, Dass S, et al. *Int. J. Hydrogen Energy*, 2014; **39**:18216-18229.
23. Abdul H, Sivaraj R, Venckatesh R. *Mater. Lett.,* 2014; 131:16-18.
24. Yuvakkumar R, Suresh J, Nathanael AJ, Sundrarajan M, Hong SI. *Mater. Sci. Eng. C.,* 2014; **41**:17-27.
25. Auld DS. *Biometals,* 2001; **14**:271-313.
26. Holmes JD, Lyons DM, Ziegler KJ. *Chem. - A Eur. J.*, 2003; **9**:2144-2150.
27. Zong Y, Li Z, Wang X, Ma J, Men Y. *Ceram. Int.,* 2014; **40**:10375-10382.
28. Dobrucka R, Długaszewska J, *Saudi J. Biol. Sci.*, 2016; **23**:517-523.
29. Anbuvannan M, Ramesh M, Viruthagiri G, Shanmugam N, Kannadasan N. *Spectrochim. Acta A Mol. Biomol. Spectrosc.*, 2015; **143**:304-308.
30. Jayaseelan C, Rahuman AA , Kirthi AV, Marimuthu

S, Santhoshkumar T, Bagavan A, et al. *Spectrochim. Acta A Mol. Biomol. Spectrosc.*, 2012; **90**:78-84.
31. Mirzaei H, Darroudi M. *Ceram. Int.,* 2017; **43**:907-914.
32. Wodka D, Bielaníska E, Socha RP, Elzbieciak-Wodka M, Gurgul J, Nowak P, et al. *ACS Appl. Mater.Interfaces.,* 2010; **2**:1945-1953.
33. Sangani MH, Moghaddam MN, Mahdi M. *Nanomed. J.,* 2015; **2**:121-128.
34. Ma H, Williams PL, Diamond SA. *Environ. Pollut.*, 2013; **172**:76-85.
35. Vimala K, Sundarraj S, Paulpandi M, Vengatesan S, Kannan S. *Process Biochem.*, 2014; **49**:160-172.
36. Nagajyothi PC, Sreekanth TVM, Tettey CO, Jun YI, Mook SH. *Bioorg. Med. Chem. Lett.*, 2014; **24**: 4298-4303.
37. Rajeshkumar S. *Resour. Technol.*, 2016; **2**:30-35.
38. Rajeshkumar S, Malarkodi C, Paulkumar K, Vanaja M, Gnanajobitha G, Annadurai G. *Int. J. Met.,* 2014; **2014**: 1-8.
39. Umamaheswari A, Lakshmana Prabu S, Adharsh John S, Puratchikody A. *Biotech. Repor.*, 2021; **29**: e00595.
40. Dhandapani KV, Anbumani D, Gandhi AD, Annamalai P, Muthuvenkatachalam BS., et al. *Biocatalysis and Agricultural Biotechnology,* 2020; 24: 101517.
41. Kumar BP, Arthanareeswari M, Devikala S, Sridharan M., Selvi JA, Malini TP. *Materials Today: Proceedings,* 2019; **14**:332-337.
42. Vijayakumar S, Mahadevan S, Arulmozhi P, Sriram S, Praseetha PK. *Mater. Sci. in Semic. Process.,* 2018; **82**:39-45.
43. Abdul Salam H, Sivaraj R, Venckatesh R. *Mater. Lett.,* 2014; **131**:16-18.
44. Dhanemozhi AC, Rajeswari V, Sathyajothi S. *Mater. Today: Proceed.,* 2017; **4(2)**:660-667.
45. Sangeetha G, Rajeshwari S, Venckatesh R. *Mater. Res. Bullet.,* 2011; **46(12)**:2560-2566.
46. Elumalai K, Velmurugan S. *Appl. Surf. Scien.,* 2015; **345**:329-336.
47. Darvishi E, Kahrizi D, Arkan E. *J. of Molecular Liqui.,* 2019; **286**:110831.
48. Ramesh P, Saravanan K, Manogar P, Johnson J, Vinoth E, Mayakannan M. *Sens. and Bio-sens. Res.*, 2021; **31**:100399.
49. Begum JPS, Manjunath K, Pratibha S, Dhananjaya N, Sahu P, Kashaw S. *J. of Science: Advan. Mater. and Devices,* 2020; **5(4)**:468-475.
50. Park JK, Rupa EJ, Arif MH, Li JF, Anandapadmanaban G, et al. Optik 2021;**In press**:166249.
51. Agarwal H, Nakara A, Menon, S, Shanmugam V. *J. of Drug Deli. Sci. and Tech.,* 2019; **53**:101212.
52. Ekennia A., Nwaji N, Udeagwu D, Olowu O, Nwanji O, Oje O, et al. *Micron,* 2021;**141**:102964.
53. Varadavenkatesan T, Lyubchik E, Pai S, Pugazhendhi A, Vinayagam R, Selvaraj R. *J. of Photochem. and Photobio. B: Biology*, 2019; **199**:111621.
54. Hu D, Si W, Qin W, Jiao J, Li X, Gu X, Hao Y. *J. of Photochem. and Photobio. B: Biology*, 2019; **195**:12-16.
55. Fahimmnisha B, Ishwarya R, AlSalhi MS, Devanesan S, Govindarajan M, Vaseeharan B. *J. of Drug Deliv. Sci. and Tech.,* 2020; **55**:101465.
56. Rad SS, Sani AM, Mohseni S. *Microbial Pathogenesis.* 2019; **131**:239-245.
57. Singh A, Neelam, Kaushik M. *Results in Physics*, 2019; **13**:102168.
58. Pai S, Sridevi H, Varadavenkatesan T, Vinayagam R, Selvaraj R. *Optik.,* 2019; **185**:248-255.
59. Ahmad W, Kalra D. *J. of King Saud Univer. –Science,* 2020; **32**:2158-2164.
60. Yedurkar SM, Punjabi KD, Maurya CB, Mahanwar PA. *Materials Today: Proceed.,* 2018; **5(10)**: 22561-22569.
61. Bayrami A, Ghorbani E., Pouran SR, Aziz H-Y, Khataee A, Bayrami M. *Ultrasonics Sonochem.,* 2019; **58**: 104613.
62. Chinnasamy C, Tamilselvam P, Karthick B, Sidharth B, Senthilnathan M. *Materials Today: Proceed.,* 2018; **5(2)**:6728-6735.
63. Santhoshkumar J, Kumar SV, Rajeshkumar S. *Resource-Efficient Technologies,* 2017; **3(4):**459-465.
64. Sohail MF, Rehman M, Hussain SZ, Huma Z, Shahnaz G, et al. *J. of Drug Deliv. Sci. and Tech.,* 2020; **59**:101911.
65. Shao F, Yang A, Yu DM, Wang J, Gong X, HX. *J. of Drug Deliv. Sci. and Tech,* 2018; **189**:267-273.
66. Vijayakumar S, Krishnakumar C, Arulmozhi P, Mahadevan S, Parameswari N. *Microbial Pathogenesis,* 2018;**116**:44-48.
67. Letsholathebe D, Thema FT, Mphale K, Maabong K, Magdalane MC. *Materials Today: Proceed,* 2021; **36(2)**:475-479.
68. Sharmila G, Thirumarimurugan M, Muthukumaran C. *Microchemical J.,* 2019; **145**:578-587
69. Umavathi S, Mahboob S, Govindarajan M, Al-Ghanim KA, Ahmed Z, et al. *Saudi J. of Bio. Sci.*

2020:**In press**: https://doi.org/10.1016/j.sjbs.2020.12.025.

70. Vijayakumar S, Arulmozhi P, Kumar N, Sakthivel B, Prathip Kumar S, Praseetha PK. *Materials Today: Proceed,* 2020;**23(1)**:73-80.
71. Soni N, Dhiman RC. *Parasite Epidemiology and Control*, 2020; **11**:e00166.
72. Mirgane NA, Shivankar VS, Kotwal SB, Wadhawa GC, Sonawale MC. *Materials Today: Proceed.,* 2021; **37(2):**849-853.
73. Anbuvannan M, Ramesh M, Viruthagiri G, Shanmugam N, Kannadasan N. *Mater. Sci. in Semicond. Process.,* 2015; **39**:621-628.
74. Mirza AU, Kareem A, Nami SAA., Bhat SA, Mohammad A, Nishat N. *Microbial Pathogenesis,* 2019;**129**:233-241.
75. Rajiv P, Rajeshwari S, Venckatesh R. *Spectrochimica Acta Part A: Molecular and Biomol. Spectro,* 2013; **112**:384-387.
76. Zare M, Namratha K, Thakur MS, Byrappa K. *Materials Research Bulletin,* 2019; **109**:49-59.
77. Happy A, Soumya M, Venkat Kumar S, Rajesh kumar S, David Sheba R, et al. *Biochem. and Biophys. Reports*, 2019; **17**:208-211..
78. Kavya JB, Murali M, Manjula S, Basavaraj GL, Prathibha M, et al. *J. of Drug Delivery Sci. and Tech.,* 2020; **60**:101982.
79. Patil BN, Taranath TC. *Inter. J. of Mycobacter.,* 2016; **5(2)**:197-204.
80. Cui P, Li J, Ma G. *J. of Drug Deliv. Sci. and Tech.,* 2020; **57:**101740.
81. Vidya C, Chandra Prabha MN, Antony Raj MAL. *Environ. Nanotech. Monitor. & Managem.,* 2016; **6**:134-138.
82. Nava OJ, Luque PA, Gómez-Gutiérrez CM, Vilchis-Nestor AR, Castro-Beltrán A. *J. of Molecul. Struct.,* 2017; **1134**:121-125.
83. Elumalai K, Velmurugan S, Ravi S, Kathiravan V, Ashokkumar S. *Mater. Scien. in Semicond. Process.,* 2015; **34**:365-372.
84. Raja A, Ashokkumar S, Pavithra Marthandam R, Jayachandiran J, Khatiwada CP, et al. *J. of Photochem. and Photobio. B: Biology*, 2018; **181**:53-58.

Jordan Journal Of Physics

Structural and Electrical Studies of Aluminium-doped Nickel-Cobalt Ferrite Nanoparticles

S. P. Waghmare[a], D. M. Borikar[a], M. A. Borikar[b] and K. G. Rewatkar[c]

[a] *Department of Chemistry, Dr. Ambedkar College, Deekshabhoomi, Nagpur, India.*

[b] *Department of Chemistry, St. Vincent Palloti College of Engg.& Tech., Nagpur, India.*

[c] *Department of Physics, Dr. Ambedkar College, Deekshabhoomi, Nagpur, India.*

Corresponding Author: D. M. Borikar **Email: drdmborikar@gmail.com**

Doi: https://doi.org/10.47011/15.1.4

Cited by : **Jordan J. Phys., 15 (1) (2022) 29-36**

PDF

Received on: 01/08/2020; 29/6/2021 *Accepted on:*

Abstract: Aluminium-doped Nickel-Cobalt ferrite nanoparticles with general formula $Ni_{0.5}Co_{0.5}Al_xFe_{2-x}O_4$ (x = 0 and x = 0.5) were synthesized by microwave-assisted sol-gel auto-combustion method. The X-ray diffraction analysis of the samples confirms single phase with cubic spinel structure belonging to space group Fd3m. The average crystallite size calculated using Debey-Scherrer formula was found to be in the range of 19-36 nm. XRD studies revealed that the lattice parameter (a), the particle size (D) and X-ray density (d_x) decrease, whereas porosity increases with Al substitution. Energy Dispersive X-ray (EDX) was used to confirm the elemental composition of synthesized powders. TEM micrograph suggests that the particle size is in nanometric range, which confirms the nanocrystalline nature of the samples. The electrical resistivity and dielectric constant have been studied as functions of temperature. It was observed that the electrical resistivity decreases with increasing temperature, exhibiting the semiconducting nature of the sample. The dielectric constant increases with increase in temperature up to transition temperature and then decreases, which is explained on the basis of hopping mechanism.

Keywords: Ni-Co ferrites, Sol-Gel, XRD, Resistivity, Dielectric constant.

References

[1] Dabagh S., Ati A., Ghoshal S. K., Zare S., Roshan R. M., Jbara A. and Othaman Z., Bull. Mater. Sci., 39(2016) 1029.

[2] Patil R. P., Delekar S. D., Mane D. R. and Hankare P. P., Results in Physics, 3 (2013)129

[3] Lakshmi M., Kumar K. V. and Thyagarajan K., Advances in Nanoparticles, 5 (2016)103.

[4] Khan S. B., Irfan S. and Long Lee S., Nanomaterials, 9 (1024) (2019) 1.

[5] Bawoumi W., J. Mater. Sci., 42 (2007)8254.

[6] Kumar K. V., Paramesh D. and Reddy P. V., World Journal of Nano Science and Engineering, 5 (2015)68.

[7] Singh H. S., Sangwa N. and Chauhan R., International Journal of Scientific and Engineering Research, 6 (12)(2015)765.

[8] Venkattesha M., Kumara G. S., Vijia S., Karthib S. and Girijab E. K., Modern Electronic Materials, 2 (2016)74.

[9] Cullity B. D., "Elements of X-ray Diffraction", 2rd edition, (Addsion-Wesley Publishing Company, 1978).

[10] Denton A. R. and Ashcroft N.W., Vedard's Law, Physics Review, A 43 (1991)3161.

[11] Birajdar A. A., Shirsath S. E., Kadam R. H., Mane M. L. and Shitre A. R., Journal of Applied Physics, 112 (2012)053908.

[12] Ladgaonkar B. P. and Vaigainkar A. S., Materials Chemistry and Physics, 56 (3) (1998)280.

[13] Narasimhan C. S. and Swamy C. S., Physica Status Dolidi (a), 59 (1998)817.

[14] Sathish Kumar G., Venkataraju C. and Sivakumar K., Materials Sciences and Applications, 1(2010) 19.

[15] Amirabadizadeh A. and Amirabadi T., World Journaul of Condensed Matter Physics, 3 (2013)131.

[16] Arvind G. and Aranind D., Int. Journal of Engineering Research and Applications, 3 (6)(2013)1414.

[17] Paramesh D., Kumar K. V. and Reddy P. V., Processing and Applications of Ceramics, 10 (3)(2016)161.

[18] Lakshmi M., Kumar K. V. and Thyagarajan K., Journal of Nanostructure Chemistry, 5 (2015)365.

[19] Bhavikatti A. M. and Mugli M., Proceedings of NCRIET-2015 & Indian Journal Science Research, 12 (1)(2015)232.

[20] Verwey E. J. W., Haayman P. W. and Romeijn C.W., J. Chem. Phys.,15 (1947)181.

[21] Li L.-Z., Zhong X.-X., Wang R., Tu X.-Q., He L., Guob, R. D. and Xu,Z.-Y., RSC Advances, 7 (2017)39198.

[22] Wang Y. Z., Qiao G. W., Liu X.D., Ding B. Z. and Hu, Z. Q., Mater. Lett., 17(1993)152.

[23] Waghmare S. P., Kakde A. S., Sisyawar A. C., Borikar D. M. and Rewatkar K. G., International Journal of Researchers in Bioscience, Agricultural & Technology, Special Issue (2) (2015) 2347.

[24] Mohan G. R., Ravinder D., Ramana Reddy A. V. and Boyanov B. S., Materials Letters, 40 (1999)39.

[25] Vara Prasad B. B.V. S., J. Theor. Appl. Phys., 9 (2015)267.

A Study of Covid -19 Pandemic Relief Package and Government Policy Stance Impact on Financial Inclusion through PMJDY.

Mrs. Shefali Rai
Research Scholar, Hislop College, Nagpur (M.S.), India.
Email: shefalirai29@gmail.com

Dr. Dini Menon
Assistant Professor, Hislop College, Nagpur (M.S.), India.
Email: dini2021@gmail.com

Abstract

When a pandemic as disastrous as Covid -19 hits any country and its economy, it is evident from the experience that it's the weaker sections that become severe victims. The reason being lack of buffer savings and safety assets to get through. In the case of India, major part of the economy got disrupted, migration of labour back to homes without transport facilities and resources was a disheartening situation. Similarly daily wage workers lost their income sources. Surprisingly there was a sudden increase in enrolment in PMJDY. The reason being government's record-breaking relief package. PMJDY became the hull bearing scheme of it, as major benefits of the package were channelized through it. Be it support transfers to farmers for promoting agricultural growth during cropping season through PM-KISAN or transfers to women account holders in tranches under PMGKY. Majority of the DBT's were routed through PMJDY. The scheme has been active since six years now and continued under the aegis of National Strategy for Financial Inclusion, however its importance has been highlighted in the pandemic .The paper studies the fluctuations in PMJDY accounts and balances after Covid-19 pandemic and the reasons of increase or decrease in accounts and balances due to various government policy stances related to relief package.

Keywords: Covid-19 Pandemic, Relief Package, Government Policy, Financial Inclusion, Pradhan Mantri Jan Dhan Yojana, Direct Benefit Transfers.

Introduction

India being the world's largest democracy and second largest population has serious implications of Covid-19 pandemic. Whether it has fared well or not, everyone has different perspectives. But on the bright side many of the developed nations appreciated the efforts, measures and controls taken by the Indian government to minimise the spread of disease. India being many times the population of several developed nations but showed commendable slow growth rates of spread in disease. On the other side the economy took a deep dive.70% of the economic activity in India was stopped as per State Bank of India (SBI), Eco-wrap report.

The relief package offered by the government for covid was a whopping 20 lakh crore which has increased the fiscal burden as well on the state. One of the engine drivers of this package was the national scheme of financial inclusion that is PMJDY. It has almost become mandatory for all who want benefits or transfers from the government to open Jan Dhan accounts. The e-Public financial management systems (e-PFMS) system and Direct Benefit transfer (DBT) tracking online helps in reducing the leakages and increasing the transparency in distribution of funds. But how much is enough, is a big question which all policy makers face while allocating such resources.

Review of Literature

(Credit delivery and financial inclusion, annual report. RBI,2011) according to RBI definition "Financial inclusion broadly refers to the process of ensuring access to appropriate financial products and services needed by vulnerable groups such as the weaker sections and low-income groups at an affordable cost, in a fair and transparent manner by mainstream institutional players" (RBI,2011).

*(*A National Mission on Financial Inclusion, Mantri, P., & Yojana, J.-D. 2014) in this document all details, phases and implementation strategies regarding PMJDY are stated which helps to understand how various features will help in achieving the national mission of Financial Inclusion.

(Accelerating India's COVID-19 Social Protection Response Program, The World Bank Report ,2020) in this report prepared by world bank team it is stated how Indian state and national government can deal with the pandemic situation by developing policies, actions and funds to deal with the situation. It also states the breakup of $2.5 billion aid given by world bank for Covid-19 Health care, social protection and economic stimulus.

(Role of public sector banks towards financial inclusion during pre and post introduction of PMJDY: a study on efficiency review, Maity, S. and Sahu, T.N. 2020) in this research paper the authors have analysed data of financial inclusion through public sector banks with empirical approach . The efficiency level pre and post introduction shows variation and even among different public sector banks.

(The COVID-19 Pandemic and Internal Labour Migration in India: A 'Crisis of Mobility', Irudaya Rajan, S., Sivakumar, P. & Srinivasan A.,2020) in this study the various aspects of labour migration and eventual traumatic situations faced are analysed and a roadmap for inclusive migrant policies is shared which covers employment, governance , health and social protection.

(Policy response to the economic challenge from COVID-19 in India: A qualitative enquiry, Gagan Deep Sharma, Gaurav Talan and Mansi Jain,2020) the study proposes a better coordination among third world countries and developed nations for cooperation in economic growth and public health. It also analyses the policies taken up by the government post covid and

suggests various measures based on sentiment analysis to policymakers to handle the pandemic situation better.

(Social Policy, COVID-19 and Impoverished Migrants: Challenges and Prospects in Locked Down India, Sohini Sen Gupta and Manisha K. Jha,2020) this study covers the tragedy of migrant workers and massive scale displacement, unemployment and insecurity faced by them. It analyses the various policy measures of the government for giving them mobility and at what level new interventions are required.

Objectives of Research Paper:

- To study the growth and trends of financial inclusion scheme Pradhan Mantri Jan Dhan Yojana(PMJDY) in post COVID-19 scenario.
- To study the change in total number of Beneficiaries and total account deposits in Pradhan Mantri Jan Dhan Yojana(PMJDY) in post COVID-19 scenario.

Research Methodology:

The study is based on secondary data which will be based on Government reports, reputed Journals, Research Paper, Magazines, Newspapers, Internet and Banking bulletin including RBI Bulletin and magazines.
Several websites used for vital data collection were:

- Ministry of Finance (Department of Financial Services): http://www.finmin.nic.in/
- Ministry of Expenditure |MOF | GOI : https://doe.gov.in/
- Pradhan Mantri Jan Dhan Yojana : pmjdy.gov.in
- Reserve Bank of India https://rbi.org.in/
- Open Government Data (OGD) Platform India :data.gov.in
- World Bank's Accelerating India's COVID-19 Social Protection Response Program : https://projects.worldbank.org/en/projects-operations/project-detail/P173943
- Public Finance Management System : pfms.nic.in
- Direct Benefit Transfer :https://dbtbharat.gov.in/scheme/scheme-list

Data Analysis and Interpretation:

Table 1 and Table 2 vertically state the total number of accounts opened under PMJDY with Public Sector Banks (PSBSs), Private Banks (PBs) and Regional Rural Banks (RRBs). Horizontally the tables also show the Number of Beneficiaries at rural/semi urban center bank branches, Number of Beneficiaries at urban metro center bank branches, Number of Total Beneficiaries, Deposits in Accounts and Number of Rupay Debit Cards issued to beneficiaries.

It can be seen that the range of trust among beneficiaries in opening PMJDY accounts with banks is highest for Public Sector Banks followed by Regional Rural Banks and least for Private Sector Banks. (PIB,2016)

Table 1:

Bank Category wise Report as on 26/02/2020

Bank Name / Type	Number of Beneficiaries at rural/semi urban center bank branches	Number of Beneficiaries at urban metro center bank branches	Number of Total Beneficiaries	Deposits in Accounts (In lac)	Number of Rupay Debit Cards issued to beneficiaries
Public Sector Banks	163988513	139984639	303973152	9207178.93	244484896
Regional Rural Banks	54278195	11019486	65297681	2106882.78	35734878
Private Sector Banks	6980325	5582295	12562620	316272.39	11526881
Grand Total	225247033	156586420	381833453	11630334.10	291746655

Source: www.pmjdy.gov.in

Table 2:

Bank Category wise as on 24/02/2021

Bank Name / Type	Number of Beneficiaries at rural/semi urban center bank branches	Number of Beneficiaries at urban metro center bank branches	Number of Total Beneficiaries	Deposits in Accounts (In lac)	Number of Rupay Debit Cards issued to beneficiaries
Public Sector Banks	203434616	128274165	331708781	10793441.16	262775252
Regional Rural Banks	65719758	9330346	75050104	2681442.88	34134802
Private Sector Banks	6817608	5690954	12508562	415280.65	11253266
Grand Total	275971982	143295465	419267447	13890164.69	308163320

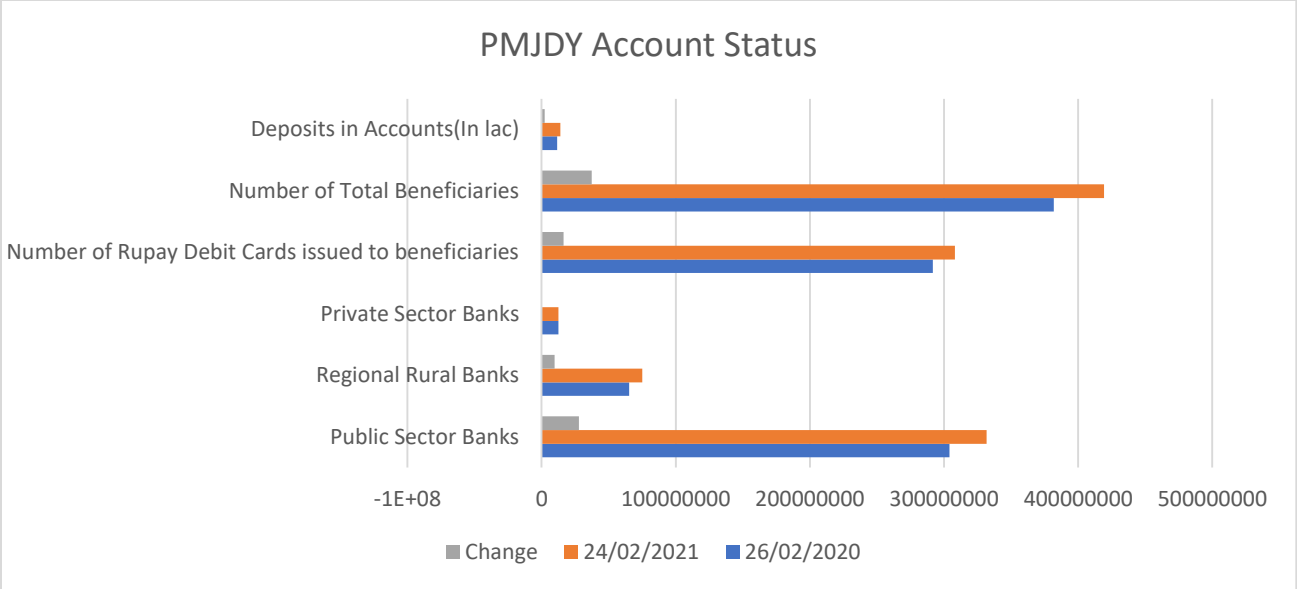
Source: www.pmjdy.gov.in

Table 3:

Analysis of change from Feb 2021(post covid, latest data available) to Feb 2020(Pre covid) under PMJDY

Category	**Status as on 26/02/2020**	**Status as on 24/02/2021**	**Change (Increase in Accounts in lacs)**	**% Change**
Public sector bank accounts	303973152	331708781	27735629	9.124368%
Regional rural bank accounts	65297681	75050104	9752423	14.93533%
Private sector bank accounts	12562620	12508562	-54058	-0.43031%
Number of Total Beneficiaries	381833453	419267447	37433994	9.803749%
Number of Rupay Debit Cards issued to beneficiaries	291746655	308163320	1641665	5.627028%
Deposits in Accounts	11630334.10	13890164.69	2259831	19.43049%

Figure 1: PMJDY accounts status pre and post covid



Source: Secondary data collected from www.pmjdy.gov.in

Table 3 analyses the change in number of accounts opened under various banks, deposits in accounts and Rupay cards issued from Feb 2020 (pre COVID-19) to Feb 2021(post COVID-19).

The total number of accounts of beneficiaries has been increased by3.74 crores that is 9.80 percent change, number of accounts with Public Sector Banks have increased by 2.77 crores that is 9.12 percent change, Regional Rural Banks have increased by 97.52 lacs that is 14.93 percent change and Private Sector banks have in fact decreased by 54058 accounts that is 0.43 percent change. Number of Rupay cards has also increased 1.64 crores that is by 5.63 percent. Increase in total accounts deposits has also been 22,59,831 lakhs which amounts to 19.43 percent change.Figure 1 depicts the changes in bar diagram format for comparison. These changes are surmounting and are indicative of several changes during lockdown.

Reasons for increase in accounts:

The increase in total number of accounts of beneficiaries of 3.74 crores is massive and can be due to ups and downs the Indian economy has gone under lockdown and post covid era. Some of them identified for the purpose of this research were:

1. Return of Migrant labour back to villages.

After the announcement of lockdown of 21 days by the government on 24th March ,2020 around 138 crores of population of India were limited to any movement. However, the hardest hit were the labours working in industries, construction and workplaces away from their homes. They faced a lot of uncertainty of income, livelihood and shortages in food supply. The government announced a 20-lakh crore relief package of which many transfers were to be made through PMJDY accounts, hence after a lot of struggles when migrants reached their home, they immediately enrolled for these accounts to get relief funds.

2. Increased Unemployment allowances under MGNREGA.

Many of the labour who were displaced also enrolled for governments "right to work" scheme Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) wherein wages were increased from Rs 182 to Rs 202 a day for beneficiaries,(Ministry of Finance, 2020).

3. DBT transfers to Women accountholders of PMJDY under Pradhan Mantri Garib Kalyan Yojana (PMGKY) scheme.

Under PMGKY wherein women account holders were granted a total amount of Rs1500 to be given in their PMJDY accounts in three consecutive months with Rs500 payment in each month. This could also be tracked by the beneficiaries through the Public Financial Management System (E-PPFMS) platform which amounted to 30,705 crores in the period of April to June 2020 .

This led to many women opening new accounts under the scheme as reported by some bankers as well.

4. DBT transfers to farmers holding PMJDY accounts under Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme.

Under Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) farmers were granted a total amount of Rs 6000 to be given in their PMJDY accounts in three consecutive tranches of Rs 2000 payment in each tranche. This led to around 19,000 crores transfers to farmers in the period of March to May 2020.

5. More publicity of PMJDY scheme during pandemic due to DBTs.

A lot of media coverage of various direct benefit transfers and covid 19 relief package led to more and more people to enrol for the PMJDY scheme in hope that they will receive these funds as well. Some inefficiencies were also reported wherein people in spite of having PMJDY could not either access it due to lockdown situations or their DBTs were not received at all. However due to various propaganda around the covid turmoil did help in encouraging more people to open their accounts under PMJDY.

6. New Employee Provident Fund subscribers and New payroll entrants.

Some other reasons apart from lockdown may also be an increase in new first time payroll entries and new EPF subscribers. Seeing the popularity of the scheme many are opening Basic Savings Bank Account (BSBA) also with PMJDY scheme wherein higher transactions are also permitted.

Fluctuations in PMJDY Total Account Deposits during 18th March-10th June

As per the data collected from the government records and shown in table 4 it was found that the total balance of accounts in PMJDY accounts fluctuated on a regular basis after lockdown that is post covid era. Earlier to it in the last two weeks of March it was stable. But after the first week of April started rising dramatically by increasing from 11968086.12 lacs on 1st April to 13356423.3 lacs on 15th April. It again started taking a dip and reached up to 12962570.38 lacs on 29th April. Then again it started rising and reached up to 13588394.63 lacs on 13th May from where it again started dropping reaching to 13133959.04 on 3rd June. This cycle again continues

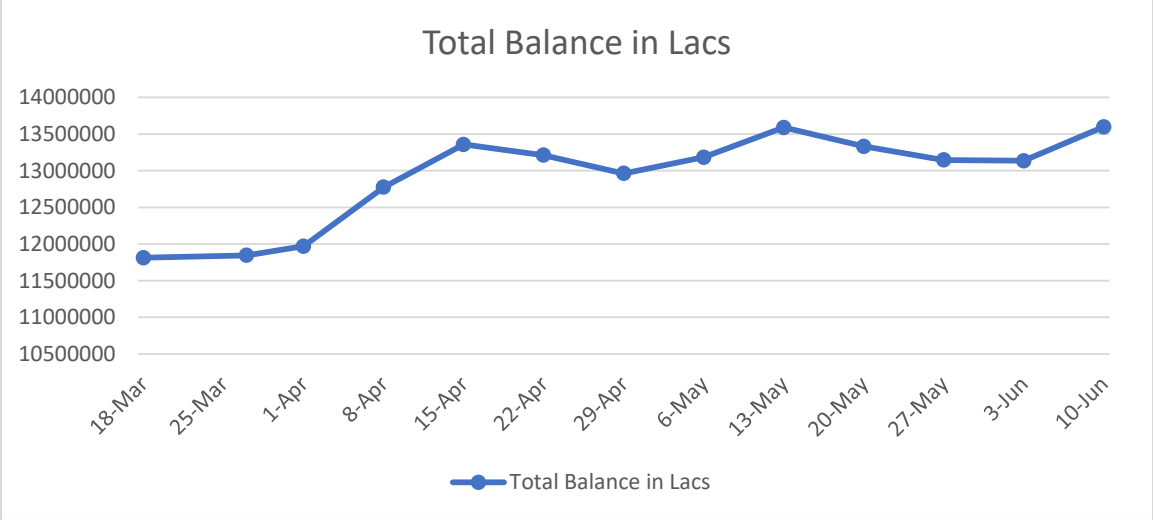
to rise up to 13597751.79 lacs on 10th June. From these patterns we can see that prior to lockdown announcement the growth was minimal in account deposits, however we can see a sudden surge along with relief package announcements in the first three weeks of April. This was also the time when women PMJDY account holders were given the first tranche of PMGKY which as per Ministry of Finance was around 10,025 crores and farmers had started receiving PM-KISAN tranches as well. Then we can see reducing account deposits in the latter two months of April which might be due to withdrawal of these relief packages by beneficiaries and its consumption. Similar pattern can be seen in May where the total accounts balance reaches its highest point of 13588394.63 lacs on 13th May and falling back to the levels of balances in April and finally coming back to almost similar level on 10th June at 13597751.79 lacs. So, we can see a withdrawal of 3000-4000 crores in between and a total increase of 17,871 crores in this whole period.

Table 4: PMJDY total account balances from 18th March to 10th June,2020

Date	Total Balance in Lacs	Date	Total Balance in Lacs
18-Mar	11810597.02	6-May	13182548.54
27-Mar	11843440.69	13-May	13588394.63
1-Apr	11968086.12	20-May	13331790.64
8-Apr	12774842.87	27-May	13144534.65
15-Apr	13356423.3	3-Jun	13133959.04
22-Apr	13211817.07	10-Jun	13597751.79
29-Apr	12962570.38		

Source: www.pmjdy.gov.in

Figure 2: Fluctuations PMJDY total account balances from 18th March to 10th June



Source: Secondary data collected from www.pmjdy.gov.in

Reasons for fluctuation (increase/decrease) in PMJDY account deposits

The reasons for these patterns and fluctuations can be due to following reasons:

1. **Increase in DBT transfers due to the relief package announced.**

Being the biggest stimulus package in the history of India and supported by international institutions like the world bank and many of its benefits being channelled through this national mission of financial inclusion PMJDY scheme. It is bound to have an impact on the account deposits by increasing it.

2. **Labour remittances through PMJDY accounts due to COVID-19 scenario.**

Due to the sudden lockdown many people and labour were stranded at places away from homes. So that leads to remittances to their families, most of them in rural areas having PMJDY accounts. This was also one of the reasons for increase in accounts deposits.

3. **Unemployment, uncertainty and Migration.**

Due to the loss of livelihood for several people, the future became uncertain with the whole economy slowing down. Further closure of many small businesses for a long period of time led to unemployment or lower salaries with various deductions. This made many beneficiaries vary of the circumstances leading to putting up precautionary savings in accounts for future use which may be required for health care to deal with pandemic.

4. **More consumption of savings.**

Displacement from work places and travelling back to homes for migrants is a costly affair. Even though many arrangements were made by the government but still catering for many other basic amenities in times of distress wherein essential commodities prices also hiked makes cost of sustaining in such times high. To top it all many people were jobless for some period of time as well. These all factors led to using the savings in these PMJDY accounts in that period of time and causing decrease in accounts balances.

5. **More withdrawal of DBTs from accounts.**

Supreme Court stated that on March 31, 2020, around 0.6 million population of India was dislocated and 22 million of the population was provided ration by the Public Distribution System (PDS). The essence of the whole relief package given through the PMJDY account in the form of DBTs through various schemes was to give money in the hands of weaker sections of society to help them sustain themselves. Along with other measures like free food grains given through PDS causing exchequer a huge cost , it is easy to analyse that the beneficiaries used it for the same.

Hence the decrease in account balances is also justified on that notion.

Conclusion

As said by John Kennedy "If a free society cannot help the many who are poor, it cannot save the few who are rich", it holds very true for India as a nation as well. Though there are several criticisms by many on the relief package of Covid 19 and how it could be planned better. But as there is a silver lining to every cloud, this research also suggests that it benefitted the poorest of the poor by giving them some support in the testing times. The national mission on financial inclusion through PMJDY has been instrumental in managing these public finances and sourcing them to the place of need, trying to reduce various barriers of corruption by the direct transfers of benefits and tracking through advance mechanisms of PFMS. The data analysis shows that PMJDY has become a tool of Public financial management, making it successful in several fronts of transparency, reliability, predictability, control and reporting. The response of beneficiaries of PMJDY to various steps taken by the government to provide them relief shows that the various measures are well received.

References

- *(*Accelerating-Indias-COVID-19-Social-Protection-Response-Program*)*. Retrieved March 8, 2021, http://documents1.worldbank.org/curated/en/685311589767271707/text/India-Accelerating-Indias-COVID-19-Social-Protection-Response-Program.txt
- (Continuation of PMJDY). Retrieved November 3, 2020, from https://pmjdy.gov.in/files/E-Documents/Continuation_of_PMJDY.pdf
- *(*Credit delivery and financial inclusion, annual report. RBI,2011). Retrieved November 3, 2020, from https://rbidocs.rbi.org.in/rdocs/AnnualReport/PDFs/9IVCDFI250811.pdf
- *Almost 86% of 417 million PMJDY accounts operative: MoS Finance | Business Standard News*. Retrieved March 4, 2021, from https://www.business-standard.com/article/economy-policy/almost-86-of-417-million-pmjdy-accounts-operative-mos-finance-121020901234_1.html
- *Almost 86% of 417 million PMJDY accounts operative: MoS Finance | Business Standard News*. . Retrieved March 4, 2021, from https://www.business-standard.com/article/economy-policy/almost-86-of-417-million-pmjdy-accounts-operative-mos-finance-121020901234_1.html
- *Cash, on delivery: How India has taken up DBT in the times of COVID-19*. Retrieved March 13, 2021, from https://www.downtoearth.org.in/news/economy/cash-on-delivery-how-india-has-taken-up-dbt-in-the-times-of-covid-19-72247
- *Continuation of Pradhan Mantri Jan Dhan Yojana (PMJDY)*. (2018). 2018.
- *Covid relief spurs PMJDY accounts past the 40-crore mark - The Hindu BusinessLine*. (. Retrieved March 3, 2021, from https://www.thehindubusinessline.com/money-and-banking/covid-relief-spurs-pmjdy-accounts-past-40-crore-mark/article32260134.ece#
- *Covid-19 relief: Jan Dhan accounts see withdrawal of over ₹2000 cr per week - The Hindu BusinessLine*. . Retrieved March 3, 2021, from

https://www.thehindubusinessline.com/money-and-banking/covid-19-relief-jan-dhan-accounts-see-withdrawal-of-over-2000-cr-per-week/article31735966.ece

- *DBT. Transfers for PMJDY. Retrieved March 11, 2021, from https://dbtbharat.gov.in/page/frontcontentview/?id=MTc=*
- *Document of the World Bank India Synthesis Study of Public Financial Management and Accountability in Urban local Bodies Financial Management Unit South Asia Region SYNTHESIS STUDY OF PFMA IN URBAN LOCAL BODIES CONTENT*. (2007).
- Gentilini, U., Almanfi, M., Dale, P., Acar, A., Ahli, H., Akhgar, N., Hassan Kashkol Al-Kazali, H., Allahoum, A., Allieu, A., Al Maazmi, S., Al Qassi, N., Andreeva, E., Andrews, C., Archibald, E., Aromolaran, T., Arulpragasam, J., Elzir Assy, A., Aziz, A., Baatarkhuu, I., … Zlatareva, M. (2020). *Social Protection and Jobs Responses to COVID-19: A Real-Time Review of Country Measures*. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/33635
- *Govt transfers over Rs 19,000 cr to 95.5 mn farmers under PM-KISAN scheme | Business Standard News*. Retrieved March 11, 2021, from https://www.business-standard.com/article/economic-revival/govt-transfers-over-rs-19-000-cr-to-95-5-mn-farmers-under-pm-kisan-scheme-120052300154_1.html
- *Improving public financial management. Supporting sustainable development. Framework for assessing public financial management. PEFA 2016, World Bank Documents.*
- Irudaya Rajan, S., Sivakumar, P., & Srinivasan, A. (2020). The COVID-19 Pandemic and Internal Labour Migration in India: A 'Crisis of Mobility.' *Indian Journal of Labour Economics*, *63*(4), 1021–1039. https://doi.org/10.1007/s41027-020-00293-8
- *Jan Dhan accounts cross 41 crore: Nirmala Sitharaman | Deccan Herald*. Retrieved March 4, 2021, from https://www.deccanherald.com/business/business-news/jan-dhan-accounts-cross-41-crore-nirmala-sitharaman-940943.html
- Maity, S., & Sahu, T. N. (2020). Role of public sector banks towards financial inclusion during pre and post introduction of PMJDY: a study on efficiency review. *Rajagiri Management Journal*, *14*(2), 95–105. https://doi.org/10.1108/ramj-03-2020-0009
- Mantri, P., & Yojana, J.-D. . *A National Mission on Financial Inclusion*. Retrieved November 3, 2020, from www.financialservices.gov.inwww.financialservices.gov.in
- Mantri, P., Dhan, J., & Minister, P. (2014). *Chapter-i introduction 1.1*. *October 2018*, 1–26.
- *PFMS tracking for PMJDY women account Holders*. Retrieved March 13, 2021, from https://pfms.nic.in/NewDefaultHome.aspx
- *Pradhan Mantri Jan-Dhan Yojana | Department of Financial Services | Ministry of Finance*. . Retrieved March 13, 2021, from https://pmjdy.gov.in/
- Quak, E.-J. *Lessons from Public Financial Management (PFM) reforms after a financial crisis*.
- Sengupta, S., & Jha, M. K. (2020). Social Policy, COVID-19 and Impoverished Migrants: Challenges and Prospects in Locked Down India. *The International Journal of Community and Social Development*, *2*(2), 152–172. https://doi.org/10.1177/2516602620933715

- Sharma, G. D., & Mahendru, M. (2020). Lives or livelihood: Insights from locked-down India due to COVID19. *Social Sciences & Humanities Open*, *2*(1), 100036. https://doi.org/10.1016/j.ssaho.2020.100036
- Sharma, G. D., Talan, G., & Jain, M. (2020). Policy response to the economic challenge from <scp>COVID</scp> -19 in India: A qualitative enquiry. *Journal of Public Affairs*, *20*(4), e2206. https://doi.org/10.1002/pa.2206
- Sharma, M., Giri, A., & Chadha, S. (2016). *Pradhan Mantri Jan Dhan Yojana Wave III Assessment*. https://www.microsave.net/wp-content/uploads/2018/10/PMJDY_Wave_III_Assessment_MicroSave.pdf
- Sriram, M. S. (2019). Financial Inclusion: Agenda for Policy Intervention. In *Vikalpa* (Vol. 44, Issue 4, pp. 163–166). https://doi.org/10.1177/0256090919900395

A study of Financial Inclusion under Pradhan Mantri Jan Dhan Yojana (PMJDY) with reference to Financial Management Framework.

Mrs. Shefali Rai [1]
[1]Research Scholar,
Hislop College,
Nagpur (M.S.),India
Email:shefalirai29@gmail.com

Dr. Dini Menon [2]
[2]Assistant Professor,
Hislop College,
Nagpur (M.S.),India
Email: dini2021@gmail.com

Abstract

PMJDY has been stalwart of financial inclusion in the history of mankind having registered itself in Guinness world book. Financial Inclusion has been the priority of developing nations for decades but PMJDY has been able to emerge better with social security schemes, direct benefit transfers, digitalization, insurance, pension and overdraft under one head. The expansion has been possible through sub service area divisions and vast network of bank mitras. This scheme has also received attention during the pandemic as major benefits of the relief package declared by Indian government were channelized through it. It has completed phase I and phase II with success and is continued under National Mission for Financial Inclusion. Financial management of public schemes helps in efficient utilization of resources for achievement of development goals. This study concentrates on analyzing how financial inclusion through PMJDY helps in facilitating financial management of resources which in turn leads to individualistic growth and eventually national growth. It also highlights the transformation through e-Public financial management systems (e-PFMS) in the financial inclusion scenario. A conceptual framework has also been developed to get a deeper insight into financial management framework through PMJDY financial inclusion.

Keywords: PMJDY, Financial Inclusion, Public Financial Management System, Financial Management, Conceptual /Theoretical Framework.

Introduction

Financial inclusion is the backbone for developing the economy and ensuring growth opportunities to the weaker section of society. Mere formation of a policy and implementation is not the only requirement but to continuously keeping a track of it and improving time to time is the need of most developing countries. There have been many financial inclusion policies in India since ages and have benefitted the people but not at the same scale as PMJDY. It has 41.13 Crore beneficiaries banked so far ₹130,458.93 Crore Balance in beneficiary accounts and 1.26 lakh Bank Mitras delivering branchless banking services in Sub-Service Areas as per official site on 3rd Nov,2020. The reason of this massive growth is meticulous financial management of the policy and modifying it on a continuous basis to bring financial inclusion to the remotest areas.

Therefore, there is a need to study the financial inclusion and financial management variables to create effective policies which can help manage the public financial resources in an efficient manner. This paper tries to analyze a research framework to measure financial management and financial inclusion through certain standard variables and how an effective policy intervention such as PMJDY can impact.

Objectives of the study:

- To explore research framework to identify Financial inclusion and Financial Management indicators.
- To study the effectiveness of financial inclusion policy PMJDY scheme for public financial management.

The first part of the paper consists of the relevant literature review. The second part focuses on the financial inclusion indicators, financial management indicators and public financial management through E-PFMS systems. The third part introduces conceptual framework as well as variables identified for the model by researcher. It is based on secondary data. For further scope of research, the conceptual framework can also be quantified through a combination of exploratory and descriptive approaches. Both qualitative and quantitative methods of measurement, can be used. The collected data can be subjected to various statistical analysis for drawing inferences.

Review of Literature

(Credit delivery and financial inclusion, annual report. RBI,2011) according to RBI definition "Financial inclusion broadly refers to the process of ensuring access to appropriate financial products and services needed by vulnerable groups such as the weaker sections and low-income groups at an affordable cost, in a fair and transparent manner by mainstream institutional players" (RBI,2011).

*(*Conceptual Framework to Investigate the Accessibility and Impact of Financial Inclusion Sequeira, M. V. S. A. H., & Varambally, K. V. M. ,2013) came up with a conceptual framework for financial inclusion and its impact on socio-economic status of households by identifying financial access variables. The conclusion of the study was financial inclusion is the basis for pro poor growth or inclusive growth.

(Payments Infrastructure and the Performance of Public Programs: Evidence from Biometric Smartcards in India, Muralidharan, K., Niehaus, P., & Sukhtankar, S. 2014) it evaluates the impact of biometrically-authenticated payments infrastructure ("Smartcards") on beneficiaries of employment (NREGS) and pension (SSP) programs over 158 sub- districts of Andhra Pradesh and 19 million people. It found that the new system was more predictable, less corrupt, more accurate and gave better accessibility to users. It also suggested that investing in secure payments infrastructure can enhance the capacity to implement welfare programs in developing countries like India.

*(*Digital Revolutions in Public Finance International Monetary Fund, Gupta, S., Keen, M., Shah, A., & Verdier, G. ,2017) this study states that the government program can and have benefitted by leakage reductions of funds transferred and tracked through PFMS. In India both Social Security Pension and National Rural Employment Guarantee Scheme have witnessed it. In addition, Financial Management Information System also helps in tracking and analyzing government financial information. Many international institutions like IMF and WB are working on the same and studying its impact if implemented at all levels.

(Public Financial Management and the Digitalization of Payments, Cangiano, M., Gelb, A., Goodwin-groen, R., & Goodwin-groen, R.,2018) the paper explores the linkages between the

digitalization of payments and PFM, through four case studies. The case study of India explains how Jan-Aadhar and Mobile, Aadhar enabled payment systems, E-KYC and UPI reforms have improved the accuracy, timelines and quality of services. In case of Estonia as well PFM strategies helped in cleaning government payrolls and strengthened tax administration.

Financial Inclusion Indicators

World Bank Banking International Standards (WB-BIS), states that in order to develop an efficient financial inclusion policy, identify current on ground situation, lacunae's, set up targets to be achieved, measure the growth, monitor and implement corrective actions, financial inclusion indicators have to be developed. There are various financial inclusion indicators like Findex (2017) which has used four broad indicators like account ownership, payment services, use of accounts and saving credit and financial resilience. Within these sub indicators have also been formulated. On the other hand, IMF Financial Access Survey (of G-20 countries which includes nine supply side indicators like number of ATMs per one lakh adults, number of commercial bank branches per one lakh adults, mobile transaction alerts per one lakh adults, life insurance and non- life insurance per one thousand adults etc. was also conducted.

For the purpose of this study, we have used WB-BIS for measurement of financial inclusion which are broadly categorized into:

Financial Inclusion Access Indicators: It includes various accessibility criteria of beneficiaries, banking network outreach, financial institutions access barriers and cost effectiveness especially in rural areas.

Financial Inclusion Usage Indicators: These include actual utilization of services as only dormant accounts do not generate growth for beneficiaries or economy. Frequency of usage of accounts by number of transactions, electronic payments etc. is measured in this category.

Financial Inclusion Quality Measures Indicators: It includes quality of financial products and services which fit the needs of beneficiaries and making them financially literate to use and benefit from them. Such financial products and services need to be designed in such a way that it provides optimum benefits with high quality to the weaker sections of the

society. It has parameters like lower interest rate credit with safety, more reliable credit source options and better saving options etc.

Financial Management Indicators

Financial Management is the use of management key principles for allocation, distribution and maintenance of financial assets of an organization. Effective financial management can lead to efficient functioning of the organization and growth. It is the most crucial need of an organization. It entails planning, organizing and directing /controlling the finances to achieve the optimal growth. If such functions are not carried out it can lead to problems in achieving organizational goals. Planning the financial activities in accordance with objectives of the organization, organizing the pool of resources for maximum utilization and controlling them to achieve desired results, this all requires good financial management (Atrill & Peter,2009). Hence for the purpose of this study we have used Planning, Organizing and Controlling as financial management criteria.

Role of Public Financial Management System (PFMS) in PMJDY

PFMS has been implemented by the Office of Controller General of Accounts. Initially started in 2008-09 known as Central Plan Schemes Monitoring System and included in the 12th year plan of planning commission. It was rolled out in four pilot states for limited schemes like MGNREGS, PMGSY, SSA and NRHM.

The main objective of PFMS is to bring transparency in the distribution of government fund and real time tracking to increase efficiency in their management. Under PFMS direct transfers of various scheme benefits can be transferred to individuals, institutions and agencies. It can validate accounts before sending payments and has Core Banking System interface with around 300 PSB's, RRB's, India Post network, Private sector banks, Cooperative banks and RBI.

PMJDY accounts have also acted as tool to manage various DBT's through while growing the financial inclusion net at the same time. (Jena ,2013) in his study stated that a country like India with complex federal structure will need a well-coordinated PFM to deliver quality services at state level and in current scenario we have already achieved treasury system interface with twenty-eight states and two union territories. Additionally, PFMS 2.0 version is also focusing on new technical upgrades like Artificial Intelligence (AI), deep learning, mobility platforms and blockchain technology. (Banerjee, et al,2017) also found out in their large-scale experiment on

that through electronic fund management platform, transparency increases, accountability improves and corruption is also reduced.

For the purpose of the study the researchers have established a relation between Financial management and Financial Inclusion variables. Keeping Planning, Controlling and Organizing as variables for financial management and Access, Usage and Quality as financial inclusion variables.

Model of Conceptual framework for Financial Inclusion created by Researchers

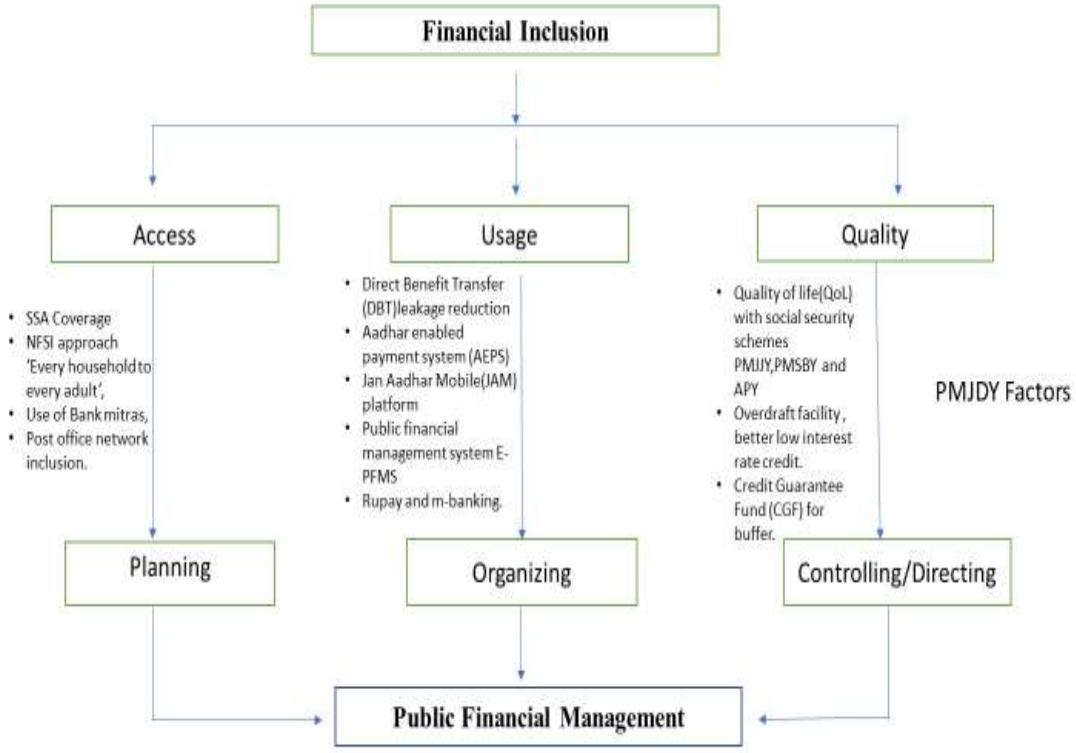


Figure 1: Schematic representation of conceptual framework.

Conceptual Framework

In the figure 1, a schematic representation of the conceptual framework of PMJDY acting as public financial management tool for financial inclusion is suggested.

The facilitation of planning of access to financial services through PMJDY factors can be measured by improvement in access through distribution into sub service areas (SSA's), every household coverage approach, 'Every household to every adult' new strategy for financial inclusion (NFSI) approach and use of Business Correspondents for extending outreach along with ease of transactions. Under the scheme a sub service area consists of 1000-1500 households and concentrates on making banking facility available within a range of 5 km. This is an improvement over Swabhimaan scheme implemented earlier which covered only villages with population above 2000. Therefore, we have shifted from village population coverage to household coverage under PMJDY which has further improved to every adult coverage under NFSI implemented for extension of PMJDY. These all improvements are due to the PMJDY scheme features which have helped in better planning of access to financial services. Also, extension to post office network for financial inclusion and including Dak Sevaks as business correspondents has been great planning initiative which will increase the access network further.

The organization of usage of financial services and how it has improved can be measured by leakages reductions through Direct benefit transfers(DBT's) from government to beneficiaries account without third agency interference , more hassle free digital transactions through Aadhar Enabled Payment System (AEPS), transparent interconnected interface network usage of Jan Aadhar Mobile (JAM), better allocation and tracking through e-PFMS, m-banking and use of Rupay card by millions of new users. All these features of PMJDY have helped in efficient organization of usage of financial services. While direct benefit transfers of various subsidies through PMJDY accounts have reduced corruption, its tracking by government PFMS has made organizing and collection of scheme data easier. Aadhar seeding and Rupay card issued to PMJDY accounts also make usage of digital financial services platform more convenient and reliable. Aadhar seeding helps further in organizing the beneficiary accounts for receipt of various benefits.

The improvement in control of quality of financial services can be measured by upliftment in the quality of life of beneficiaries by availability of social security schemes like PMJJBY-Life insurance, PMSBY-Accident insurance and APY-Pension for unorganized sectors along with Jan Dhan accounts. This has been first time when social security schemes have been offered with

basic banking services through government scheme that too in several financially excluded areas at very reasonable costs. The efficiency of control and direction of quality of financial services can also be measured by low interest rate credit available by the facility of overdraft with just six months of transaction or credit history preventing poorest of the poor from exploitation at the hands of moneylenders. Lastly CGF has also been created as buffer in case of defaults to prevent the scheme from any lapses and keep its integrity intact. Thus, all these PMJDY scheme factors ensure good control over quality of financial services provided to beneficiaries.

Data collection and Research Methodology:

The conceptual framework can also be quantified through a combination of exploratory and descriptive approaches. To measure the facilitation of management functions through PMJDY factors on financial inclusion indicators both qualitative and quantitative methods of measurement, can be used. Primary data can be collected from beneficiaries and business correspondents. A structured questionnaire can be used along with interview schedule for the intermediaries, officers in charge and beneficiaries. Secondary data can be collected through various central agencies like Department of Financial Services, Reserve Bank of India and state agencies like State Level Bankers Committee, Lead Bank, participating banks and state government departments. The collected primary and secondary data can be subjected to various statistical analysis for drawing inferences. Correlation test, Regression test, Garrets ranking, Fuzzy logic and factor analysis are some that can be applied.

Conclusion:

Through the conceptual framework discussed in this paper, one can see that the planning of access to financial services through PMJDY is facilitated through various factors like SSA coverage, NFSI approach, Bank Mitras and Post Office Network. Similarly, organization of usage to financial services through PMJDY is contributed by factors like DBT, AEPS, JAM, PFMS, Rupay and M-banking. Lastly, controlling of quality regarding financial services is also contributed through PMJDY factors like improvement in quality of life by Social Security Schemes, availability of Overdraft facility and CGF. Various indicators, variables and conceptual framework worked out would help in building a strong foundation for further efficient public financial management and financial inclusion. Study shows that PMJDY has transformed the financial inclusion scenario by bringing lots of new financial services along with basic zero

balance account which can help in better public financial management of old as well as new earlier untapped resources. PFMS in India has also developed at a humongous rate and plays a crucial role in all centrally planned schemes. Government has already been continuously improving the current infrastructure to achieve further success through National strategy for financial inclusion.

References

- *(*Credit delivery and financial inclusion, annual report. RBI,2011). Retrieved November 3, 2020, from https://rbidocs.rbi.org.in/rdocs/AnnualReport/PDFs/9IVCDFI250811.pdf
- Atrill, P. (2009). Financial management for decision makers. Pearson Education.
- Banerjee, A., Duo, E., Imbert, C., Santhosh, M. ¶ & Pande, R. (2015). Can E-Governance Reduce Capture of Public Programs? Experimental Evidence from a Financial Reform of India's Employment Guarantee .
- Bietenhader, D., & Bergmann, A. (2010). Principles for Sequencing Public Financial Reforms in Developing Countries. International Public Management Review, 11(1), 52–66. https://doi.org/10.21256/zhaw-3331
- Dahiya, S., & Kumar, M. (2020). Linkage between Financial Inclusion and Economic Growth: An Empirical Study of the Emerging Indian Economy. Vision: The Journal of Business Perspective, 24(2), 184–193. https://doi.org/10.1177/0972262920923891
- Gupta, S., Keen, M., Shah, A., & Verdier, G. (2017). Digital Revolutions in Public Finance©IMF. www.bookstore.imf.org
- How to Measure Financial Inclusion.Retrieved September 29, 2020, from https://www.worldbank.org/en/topic/financialinclusion/brief/how-to-measure-financial-inclusion
- Muralidharan, K., Niehaus, P., & Sukhtankar, S. (2014). Building State Capacity: Evidence from Biometric Smartcards in India. *National Bureau of Economic Research*. https://doi.org/10.3386/w19999

- Ranjan Jena, P. (2013). Improving Public Financial Management in India: Opportunities to Move Forward. http://www.nipfp.org.in
- Sequeira, M. V. S. A. H., & Varambally, K. V. M. (2013). Conceptual Framework to Investigate the Accessibility and Impact of Financial Inclusion, Soc. 47–49.
- Sriram, M. S. (2019). Financial Inclusion: Agenda for Policy Intervention. In Vikalpa (Vol. 44, Issue 4, pp. 163–166). https://doi.org/10.1177

DOI PREFIX 10.22183
JOURNAL DOI 10.22183/RN
SIF 7.399

RESEARCH NEBULA
An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Arts, Commerce, Education & Social Sciences

ISSN 2277-8071

One Day International E – Conference On
Covid-19 Pandemic: Challenges, Opportunities & Solutions in Front of Higher Education
on 21st August, 2021 @
S.K. College Akola, AS College Kurha, S.K. Maha Dahihanda & PEFI, New Delhi.

कोरोना-१९ महामारी च्या दरम्यान ऑनलाइन शिक्षणात येणारी आव्हाने आणि मिळणाऱ्या सुवर्णसंधी

डॉ. डी. एच. पुट्टेवार

असिस्टंट प्रोफेसर
डॉ. आंबेडकर कॉलेज,
दीक्षाभूमी, नागपूर
वाणिज्य विभाग
deepaliputtewar18@gmail.com

ABSTRACT

कोरोना-१९ आणि त्यामुळे आलेल्या टाळेबंदीमुळे सर्वच क्षेत्रापुढे अनेक प्रश्न उभे आहेत. त्यात शैक्षणिक क्षेत्रही अपवाद नाही. कोरोना नंतरच्या काळात शैक्षणिक सत्र सुरळीत सुरू करण्याबरोबरच विद्यार्थ्यांनाही सुरक्षित ठेवण्याकरिता ऑनलाइन शिक्षणावर भर दिला जात आहे. कोरोना-१९ या आपत्कालीन परिस्थितीत ऑनलाइन शिक्षण उपयोगात येत असले तरी ऑनलाईन शिक्षण प्रणालीमुळे कोणकोणती आव्हाने विद्यार्थी, पालक आणि शिक्षकांसमोर उभी आहे, तसेच ऑनलाइन शिक्षणप्रणालीमुळे कोणत्या सुवर्णसंधी निर्माण झालेल्या आहेत याची सविस्तर चर्चा या संशोधनात केलेली आहे.

KEY WORDS- *ऑनलाइन **शिक्षण,** कोरोना-१९, महामारी, तंत्रज्ञान*

प्रस्तावना

कोरोना-१९या आपत्कालीन परिस्थितीत महाविद्यालय बंद असले तरी शिक्षण सुरू राहिले पाहिजे, अशा या राज्य आणि केंद्र शासनाच्या या धोरणानुसार ऑनलाइन शिक्षण पद्धतीने शिक्षणाची प्रक्रिया सुरू झालेली आहे आणि ऑनलाइन शिक्षण उपयोगात येत आहे. आज ऑनलाइन शिक्षण सर्वत्र लोकप्रिय झाले आहे. ऑनलाइन शिक्षण हे असे माध्यम आहे, ज्याद्वारे देशातील आणि जगाच्या कोणत्याही कोपऱ्यातून शिक्षक आपल्या विद्यार्थ्यांसोबत ऑनलाइन संपर्क साधू शकतात, झूम, गुगलअॅप्स द्वारे व्हिडिओ कॉल करतात, लॅपटॉप किंवा संगणकावर विद्यार्थी शिक्षकांना पाहू आणि ऐकू शकतात. शिक्षक मुलांना शिकविण्यासाठी आपल्या संगणकावर स्क्रीन शेअर करतात. लॉकडाऊन च्या काळात सर्व शिक्षण केंद्रे बंद असताना ऑनलाइन शिक्षणामुळे आज विद्यार्थी घरी बसून अभ्यास करीत आहे, नवनवीन माहिती मिळवीत आहे. कोरोनाच्या परिस्थितीत विद्यार्थी महाविद्यालयांमध्ये जाऊन शिक्षण घेऊ शकत नसला तरीही ऑनलाइन शिक्षणामुळे शिक्षणाचा मार्ग सोपा झालेला आहे.करियर संदर्भातील विविध सुवर्णसंधी घर बसल्या विद्यार्थ्यांना मिळू लागल्या आहेत. रोजगार संदर्भाची माहिती असो की उद्योजक, विविध व्यवसाय इत्यादींची माहिती असो, ऑनलाईन शिक्षणामुळे प्राप्त होत आहे, असे असले तरी ऑनलाइन शिक्षणात विविध अडचणी विद्यार्थ्यांना येत आहे. तंत्रज्ञानाचा जेवढा जास्त वापर होऊ शकतो तेवढा अन्य कशाचाही होऊ शकत नाही. ऑनलाइन शिक्षणामुळे विकासाचे पुढचे पावले टाकले जाऊन विद्यार्थी व शिक्षकांसाठी ज्ञानाचे भंडार उघडले गेले आहे. गूगल क्लासरूम आणि व्हाट्सअप च्या माध्यमातून ऑनलाइन पद्धतीने शिक्षण शिकवण्याची ही प्रक्रिया शिक्षक राबवत आहे

काहीतरी नवी नवीन शिकायला मिळणार म्हणून एक जिज्ञासा, कुतूहल आणि नाविन्यपूर्ण तंत्रज्ञान युक्त पद्धत सुरुवातीला खूप छान व परिस्थितीनुरूप सोयीस्कर मांडण्यात आली. महामारी च्या काळात शिक्षण क्षेत्रात एक पर्यायी उपलब्धता म्हणून स्वीकारलेली ही एक पद्धत आहे. परंतु विद्यार्थ्यांच्या सर्वांगीण विकासासाठी शैक्षणिक विकासाबरोबरच शारीरिक व मानसिक विकास देखील खूप महत्त्वाचा आहे तो ऑनलाइन शिक्षणामध्ये होऊ शकतो का? या दृष्टिकोनातून विचार होणे ही काळाची गरज आहे.

ऑनलाइन शिक्षण हे कितपत योग्य आहे की अयोग्य आहे याचा विचार तसेच ऑनलाईन शिक्षण पद्धती ही पारंपारिक शिक्षण पद्धतीला पर्याय ठरू शकते का? याचा सकारात्मक आणि नकारात्मक या दोन्ही बाजूंची चर्चा या संशोधनात करण्यात आलेली आहे. तसेच ऑनलाईन शिक्षण प्रणाली मध्ये कोण कोणती आव्हाने विद्यार्थी, पालक आणि

DOI PREFIX 10.22183
JOURNAL DOI 10.22183/RN
SIF 7.399

RESEARCH NEBULA
An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Arts, Commerce, Education & Social Sciences

ISSN 2277-8071

शिक्षकां समोर उभी आहे, याचा ही उहापोह या संशोधनात केलेला आहे. तसेच कोरोनाच्या या संकटामध्ये ऑनलाइन ही शिक्षण प्रणाली विद्यार्थ्यांसाठी, शिक्षकांसाठी आणि पालकांसाठी कशी सुवर्ण संधी म्हणून प्राप्त झालेली आहे याचीही सविस्तर चर्चा या संशोधनात करण्यात आलेली आहे.

ऑनलाइन शिक्षणाचा अर्थ -

ऑनलाईन शिक्षण म्हणजे, "आपण जे शिक्षण, आपल्या शिक्षकाकडून ब्लॅक बोर्ड आणि पुस्तकांच्या माध्यमातून महाविद्यालयात प्रवेश मिळवून घेत होतो, तेच शिक्षण आज संगणक, मोबाईल आणि इंटरनेटच्या माध्यमातून घरबसल्या प्राप्त करतो, यालाच ऑनलाईन शिक्षण असे म्हणतात".

लॉक डाऊन सारख्या महान संकटामध्ये शिक्षणा1. दर्जात सुधारणा घडवून आणि विद्यार्थ्यांना पुस्तकी ज्ञाना सोबतच इतर नवीन ज्ञान देणारी आनंददायी शिक्षण प्रणाली म्हणजे ऑनलाइन वर्ग होय.

ऑनलाइन **शिक्षण** एक अशी **शिक्षण** प्रणाली आहे ज्यात शिक्षक इंटरनेटचा वापर करून देशातील किंवा जगभरातील कोणत्याही कोपऱ्यात असलेल्या विद्यार्थ्यांना शिकवू शकतात. 2.

ऑनलाइन शिक्षणामध्ये मोबाईल, लॅपटॉप, संगणक आणि इंटरनेट कनेक्शन, डीव्हीडी, एलसीडी, मॉनिटर इत्यादी साधने तसेच ॲनिमेटेड क्लिप्स युट्युब, पीपीटी स्लाईड्स, 3D मोडेल, वेबसाईट आणि ब्लॉक इत्यादींचा समावेश होतो, तसेच ऑनलाइन शिक्षण इंटरॅक्टिव्ह मल्टिमीडिया व्हिडिओ लेसन आणि टच पेन चा पडद्यावर वापर करून स्क्रीनवर अध्यापनाचे कार्य करण्यात येते. एवढेच नाही तर शिक्षक विविध प्रोजेक्टवर विद्यार्थ्यांना शिकवीत असतात. ऑनलाइन व्याख्यानासाठी स्काईप, व्हाट्सअप, झूम किंवा Google Meet असे ॲप्स वापरले जातात.

आज प्रत्येक क्षेत्रामध्ये मोबाईल आणि कॉम्प्युटर3. सर्रास वापर केला जात आहे, त्यामुळे विद्यार्थी ऑनलाईन शिक्षणाच्या माध्यमातून सर्व गॅझेट हाताळू लागला आहे. जिथे करोना मुळे संपूर्ण क्षेत्र बंद पडलेली आहे मात्र त्या परिस्थितीमध्येही विद्यार्थी ऑनलाईन शिक्षणाच्या माध्यमातून मार्गदर्शन आणि ज्ञान प्राप्त करीत आहे, यामुळे शिक्षण प्रणाली ही गतिमान झाली आहे.

ऑनलाइन शिक्षणाचा मुख्य उद्देश :

- चहूबाजूंनी मिळणारे ज्ञान आत्मसात करणे
- उत्तम व्यक्तिमत्व घडविणे 4.
- विद्यार्थ्यांच्या सर्वांगीण विकासासाठी

माहिती संकलन व संशोधन पद्धती :

प्रस्तुत शोधनिबंध हा दुय्यम स्त्रोतांवर आधारित असून प्रकाशित पुस्तके, मासिके, वृत्तपत्रे व वेबसाईटचा आधार घेण्यात आलेला आहे.

संशोधनाचा उद्देश :

कोरोना-१९ या आपत्कालीन परिस्थितीत महाविद्यालय बंद असले तरी या परिस्थितीत अल्प कालावधीसाठी पर्यायी व्यवस्था म्हणून ऑनलाइन शिक्षण परवडणारे असले तरी सक्षम अध्ययन अध्यापन प्रक्रिये करीता ऑनलाईन शिक्षण पद्धत ही योग्य आहे की अयोग्य, संयुक्तिक आहे की असंयुक्तिक यावर अभ्यास करणे.

<u>ऑनलाइन शिक्षणात येणारी आव्हाने / तोटे :</u>

ऑनलाइन शिक्षणातील तांत्रिक अडचणी :

भविष्यात बाहेर पडणे तितकेसे सुरक्षित नसल्यामुळे ऑनलाइन शिक्षणाचा पर्याय समोर आला. त्यामुळे ऑनलाईन शिक्षणाची गरज भागवण्यासाठी आवश्यक असलेल्या साधनांची मागणी सुद्धा वाढली. उत्तम दर्जाचे इंटरनेट इंटरनेट आणि ग्याजेट च्या कमतरतेमुळे ऑनलाइन शिक्षणात तांत्रिक अडचणी निर्माण झाल्यात.

ऑनलाईन शिक्षण निरुपयोगी :

ऑनलाईन अभ्यास करायचा म्हटलं तर त्यासाठी घरी स्वतःचा संगणक किंवा अद्ययावत दर्जाचा मोबाईल फोन असणं अत्यंत आवश्यक आहे. तसा असेल तरी दर महिन्याला नेट रिचार्ज वेळेवर भरुन घेणं आवश्यक आहे. ज्यांची आर्थिक ऐपत आहे त्यांच्यासाठी ठीक आहे. परंतु, सर्वसामान्य माणसाच्या उपजीविकेचे सगळे मार्ग बंद आहेत. ग्रामीणभागात पावसाळ्यात विद्युत पुरवठा वारंवार खंडीत होतो. नेटवर्कची समस्या भेडसावत असते. अशावेळी ऑनलाईन शिक्षण पद्धती ग्रामीण भागातील विद्यार्थी /जनतेसाठी निरुपयोगी ठरणारी आहे.

ऑनलाइनसाठी पुरेशी तयारी नाही :

उच्च शिक्षण संस्थांमध्ये शिकवणा-या प्राध्यापकांना ऑनलाइन शिकविण्याचा पुरेसा अनुभव नसल्यामुळे या तंत्रात ते फारसे प्रशिक्षित नाहीत. हीच कारणे अधिकाधिक ऑनलाइन अभ्यासक्रम राबविण्याच्या कामात मोठ्या प्रमाणात अडसर ठरत आहेत. अभ्यासक्रम पूर्णतः ऑनलाइन करण्यासाठी आवश्यक पूर्वतयारीसाठी सहा ते नऊ महिन्यांचा कालावधी आवश्यक असतो. मात्र, सध्याच्या कोरोना संकटाने शिक्षण क्षेत्राला पूर्वतयारीसाठी तेवढाही कालावधी दिलेला नाही.

ऑनलाइन शिक्षणामध्ये अध्ययन-अध्यापन प्रक्रियेत नकारात्मकता :

DOI PREFIX 10.22183
JOURNAL DOI 10.22183/RN
SIF 7.399

RESEARCH NEBULA
An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Arts, Commerce, Education & Social Sciences

ISSN 2277-8071

एक शिक्षक जोपर्यंत प्रत्यक्षात विद्यार्थ्यांसमोर बसून शिकवत नाही तोपर्यंत अध्ययन-अध्यापन प्रक्रियेत सजीवता निर्माण होत नाही. विद्यार्थ्यांना प्रत्यक्ष अध्यापन करीत असताना त्यांच्या संवाद साधला जाणारा भावनिक संवाद देखील महत्त्वाचा असतो. जोपर्यंत शिक्षक व विद्यार्थी यांच्यामध्ये हे प्रत्यक्ष आंतरक्रिया होत नाही, तोपर्यंत अभ्यासातील समस्या, अडचणी सोडविता येणे शक्य होत नाही.

विद्यार्थ्यांना शिकविण्याच्या चार सहली शैली आहेत. बसून, ऐकून, स्पष्ट करून आणि कृतीतून शिकविणे. परंतु विद्यार्थी हा 80 टक्के अनुभवातून शिकत असतो तो अनुभव पद्धतीमुळे येत नाही.

5. **डोळ्यावरही परिणाम :**

ऑनलाइन शिक्षणामुळे डोळ्यावर परिणाम होत असल्याचे नेत्ररोग तज्ज्ञांनी सांगितले. डोळ्याच्या वाढीसाठी नैसर्गिक सूर्यप्रकाश खूप आवश्यक असतो जास्त वेळ ऑनलाईन स्क्रीन टाईम असेल तर चष्म्याचा नंबर वाढू शकतो,याबरोबरच अन्य त्रास ही जाणवतो

6. **तंत्रज्ञाना बद्दल विद्यार्थी, पालक आणि शिक्षकांची अनभिज्ञ :**

विद्यार्थ्यांच्या शिक्षणात अभ्यासात खंड पडू नये म्हणून ऑनलाइन शिक्षण हा पर्याय ऑनलाईन शिक्षणाद्वारे शिक्षण देण्याचा पर्याय आलेला आहे, परंतु नवीन तंत्रज्ञानाची माहिती विद्यार्थी, पालक व शिक्षकांना नसल्यामुळे शिक्षण प्रभावीपणे होऊ शकत नाही.

7. **विद्यार्थ्यांमध्ये निर्माण होणाऱ्या एकलकोंडेपणा:**

नेहमी मित्रांच्या गराड्यात शाळेत जाणाऱ्या मुलांना एकलकोंडेपणा जाणवू लागला आहे.

8. **ऑनलाईन शिक्षणाचा वाढता खर्च** :

घरात एकापेक्षा जास्त विद्यार्थी शिक्षण घेणारे असतील तर एकापेक्षा जास्त लॅपटॉप, नेटवर्क, मोबाईल ची आवश्यकता भासणार यासाठी आर्थिक खर्च होऊन होऊन त्याचा भार पालकांवर येणार

9. **गरीब विद्यार्थ्यांचे नुकसान :**

आधीच कोरोना मुळे हातचा रोजगार हिरावलाय. या संकट काळात बर्याचशा पालकांकडे चांगले मोबाईल नसल्याने गरीब विद्यार्थ्यांचे नुकसान होत आहेत.

10. **इंटरनेटची उपलब्धता नसणे :**

आपल्या देशात अजूनही अनेक खेड्या गावात इंटरनेट उपलब्ध नाही आहे व ज्या लहान शहरांमध्ये इंटरनेट आहे तेथे त्या गुणवत्ता फार चांगली नाही आहे. ऑनलाईन शिक्षणासाठी योग्य नेटवर्कची आवश्यकता असते. ग्रामीण भागात नेटवर्क नसल्याने व्हिडिओ थांबणे, आवज ऐकू न येणे किंवा व्हिडिओ अडकणे या सारख्या समस्यांना सामोरे जावे लागते.

11. **विद्यार्थ्यां मध्ये शिस्तीची कमतरता:**

ऑनलाईन शिक्षणात विद्यार्थ्यां मध्ये शिस्तीची कमतरता निर्माण होते. आधी शाळेत गेल्यावर शिक्षेचे भयाने विद्यार्थी लक्ष देऊन शिक्षकांचे शिकवणे ऐकत असे. परंतु ऑनलाईन शिक्षणात विद्यार्थी काय करत आहे हे शिक्षकांना दिसत नाही. ज्यामुळे विद्यार्थी बेशिस्त होतात आणि कित्येकदा ऑनलाईन शिक्षणाला गांभीर्याने घेत नाहीत.

12. **शिक्षणात प्रात्यक्षिक शिक्षणाचा अभाव :**

व्यवहारीक अनुभव आणि प्रात्यक्षिकेही शिक्षणाच्या दृष्टिने खूप महत्त्वाची आहेत. ऑनलाईन शिक्षणात जास्त करून प्रात्यक्षिकांचा आभाव दिसून येतो. या शिक्षणात ॲनिमेटेड व्हिडिओचा उपयोग केला जातो. शाळेत विद्यार्थी भौतिक वस्तूंचे निरीक्षण करून अभ्यास करतात. हा प्रात्यक्षिक स्पर्श त्यांना अभ्यासाविषयी आवड निर्माण करतो. परंतु ऑनलाईन शिक्षणात याची कमी असते.

13. **अध्यापनात ऑनलाइन शिक्षणाप्रती विद्यार्थ्यांची अनास्था :**

वर्ग अध्यापन सारखे प्रत्यक्ष प्रभावी शिक्षण मिळत नसल्याची खंत विद्यार्थ्यांनी व्यक्त केली. त्यामुळे ऑनलाइन शिक्षणवर्ग अध्यापनात विद्यार्थ्यांची अनास्था दिसून आली.

14. **व्यवहारीक अनुभव /व्यापारी ज्ञानाचा अभाव :**

व्यवहारीक अनुभव /व्यापारी ज्ञानही शिक्षणाच्या दृष्टिने खूप महत्त्वाची आहेत. ऑनलाईन शिक्षणात अभाव दिसून येतो.

15. **विधार्थ्यंची खालावली आर्थिक परीरस्थिती :**

ऑनलाईन शिक्षणाचं एक नुकसान असं आहे कि, आपल्या देशात बरीच विधार्थ्यंची आर्थिक परीरस्थिती खालावली असते, आणि म्हणून ते एवढा महाग मोबाईल, किंवा लॅपटॉप घेऊ शकत नाही. आणि म्हणून मागासलेल्या क्षेत्रात विद्यार्थी ऑनलाईन शिक्षणपासून वंचित राहतात.

16. **एकतर्फी शिक्षण**

'सध्याचे ऑनलाइन शिक्षण एकतर्फी आहे. त्यामध्ये मुलांचा सक्रिय सहभाग नाही. त्यांनी केवळ ऐकण्याचे काम करायचे. विविध प्रयोग सादर करण्याची किंवा प्रश्न विचारण्याची सोय नाही. मुलांना शिकण्याचा अवकाश आणि स्वातंत्र्य नाही. आपण सैनिक तयार करतोय असे परखड मत प्रसिद्ध लेखक आणि बालसाहित्यक राजीव तांबे यांनी 'मटा' शी बोलताना व्यक्त केले.

17. **ऑनलाइन शिक्षण हे गुणवत्तापूर्ण प्रत्यक्ष शिक्षणाच्या तुलनेत कमी :**

DOI PREFIX 10.22183
JOURNAL DOI 10.22183/RN
SIF 7.399

RESEARCH NEBULA
An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Arts, Commerce, Education & Social Sciences

ISSN INTERNATIONAL STANDARD SERIAL NUMBER INDIA
ISSN 2277-8071

अजूनही अनेक शिक्षक आणि विद्यार्थ्यांमध्ये आश्
गणिताबद्दलही ऑनलाइन शिक्षण हे प्रत्यक्ष शिक्षणा
तुलनेत कमी दर्जाचे समजले जाते या दोन्हीं पैकी एकाचा पर्
निवडायचा झाल्यास अनेकांची पसंती कॅपस आधा
शिक्षणालाच असेल.

18. विद्यार्थी अधिक काळ ऑनलाईन राहिल्यामुळे पालकांची न
चुकवून अध्यापन शिक्षणाव्यतिरिक्त इतरही आक्षेपार्ह व्हिडि
पाहण्याची शक्यता वाढली.
19. ऑनलाइन शिक्षण प्रणालीमुळे मुलांची मानसिक तर
करण्याची जबाबदारी पालकांवर येऊन पडले.
20. अनेक शाळांकडे आवश्यक इन्फ्रास्ट्रक्चर उपलब्ध नाही.
21. ऑनलाइन शिक्षणामुळे मेंदूतील चेतापेशी डॅमेज होऊन ऑटि
हा आजार होऊ शकतो. यामुळे मेंदूत बिघाड होत नाही
स्वमग्नता येण्याची शक्यता असते, असे मानस शास्त्रज्ञांचे
आहे.
22. काही विद्यार्थी तर फक्त लॉगिन करून ठेवतात आणि
दुसरेच कोणते तरी काम करीत असल्याचेही निदर्शनास आ

<u>ऑनलाइन शिक्षणामुळे मिळणाऱ्या सुवर्णसंधी / फायदे :</u>

1. **घरबसल्या शिक्षण :**

ऑनलाइन शिक्षणाला आधुनिक शिक्षणाचे नवीन स्वरूप म्ह
जाऊ शकते. ज्यात विद्यार्थ्यांना लांब प्रवास न करता
बसल्या मोबाईल, स्मार्टफोन किंवा संगणक, लॅपटॉप वरू
शिक्षकांशी संपर्क करता येतो. आज शाळा, कॉलेज तसेच स्
परीक्षांची तयारी करणारे विद्यार्थी कोचिंगसाठी घराबाहेर
जाता, घरीच राहून निश्चिंतपणे शिक्षण घेत आहेत.

2. **स्पर्धा परीक्षांचा अभ्यासासाठी :**

विविध स्पर्धा परीक्षांचा अभ्यास करणारे विद्यार्थी महाराष्ट्रा
विविध भागातून पुण्या-मुंबई सारख्या शहरात येतात. ऑनल
शिक्षणाच्या योग्य अंमल बजावणी ने थेट प्रसारणा
माध्यमातून विद्यार्थी घर बसल्या शिक्षण घेऊ शकतात. हे
माध्यमाद्वारे होऊ शकते. आधीच रेकॉर्ड केलेली व्हिडिअ
बँक विद्यार्थ्यांना मदत करू शकते व जसे प्रत्यक्ष वर्गात शि
शिकवतात त्याचप्रमाणे ऑनलाइन माध्यमातून शिक्षण
शक्य आहे.

3. **वेळेची आणि पैशाची बचत :**

मुंबई सारख्या महानगरांमध्ये विद्यार्थी रोज दीड ते दोन त
फक्त प्रवास करतात व कॉलेजला येतात. प्राध्यापकांची ऑडिओ
अथवा विडिओ माध्यमातील लेक्चर्स विद्यार्थ्यांच्या मोबाई
फोनवर असतील तर ट्रेनमधील प्रवासात अभ्यास करणे सुद
शक्य आहे.

4. जर ऑनलाईन वर्गाच्या वेळी विद्यार्थ्याला एखादा मुद्दा स्पष्टपणे समजला नसेल तर तो शिक्षकांना पुन्हा तो मुद्दा सांगण्यास सांगू शकतो. याशिवाय विद्यार्थ्याला कोणताही टॉपिक जर समजत नसेल तर तो रेकॉर्ड केलेल्या लेक्चर ला पुन्हा पाहू शकतो.
5. विदेशात शिक्षणाची ईच्छा असूनही आर्थिक परिस्थिती ठीक नसणाऱ्या विद्यार्थ्यांना या शिक्षणाचा फायदा झाला आहे. विद्यार्थी देशातील व परदेशातील कोणत्याही संस्थेचे शिक्षण मिळवू शकेल. शहरात मिळणारे दर्जेदार शिक्षण गावातील मुलांना देखील मिळत आहे.
6. ऑनलाईन शिक्षणामध्ये तांत्रिक क्षमता विकसित करण्याच्या संधी असतात. जागतिक साधन आणि ग्रंथालय मिळण्याची शक्यता असते.
7. पारदर्शकता, कागदपत्रे, उतारा, जिवंत चर्चा, प्रशिक्षण साहित्य सहज उपलब्ध.
8. ऑनलाईन शिक्षण व्यवस्थेमुळे शिक्षणाचे सार्वत्रिकीकरण, ज्ञानाची देवाण-घेवाण होण्यास मदत होईल. गरीब, श्रीमंत, सामान्य विद्यार्थी, व्यावसायिक, शहरी, ग्रामीण साठी ऑनलाईन शिक्षण हे सर्वासाठी सोयीचे झाले आहे. उच्च शिक्षण व्यवस्थेत बदल घडवून आणण्याची क्षमता याच व्यवस्थेत आहे असे म्हटले तरी ती अतिशयोक्ती ठरू नये.
9. मुलांना अभ्यासात काय अडचणी येत आहेत, हे त्यांच्या आई-वडिलांना कळते.
10. कोरोना-१९ चा कोणताही धोका न पत्करता विद्यार्थी व शिक्षक ऑनलाइन शिक्षण पद्धतीचा वापर करू लागले. शिक्षक नवनवीन तंत्रज्ञान व विविध ॲप्स ची ज्ञान आत्मसात करून आधुनिक काळातील टेक्नोसॅव्ही शिक्षक बनत आहे.
11. आपला मुलगा ऑनलाइन शिक्षण कशा पद्धतीने आत्मसात करतो यावर पालकांचे लक्ष असून पालकांनाही आपल्या मुलाच्या ज्ञानाची व शिक्षण आत्मसात करण्याची कल्पना येऊ लागली. मोबाईलवर व्हिडिओ गेम खेळणे, टीव्ही पाहणे या ऐवजी ऑनलाइन अध्ययनात मुले व्यस्त झाली.
12. यांत्रिक क्षमता विकसित करण्याच्या संधी मिळतात
13. रोजगाराच्या सुवर्णसंधी प्राप्त होतात, व्यवसाय बद्दल माहिती मिळते, कोणतीही अडचण आल्यास युट्युब वरील व्हिडीओ पाहून विद्यार्थी ती समस्या सोडविण्याचा प्रयत्न करतात.

धोरणे आणि उपाययोजना :

कोरोना संकटाच्या काळात धोरण कर्त्यांना पोषण आणि मुलांचे शिक्षण या दोन समस्या तीव्रपणे भेडसावत आहेत. शाळेत मिळणा-या आहारावरच जर गदा येणार असेल तर शाळेत जावे तरी का? असा प्रश्न मुलांना पडण्याची शक्यता अधिक आहे.

DOI PREFIX 10.22183
JOURNAL DOI 10.22183/RN
SIF 7.399

RESEARCH NEBULA
An International Refereed, Peer Reviewed & Indexed Quarterly Journal in Arts, Commerce, Education & Social Sciences

ISSN 2277-8071

तेव्हा हा भयगंड मोठ्या प्रमाणात मुलांमध्ये निर्माण होऊ नये, यासाठी सरकारने मुलांना शाळांमध्ये पोषण आहार मिळेल, याची शाश्वती द्यायला हवी. केरळ, पश्चिमबंगाल, दिल्ली आणि आंध्र प्रदेश या राज्यांच्या सरकारांनी याबाबतीत वेळीच योग्य पाऊल उचलले आहे. मुलांच्या शाळा बंद असल्या तरी त्यांना घरपोच माध्यान्ह भोजन प्राप्त होईल, याची तजवीज या राज्यांनी अंगणवाडी सेवकांच्या माध्यमातून करून ठेवली आहे.

2. शिक्षकांनीही संगणक, वायरलेस, इंटरनेट किंवा अभ्यासासाठी समर्पित ठिकाण या सुविधांशिवाय विद्यार्थ्यांना विद्यादान कसे करता येईल, या दृष्टीने अभ्यास करून त्या पद्धतीने अभ्यास क्रमाची रचना करावी, असा विचार आता पुढे येऊ लागला आहे. दूरस्थ शिक्षण म्हणजे फक्त ऑनलाइन शिक्षण असे नाही तर संमिश्र माध्यमातून शिक्षण होय. अशा प्रकारच्या शिक्षणाचे उद्दिष्ट टीव्ही, रेडिओ आणि लघुसंदेश सेवा या माध्यमांतून अधिकाधिक विद्यार्थ्यांपर्यंत पोहोचणे, हे असते. टीव्ही द्वारे मुलांना शिक्षण देण्याच्या प्रक्रियेला पश्चिम बंगालमध्ये सुरुवात देखील झाली आहे. महाराष्ट्रातही असा प्रयोग राबविण्याचा विचार शासन पातळी वर गांभीर्याने केला जात आहे. साक्षरता आणि सामाजिक-आर्थिक दर्जा यांच्या पलीकडे जाऊन आज प्रत्येक पालक किंवा कुटुंब त्यांच्या पाल्याच्या शिक्षण प्रक्रियेत सहभागी होत आहे..

धोरणांची आखणी ही अशा पद्धतीने केली जावी की, ऑनलाइन पद्धतीने शिक्षण क्षेत्रातील सर्व समावेशकता आणि ना-नफा किंवा राजकीय प्रभावा पासून दूर राहणे इत्यादी घटकांना प्राधान्य द्यायला हवे. तसेच धोरण निश्चितीतही सर्जनशीलता, शैक्षणिक स्वातंत्र्य हवे. तसेच कायम स्वरुपी उपाय हवा.

3. ऑनलाईन पद्धतीने स्वयंअध्ययन काळाची गरज :

आजचा विद्यार्थी आणि त्याचे शिक्षण कोरोनामुळे लॉकडाऊन झाले आहे. त्याला पर्याय म्हणून ऑनलाइन शिक्षण अवलंबिले. मुले गेम खेळण्यासाठी 2-3 तास मोबाईल सहज हातात घेऊन असतात त्यामुळे ऑनलाईन मुळे आरोग्यास धोका होण्याच्या शक्यतेबाबत कोणताही आक्षेप नाही. शिवाय डिजिटल जगात जगण्याचा नवीन अनुभव त्यांना मिळतोय ही चांगली गोष्ट आहे. कॉलेजमधील विद्यार्थ्यांसाठी स्वयंअध्ययन ही संकल्पना उत्तम आहे. ऑनलाईन हि काळाची गरज आहे. मुंबईतील भारतीय तंत्रज्ञान संस्थेच्या (आयआयटी) प्राध्यापक सहाना मूर्ती यांच्या सारख्या तज्ज्ञांनी या परिस्थितीचे वर्णन आणीबाणीतील दूरस्थ शिक्षण असे केले आहे.

4. ऑनलाईन पद्धतीने अध्ययन - भारतीय उच्च शिक्षण संस्थांची सुरुवात :

उच्च शिक्षण संस्थांनी फारच संथ गतीने ऑनलाइन शिक्षण व्यवस्थेचा अंगीकार केला. त्यामुळे अचानक उद्भवलेल्या कोरोना संकटातून मार्ग काढण्यासाठी जेव्हा ऑनलाइन शिक्षणाची तातडीने गरज होती, तेव्हा साहजिकच उच्चशिक्षण संस्थांची तयारी पुरेशी नव्हतीच. ऑनलाइन अभ्यासक्रम किंवा कार्यक्रम या संदर्भात विद्यापीठ अनुदान आयोगाने २०१८ मध्ये तयार केलेल्या नियमांतर्गत ऑनलाइन शिक्षणाचे उपक्रम चालविण्यासाठी परवानगी मिळावी म्हणून देशातील केवळ सात उच्च शिक्षण संस्थांनीच अर्ज दाखल केले होते. ३० जानेवारी २०२० रोजी पर्यंत ची ही स्थिती. उल्लेखनीय म्हणजे ऑनलाइन अभ्यासक्रम चालवण्यासाठी ४० हजार उच्च शिक्षण संस्थांकडे कोरोना पूर्व काळात परवानगीच नव्हती. याचाच अर्थ असा की, कोरोना प्रादुर्भावाच्या पार्श्वभूमीवर सरकारने जेव्हा सर्व शिक्षण संस्थांना ऑनलाइन शिक्षण देण्याचे फर्मान सोडले तेव्हा बदललेल्या परिस्थितीशी जुळवून घेण्या इतपत या संस्थांची तयारी नव्हती, हे स्पष्ट होते. देशातील राष्ट्रीय संस्थात्मक श्रेणी रचनेतील (नॅशनल इन्स्टिट्यूशनल ऑफ रँकिंग फ्रेम वर्क-एन आय आर एफ) सर्वोच्च १०० संस्थांना ऑनलाइन कार्यक्रम चालविण्याची मंजुरी आपोआप मिळेल, असे माननीय अर्थमंत्र्यांनी मे महिन्याच्या मध्यात जाहीर केले.

निष्कर्ष :

ऑनलाइन शिक्षणाचे अनेक फायदे आहेत परंतु त्यासोबत दुष्परिणाम देखील आहेत. परंतु लॉकडाऊनच्या काळात याच शिक्षणामुळे विद्यार्थ्यांच्या शिक्षणात मदत झाली. याशिवाय दूर राहणाऱ्या तसेच वयस्क विद्यार्थी जे स्वशिस्त आहेत त्यांच्यासाठी ही शिक्षण पद्धत योग्य आहे. आज ऑनलाईन शिक्षणपद्धतीत सुधारणा करण्याची आवश्यकता आहे. परंतु बाल व किशोरवयीन मुलांसाठी पारंपारिक पद्धतीने शाळेत जाऊन शिक्षण घेणे जास्त योग्य आहे. शिक्षणाच्या या दोन्ही पद्धती वापरून विद्यार्थी आपल्या ज्ञानात वृध्दी करून आयुष्यात यश मिळवू शकतो. ऑनलाइन शिक्षणात सर्व प्रकारचे मार्ग आहेत. हा काही विशिष्ट वर्गांसाठी, विशिष्ट वयोगटांवरील विद्यार्थ्यांसाठी उत्तम पर्याय होऊ शकतो. यासाठी शिक्षकांबरोबरच विद्यार्थ्यांना सुद्धा आपल्यात योग्य तो बदल करून घ्यावा लागेल. सरकारने एकूणच शिक्षण पद्धतीवर कायम स्वरूपी योग्य उपाय योजना करणे गरजेचे आहे.

संदर्भ ग्रंथ सूची :

1. https://maharashtratimes.com/maharashtra/pune-news/one-way-online-learning/articleshow/77334508.cms

2. https://www.navshakti.co.in/online-learning-what-do-you-think/
3. https://www.orfonline.org/marathi/sustained-shift-to-virtual-classrooms-may-not-be-a-good-idea-for-india-65701/
4. https://www.orfonline.org/marathi/graduating-from-emergency-remote-teaching-to-online-higher-education-in-india-67434/
5. https://www.navshakti.co.in/online-learning/
6. https://marathi.momspresso.com/parenting/tiche-apurna-svapna/article/onnalaina-shikshana-phayade-ani-tote-us2zhev1n8r9
7. https://maharashtratimes.com/editorial/article/article-on-inside-classroom-education-and-online-education-by-deepak-phatak/articleshow/79949433.cms
8. महाराष्ट्र टाइम्स
9. https://360marathi.in/online-shikshan-marathi-nibandh/
10. https://www.lokmat.com/vashim/impact-online-learning-students-health-a310/
11. https://www.bhashanmarathi.com/2021/02/online-education-essay-in-marathi.html
12. https://www.saamana.com/article-on-online-education-3/
13. https://kartavyasadhana.in/view-article/snehalata-jadhav-writes-about-online-education
14. https://mh20live.com/online-learning-is-a-need-of-the-hour/
15. https://www.educationalmarathi.com/2021/03/online-shikshan-kalachi-garaj.html
16. https://marathi.thewire.in/coronavirus-lockdown-and-online-education

COVID-19 and its Implications on the Digital Marketing

Dr. D. H. Puttewar
Assistant Professor, Department of Commerce Dr. Ambedkar College, Deekshabhoomi, Nagpur ,Email: deepaliputtewar18@gmail.com

ABSTRACT

The COVID-19 has been the worst pandemic in world history in terms of size and scope of global spread, casualties, economic impact, and negative effect on human health. The COVID-19 crisis has also impacted the style of implementation of integrated marketing and its related spending in businesses. Digital marketing is becoming the substitute for the business to cope up with the pandemic situation. This paper focuses on the implications of COVID-19 on Digital Marketing

Keywords: Pandemic, digital marketing, business

Introduction

COVID-19 spreads across all the nations, people of entire world had learned to cope with a new way of living. While businesses were already losing favor among shoppers, stay-home orders have all but crippled the market.The organizations that are best positioned to survive in this environment are those that had already begun to pivot to a digital marketplace. But having a working website and ecommerce presence is only half the battle. It is important ability to get customers to those product pages. The pandemic had transformed the business. The businesses are adopting various strategies to grab the customer's base. The businesses who have adopted the digital marketing strategies are moving forward and getting more and more customers. And those businesses were survived during the pandemic situation.

Objectives

1.To study the Pandemic situation
2.To study the role of Digital Marketing in business.
3.To analyze the impact of COVID-19 on Digital Marketing

Hypothesis

Ho : There is no significant impact of COVID-19 on the business through Digital Marketing
H_1 : There is a significant impact of COVID-19 on the business through Digital Marketing

Pandemic

The coronavirus outbreak came to light on December 31, 2019 when China informed the World Health Organisation of a cluster of cases of pneumonia of an unknown cause in Wuhan City in Hubei Province. Subsequently the disease spread to more Provinces in China, and to the rest of the world. The WHO has now declared it a pandemic. The virus has been named SARS-CoV-2 and the disease is now called COVID-19.

More than 1.7 million people died. Around 80 million people are known to have contracted the virus, though the actual number is likely much higher. Children became orphans, grandparents were lost and partners bereaved as loved ones died alone in hospital, bedside visits considered too dangerous to risk.

This is a pandemic experience that's unique in the lifetime of every single person on Earth," says StenVermund, infectious disease epidemiologist and dean of Yale School of Public Health. "Hardly any of us haven't been touched by it."

Businesses closed. Schools and colleges shut. Live sport was cancelled. Commercial airline travel saw its most violent contraction in history. Shops, clubs, bars and restaurants closed. Spain's

lockdown was so severe that children couldn't leave home. People were suddenly trapped, cheek by jowl in tiny apartments for weeks on end.

Those who could, worked from home. Zoom calls replaced meetings, business travel and parties. Those whose jobs were not transferrable were often sacked or forced to risk their health and work regardless.

Impact of Pandemic on Business

The consumers are now online. And so are our competitors. That means business owners need to emphasis on positioning their brands front and center so that they remain in the path of their target audience. And so you've noticed, more virtual, remote, and contactless solutions are launching themselves as commonplace in every facet. This has helped digital marketers to reach out, engage, and connect with consumers where they may be and that is not going to change anytime soon.

What has really been a deal-breaker is that COVID was the specific reason for brands to stand out in the crowd and connect with existing as well as dormant customers. While some brands were left scrambling to get on board the digital network, those previously established in the space were able to claim the customers their competitors were losing, whether it was by present up-to-date information, products that consumers needed, or delivery options.

Research from McKinsey found that 75% of American purchasers had changed their shopping behavior and brand preference amongst the pandemic. More interestingly, more than 60% plan to stick with these purchasing habit changes post-crisis. Brands need to refine their strategies to understand the impact of COVID is going to go far beyond a year or two. The focus of many digital marketers is on improving customer loyalty and retention as well. Forrester supposes spending on improving the customer experience to upsurge by 30% this year, allowing businesses to hold onto the new online customers that were increased during the 2020 e-commerce boom.

The Growing Role of Digital Marketing

As majority of businesses enter the online marketplace, the competition for traffic converts even greater. Against market leading online traders like Amazon, Walmart, and Target, smaller brands face a challenge in being found by online purchasers.

For this reason, digital marketing is critical in building brand recognition and increasing traffic to business websites. A complete digital marketing policy starts with creating a search-optimized website and includes an active social media presence.

While many small companies stress on organic marketing efforts like social media and traditional outreach, paid media is becoming additionally important in the fight for customer attention online.

This includes social media ads and Pay Per Click (PPC) promotions and falls under the term of search engine optimization and marketing (SEM).

Role of Digital Marketing during Pandemic

In the marketing world no arena of businesshas changed faster than digital marketing and credit goes to the COVID-19 pandemic. As Technology is altering our world at an astonishing pace, it becomes difficult to keep up with dissimilar new trends in the industry. With the arrival of the pandemic, people started expenditure more time online than ever before and enhanced their online presence widening the online business opportunity likely a bright future for digital marketing agencies.

With the advent of COVID-19, people around the world narrowed to their homes for long periods followed by the norms of social distancing which resulted in enduring behavior change of the consumers producing a great shift in the consumption pattern of information, goods, and services. More the people cooperate with the technologies more enjoyed the experience, making it a regular part of their lives regardless of pandemic or no pandemic.

Digital Marketing and Advertising houses need to Get off the cutting edge and leap to the bleeding edge to make thrilling changes and lead the Marketing profession. It's clear that digital marketing is evolving to keep pace with new technological inventions and changing consumer preferences, such as the expectation for ads and gratified to be increasingly personalized and relevant to the individual.

The pandemic has obliged businesses also to shift online to showcase their products and services which have prompted brands to create content that is contextual and applicable to garner larger mindshare from their customer base. Marketing agencies will have to endure to innovate and develop whether that's investing in graphic designers or taking advantage of tech inventions that prioritize user experience to derive success. We need to remove all barriers to guarantee their marketing efforts are successful in this COVID world.

Digital marketing has become a solution as well as a means to content needs as basic as food, but also contact with friends and family, entertainment and attainment of information, goods, and services normally accessed physically and in person. However, the influx of lockdown has dramatically increased the size, availability, and profile of the digital audience and has changed their behaviors, expectations, consumption of content, and the way they expect to be interrelated with as customers.

With more consumers online than ever before, activities can't afford to slack. These agencies realized they could do away with luxurious offices and saving on fixed costs, utilize the freelance economy to provide excellent work for clients as needed. Technology has made this a seamless process, allowing agencies to get highly professional work done without having to maintain full-time employees.

Last but not the least, COVID-19 might not totally change the future of digital marketing agencies, but it has modified existing trends. Marketing agencies have been successful at adapting to these variations during the pandemic, but they need to endure to do so even after the pandemic is gone.

Hypothesis Testing

Hypothesis assumed during this research have been the *proposition* as statements about the observable phenomena in this study that may be judged as *true* or *false*. As a declarative statement about the two or more variables, the hypotheses stated were of the tentative and notional nature. The Hypotheses assumed during the study are :

Ho :There is no significant impact of COVID-19 on the business through Digital Marketing

H_1 : There is a significant impact of COVID-19 on the business through Digital Marketing

The hypotheses stated above have been formed after carefully analyzing the research objectives and the problem definition. In a nutshell, the hypothesis assumed during this research study has been the best expression of the research objective in the form of a well-formed and testable statement which could be disproved or proved by empirical data.

This hypothesis regarding impact of COVID-19 on the business through Digital Marketing is tested through the One Sample t-test using statistical software SPSS.

To test this hypothesis; a Likert scale is used. Response of 1499 member respondents are recorded and inputted in the SPSS software. The mean value generated is 2.68 and Standard Deviation is 1.2146. The test value is set as 5 as Likert scale is five level scale to record the responses. From the above One Sample t-test hypothesis is significant i.e. 0.023. So the NULL hypothesis is rejected and the alternate hypothesis 'There is a significant impact of COVID-19 on the business through Digital Marketing' is accepted.

Conclusion

It is essential to understand that both consumers and providers have changed their behaviours and interrelatingtherefore as per the new norms. There may be a greater demand for digital marketing going onward, but this will be balanced out by increased competition and to stand out, one will have to develop a strong brand and invest in business suppleness that works better with clients.

Undoubtedly, the future is bright for digital marketing organisations, but as ever, only for those that are able to convert pandemic situation to an opportunity and adapt the technology accordingly to improve the business.

The COVID-19 had transformed the businesses and the consumers. The consumers become online and they purchase through online mode. The business who adopted had gain the consumer preference and business. Thus COVID-19 on the business through Digital Marketing'

Reference:

Akca, Y., &Ozer, G. (2014).Diffusion of innovation theory and an implementation on enterprise resource planning systems. International Journal of Business and Management, 9, 92-103. doi:10.5539/ijbm.v9n4p92

Alharbie, A. (2015). Business growth thru social media marketing. International Journal of Innovation and Applied Studies, 13, 873-880. Retrieved from ww.ijias.issrjournals.org

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: A tool to enhance trustworthiness or merely a nod to validation? Qualitative Health Research, 26, 1802-1811. doi:10.1177/1049732316654870

Chandna, V., &Salimath, M. (2018). Peer-to-peer selling in online platforms: A salient business model for virtual entrepreneurship. Journal of Business Research, 84, 162-174. doi:10.1016/j.jbusres.2017.11.019

Gaikwad, M., & Kate, P. (2016). E-marketing: A modern approach of business at the door of consumer. International Journal of Research in Commerce and Management, 7, 56-61. Retrieved from www.ijrcm.org.in

Gopinath, S., Thomas, J., &Krishnamurthi, L. (2014).Investigating the relationship between the content of online word of mouth, advertising, and brand performance. Journal of Marketing Science, 33, 159-314. doi:10.1287/mksc.2013.0820

Morse, J. M. (2015). Analytic strategies and sample size. Qualitative Health Research, 25, 1317-1318. doi:10.1177/1049732315602867

Roy, G., Datta, D., &Basu, R. (2017).Effect of EWOM valence on online retail sales. Global Business Review, 18, 198-209. doi:10.1177/097215091666966

Sutton, J., & Austin, Z. (2015). Qualitative research: Data collection, analysis, and management. Canadian Journal of Hospital Pharmacy, 68, 226–231. Retrieved from www.cjhp-online.ca

Yin, R. (2014). Case study research: Design and methods (5th ed.). Thousand Oaks, CA: Sage

https://www.prismglobalmarketing.com/blog/how-covid-19-pandemic-impacted-digital-marketing

https://www.simplilearn.com/digital-marketing-during-the-pandemic-article

https://www.republicworld.com/opinions/blogs/how-covid-19-pandemic-has-changed-the-future-of-digital-marketing-and-advertising-agencies.html

https://www.tritoncommerce.com/blog/articleid/190/the-importance-of-digital-marketing-during-and-after-covid-19

https://www.wordstream.com/blog/ws/2020/10/27/post-pandemic-marketing-strategies

B.Aadhar' International Peer-Reviewed Indexed Research Journal

Impact Factor -(SJIF) –8.575,Issue NO, 345 (CCCXLV)

ISSN : 2278-9308

March, 2022

Role of Skill Development Programs on the Entrepreneurship Development in line with the New Education Policy

Dr. D. H. Puttewar

Assistant Professor Department of Commerce Dr. Ambedkar College,Deekshabhoomi, Nagpur

E. Mail- deepaliputtewar18@gmail.com , Mob. No. 7755992664

Abstract:

The skill development is the training which provides by the institutions/ employers/ government to improve the skill, quality and efficiency of the students/ employee, entrepreneurs at the workplace. The importance of the training to ensures availability of skilled manpower at all levels including management levels, Enhancing abilities, Potential among entrepreneurs, Increase efficiency, Maintain and enhance product quality, Minimize wastages in production process, Minimize accidents on the job, Reduce fatigue and increase speed of work, Standardizations in industry and internal processes. This paper focuses on the various skill development programmeswhich helping in improving the employability skills amongst students.

Keywords : skill development, entrepreneurship development , NEP

Introduction :

The Indian economy is currently valued at around 3 Billion USD and the government aims to be a Five Trillion USD by 2025. This aim can be achieved only if we are increasing economic activities and promote new business, ideas and provide industrial opportunities that form a basis for development. Besides, it will require factors like entrepreneurship, Skill development, Skilled Human resource, modern technologies, knowledge and innovation etc. this is because these modern business and industries are acting as a catalyst in promoting this aspiration amongst us towards that path. Or it can also be said that India, with its Unity in Diversity, is looking at entrepreneurship and skill development as those factors which will help in achieving National Integration via Economic Development. But for this purpose, we need skilled work force as any business will depend upon them for its uninterrupted operations and for providing goods and services as per the need and requirement of the customers.

Skill Development is an essential element for a successful entrepreneurial culture in a country, and, so both complement each other. The India Economic Survey 2018-19 has discussed the importance of Entrepreneurship and has called for making the Indian MSME sector more productive and competitive at the International Level.

Given the current economic challenges facing many countries across the globe, the notion of engendering greater entrepreneurial activity has become a prominent goal for many national governments. The relevance of entrepreneurship to economic development has been highlighted by many researchers. Training opportunities play a key role in cultivating future entrepreneurs and in developing the abilities of existing entrepreneurs to grow their business to greater levels of success.

More globally, governments across the world are increasingly recognising the positive impact that the creation of new businesses can have on employment levels, as well as the competitive advantages that small firms can bring to the marketplace (Scase, 2000). Moreover, while entrepreneurship provides benefits in terms of social and economic growth, it also offers benefits in terms of individual fulfillment, with entrepreneurship now breaking through the barriers of class, age, gender, sexual orientation, and race. However, because the relationship between entrepreneurship and economic growth is quite complex, many different approaches to encouraging entrepreneurship have been applied by a wide variety of agencies, with enterprise policies varying from country to country.

Skills and knowledge are the dynamic forces for the growth of economy and social development of the country. Those Countries having higher and better levels of skills can cope-up more effectively to the challenges and opportunities of work. As India moves progressively towards becoming a knowledge economy it becomes increasingly important that the country should focus on advancement of skills and these skills have to be relevant to the emerging economic environment. In order to achieve the twin

targets of economic growth and inclusive development, India's Gross Domestic Product has to grow consistently at 8% to 9% per annum. This requires significant progress in several areas, including infrastructure development, agricultural growth coupled with productivity improvements, financial sector growth, a healthy business environment, ably supported by a skilled workforce.

The development of manpower is a key concept and challenging task before concern authority through proper education system and training activities in the current scenario. The developing economy does not require only human employees but skilled and trained employees in the various sectors by way of new skills and the training curriculum. This requires a new syllabus, new trainers who can teach new skills and the infrastructure where people can be trained. The demand for specific skills is very high, and it is often not met by the educational institutes due to lack of training institutes, training facilities, education policy or it can be due of availability of trained trainers to train required skills. For instance, in spite of the boom in the construction sector, simple skills like water-proofing, fencing, or scaffolding has shortage of supply.

The demand for employment in India in the year 2007 is estimated to grow to 800 million. Most of this demand will be for youth equipped with technical and soft skills. It will require training in flexible and varied skills like Critical thinking, Teamwork, Multilingual abilities and Customer orientedness. However, according to the Planning Commission, there are 940 million in the workforce, 60% of whom are between the ages 15 to 35, it may be a good news but the reality is unemployability because they are trained in civil service type of jobs which are characterized by rote learning, a hierarchical structure, a focus on one skill, one language, a rigid and inflexible attitude. The numbers say that a billion plus population with unemployment at 9.1% i.e. 42 million people and by 2025 it will grow to 2 billion people. The number of college graduates is expected to rise by 2025 in-between 1.5 billion to 2 billion annually and in the same period about 20 million new jobs will be created. Although it looks like a perfect demand-supply balance, 80% of the manpower will be unemployed which is quite an irony. The labour force participation is as low as 940 million of a 1 billion population. Organized employment has been stagnant at 940 million for thirty years (200 million in Public Sector, 100 million in Private Sector). Given that 600 million people are below the poverty line, even the majority of those employed can barely sustain themselves.

Skill development and entrepreneurship efforts across the country have been highly fragmented so far. As compared to developed countries, where the percentage of skilled employees is between 60% to 90% of the total workforce, India records as low as 5% of workforce (20-24 years) with formal vocational skills. There is a need for speedy reorganization of the ecosystem of skill development and entrepreneurship promotion in the country to suit the needs of the industry and enable decent quality of life to its population. Today, more than 20 Ministries/Departments run 70 plus schemes for skill development in the country. The various ministries of central government engaged in skill development programmes. There are gaps in the capacity and quality of training infrastructure as well as outputs, insufficient focus on workforce aspirations, lack of certification and common standards and a pointed lack of focus on the unorganized sector.

Skill Development :

Skills development is the process of (1) identifying your skill gaps, and (2) developing and honing these skills. It is important because your skills determine your ability to execute your plans with success.

Imagine a carpenter trying to build a house. He has the raw materials but lacks good wood working tools. He has, however, a flimsy hammer and a small screwdriver. Without the right tools like a hand saw, he can't turn these raw materials into house building pieces.

It's the same with goal achievement. In goal achievement, your skills are your tools. The house is your goal. Just as you need the right tools to build a house, you need the right skills to build your goal. **Without the right skills, you will only frustrate yourself, waste your time, and spend a lot of time dealing with rudimentary issues caused by the lack of knowledge or lack of skills, as opposed to progressing in your goal.** While difficulty and struggle is part and parcel of any goal pursuit, without the right skills, you find yourself struggling more than necessary. Worse still, this struggle is unconstructive and doesn't help you move forward.

Government of Maharashtra has put in place an institutional structure for skill development in the State up to the district level. It has set itself up a target of generating 4.5 crore skilled manpower by 2022. It has formed the State Management Committee of Skill Development Initiative for Maharashtra and Sectoral Skill Committees under the Department of Higher and Technical Education.

Key skill development initiatives taken by the Government so far include:

- Sectoral Skill Development Committees have identified 11 high demand trades in the State: Construction, Production & manufacturing; textile; automobile; hospitality; healthcare; BFSI; retail; pharmaceuticals and chemicals; IT / ITeS and agro processing
- Of these, sector skill reports have been released for nine sectors so far
- Maharashtra State Skill Development Society has been established as a Single Nodal Agency for skill development initiative with the objective of preparation and continuous updating of 'State Skill Gap Assessment Report' and 'State Skill Development Plan'. It is also responsible for empanelling and grading training providers; and to provide support to district and division level committees and sectoral / territorial skill mission officers in the state for the preparation and effective implementation of 'Annual Action Plans'
- Knowledge Management Centre on Skill Development has been proposed to be established at Yashada, Pune
- Directorate of Establishment & Self Employment has set up a dynamic Labour Market Information System (LMIS)

Various skill development programmes are run by many Government Departments as well. Some of these are as follows:

- Employment Promotion Programme (EPP): On-the-job training or other practical training to educated unemployed persons. The programme is run by Department of Employment & SelfEmployment, Maharashtra. EPP is a stipend based scheme. The stipend paid to persons varies between Rs.300 to Rs.1000 per month, based on their educational qualification. Duration of each training programme is six months. On completion of training, the candidates may get absorbed.
- Apprenticeship Training Programme: Supply of skilled manpower to the industry through apprenticeship training. The programme is run by Directorate of Vocational Education & Training, Maharashtra. About 238 trades relating to both engineering and non-engineering industries have so far been designated under the programme. Duration of training varies from 6 months to 4 years. Stipend is also paid as a part of the training programme.
- Entrepreneurial Development & Training Programme: Motivate and train the educated unemployed youth for self-employment. It is run by Directorate of Industries, Maharashtra. The programme is run by recognized training institutions such as MITCON Consultancy Services Ltd. and Maharashtra Centre for Entrepreneurship Development (MCED). Under this scheme, the aspects such as the Entrepreneurship Development and Technical Training are covered

Factors related to Entrepreneurship and Skill development

- Why Entrepreneurship and Skill development are important in economy of a nation.
- Review of Policy and Institutional efforts taken by the government in promoting entrepreneurship and skill development and its challenges.
- Role of Entrepreneurship and Skill development in Women Empowerment and for youth.
- Potential efforts and areas for promoting Entrepreneurship and Skill development.
- Role of Entrepreneurship and Skill development in attainment of SDGs in the coming decade (2020-30).

Entrepreneurship refers to those business and industries that undertake different economic activities by utilization and effective management of available resources to provide for and fulfill needs of people and organizations by producing and distributing required goods & services. This is also marked by the risks of market Demand. Skills can be defined as the capability acquired by a person to work in any particular field. Thus, Skill development can be defined as honing up of one's skills that will help him in becoming an efficient and able Human Resource.

National Education Policy 2020

Education is fundamental for achieving full human potential, developing an equitable and just society, and promoting national development. Providing universal access to quality education is the key to India's continued ascent, and leadership on the global stage in terms of economic growth, social justice and equality, scientific advancement, national integration, and cultural preservation. Universal high-quality education is the best way forward for developing and maximizing our country's rich talents and resources for the good of the individual, the society, the country, and the world. India will have the highest population of young people in the world over the next decade, and our ability to provide high-quality educational opportunities to them will determine the future of our country. The global education development agenda reflected in the Goal 4 (SDG4) of the 2030 Agenda for Sustainable Development, adopted by India in 2015 - seeks to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" by 2030. Such a lofty goal will require the entire education system to be reconfigured to support and foster learning, so that all of the critical targets and goals (SDGs) of the 2030 Agenda for Sustainable Development can be achieved. The world is undergoing rapid changes in the knowledge landscape. With various dramatic scientific and technological advances, such as the rise of big data, machine learning, and artificial intelligence, many unskilled jobs worldwide may be taken over by machines, while the need for a skilled workforce, particularly involving mathematics, computer science, and data science, in conjunction with multidisciplinary abilities across the sciences, social sciences, and humanities, will be increasingly in greater demand. With climate change, increasing pollution, and depleting natural resources, there will be a sizeable shift in how we meet the world's energy, water, food, and sanitation needs, again resulting in the need for new skilled labour, particularly in biology, chemistry, physics, agriculture, climate science, and social science. The growing emergence of epidemics and pandemics will also call for collaborative research in infectious disease management and development of vaccines and the resultant social issues heightens the need for multidisciplinary learning. There will be a growing demand for humanities and art, as India moves towards becoming a developed country as well as among the three largest economies in the world.

The gap between the current state of learning outcomes and what is required must be bridged through undertaking major reforms that bring the highest quality, equity, and integrity into the system, from early childhood care and education through higher education. The aim of policy must be for India to have an education system by 2040 that is second to none, with equitable access to the highest-quality education for all learners regardless of social or economic background.

Role of Entrepreneurship and Skill Development in Economy of a Country

- To assist in elimination of social problems like Poverty, Hunger, Unemployment etc. in both urban and rural settings.
- Changes in the lifestyle of common man and participation in Nation Building through economic activities.
- Providing opportunity for young entrepreneurs to showcase their talent through various creative activities.
- Important contribution in providing skilled work force in various fields.
- To ensure social integration by providing better livelihood activities to all including women, Specially-abled people, Transgender etc.
- To promote Innovation and help in raising living standards of the people.
- Encouraging Industrial and commercial activities in rural and urban areas that will help our youth in becoming self-reliant.
- Development of MSMEs especially in rural sectors and encourage them to take risks and ensure growth.
- Important role in eradication of various social evils.

It is evident that Industries, Businesses and other commercial activities are always possible due to high quality skills and workmanship. The reason India was called as 'Golden Bird' was its abundant resources, entrepreneurial environment and market opportunities. And hence, various efforts have been undertaken to promote Entrepreneurship and Skill Development in our country since Independence.

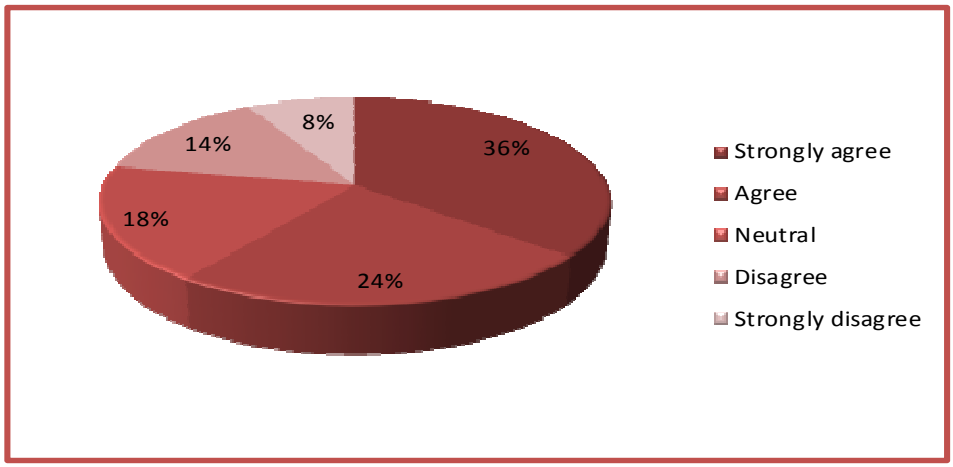
Also, after the New Economic Policy of 1991-92 that initiated liberalization, Privatization and Globalization, the Government, private Sector and people in general were drawn towards realizing their goals of better living standards and economic growth. The decade from 2011-2019 has been quite important with respect to Entrepreneurship and Skill Development in rural and urban areas alike as it was pushed greatly due to e-commerce and Information & communication technology. The Central and various state Governments have played an important role in providing conducive environment for growth of Entrepreneurship and Skill Development.

Table 1 : Does NEP fulfills the requirement of Skill Based Education

Total Respondents : 50

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
18	12	9	7	4

Graph 1 : Does NEP fulfills the requirement of Skill Based Education



The above graph shows the impact of NEP on the requirement of Skill Based Education. From the above graph it is found that 36% respondent are strongly agree with the statement 'NEP fulfills the requirement of Skill Based Education', while 24% are agree with the statement, 18% are neutral with the statement, 14% are disagree with the statement and 8% are strongly disagree with the statement.

That means majority of the respondents feels that 'NEP fulfills the requirement of Skill Based Education'.

Conclusion

Skill development programs on Employment and self-employment and a relevant contribution need to be made for the nation's economy. It is necessary to bridge the gap of employability and job placement among commerce students. So in view of institutions should start specialized skill development programme in collaboration with the industries, so that students become employable. Entrepreneurship & Skill Development are considered as the backbone of any country for achieving socio-economic development. India is taking huge efforts to promote Industries, businesses and other commercial activities and at the same time emerging entrepreneurs are being attracted and provided support also. On the other hand, it is an opportunity to carry out the ground work which is required to interlink Education and Skill development to Entrepreneurship, employment and self-employment so that we are able to provide quality and sustainable development to our next generations and the entire education system should be based on the NEP 2020. Also majority of the respondents feels that 'NEP fulfills the requirement of Skill Based Education'.

References

- BagulSnehal Ashok (2017), Skill Development Programs For Entrepreneurship Development By Government Of India, Pune Research Time, ISSN 2456-0960 Vol 2, Issue-1
- Binod Kumar Khadra, "Determinants of Skill Formation: An Analysis of interaction between the Education Market and the Rest of the Economy", Doctoral Thesis submitted to Jawaharlal Nehru University, New Delhi, 1982
- Cheng (1997), Becoming Self-Employed: The Case of Japanese Men. Sociological Perspectives, vol 40, pp 581–600.
- Deepak Chawla and NeenaSondhi (2011), "Research Methodology Concepts and Cases", Vikas Publishing House Pvt. Ltd.Entrepreneurship in India, NKC, 2019.
- GahaneRamlal (2019), Study of Performance of Skill Development Programmes and its impact on Job Placement of Commerce Students, International Journal of Research in Economics and Social Sciences(IJRESS), Volume 9 -Issue 1, pp 268-275.
- Patil, M.R. and Arolkar, D.B. (2011), "Industry Academia Interface: An Effective Tool Toward Skill Development", University News, vol 49(17), pp 9-17
- Satish Chandra (1975), "Higher Education in India, Lans and Prospect", Journal of higher Education, vol I (1), pp 5-14.
- Malwade, Varsha & Vijay, Tapas,. (2011). 'Human Resource and Skill Development in Maharashtra'.
- https://www.inspirajournals.com/uploads/Issues/1730929636.pdf
- http://puneresearch.com/media/data/issues/586fda7f7679d.pdf

IMPACT FACTOR 5.473(SJIF)
UPA NATIONAL E-JOURNAL
Interdisciplinary Peer-Reviewed Indexed Journal
Volume -8 : Issue-1 (February-2022)
ISSN 2455-4375

IMPACT OF DATA WAREHOUSING AND DATA MINING IN BUSINESS

***Dr. Prashant P. Yende*[1]**
Dr. Ambedkar College,Deekha Bhoomi, Nagpur
E-mail- drprashantyende@gmail.com
Mobile No.- 9822945982

***Dr. Pankaj V.Nimbalkar*[2]**
Dr. Ambedkar College,Deekha Bhoomi, Nagpur
E-mail- pankajnimbalkar3@gmail.com
Mobile No.- 9011095977

Abstract : *Information technology is now required in every aspect of our lives which help business and enterprise to make use of applications like decision support system, query and reporting online analytical processing, predictive analysis and business performance management. In this aspect this paper focuses on the significance and role of Data Warehousing and Data Mining technology in e-business. A Data Warehouse is a central repository of relational database designed for query and analysis. If helps the business organization to consolidate data from different varying sources. These warehouses are analyzed by the latest technique known as Data Mining. In Data Mining data sets will be explored to yield hidden and unknown predictions which can be used in future for the efficient decision making. Now companies use techniques of Data Mining that involves pattern recognition, mathematical and statistical techniques to search Data Warehouses and help the analyst in recognizing significant trends, facts relationships and anomalies.*

Keywords: Data Warehousing, Data Mining, OLAP, OLTP, CART & CHAID.

Introduction :

Since Data Warehouses are gaining enormous ground in Business Intelligence (BI), every organization gives highest priority to maintain a corporate Data Warehouse. Most business applications like online analytical processing, statistical/predictive analysis, complex query processing and critical business decisions are based on the data available in the Data Warehouse. Data Warehouse (DW) is a system that extracts, cleans, confirms and source data into a dimensional data store and then supports and implements querying and analysis for the purpose of decision making. Sophisticated OLAP and Data Mining tools are used to facilitate multinational analysis and complex business models. In mon W.H defines the Data Warehouse as a subject oriented, integrated, time variant andnon-volatile collection of data in support of management's decision making process [1].

BI applications in enterprises provide reports for the strategic management of business by collaborating the business data and electronic data interchange. This ensures competitive intelligence and thereby helps in good decision making [2]. According to B de Ville, BI refers to the technologies and application for collecting, storingand analyzing business data that helps

the enterprise to make better decisions [3]. Data Marts were used to analyze the data and it's a complex task that is time consuming. Thus for the improved analysis if data, Data Mining methodologies is used. The Data Mining process involves computer assisted analysis and extraction of large volume of business data. Frawley, Piatetsky and Mathues defined Data Mining as a nontrivial extraction of implicit, previously unknown and potentially useful information from data [4].

The combination of data warehousing and Data Mining technology has become an innovative idea in many business areas through the automation of routine tasks and simplification of administrative procedures.

Data Warehouse: Definition :

Data Warehouse is a repository of enterprise or business databases which provides a clear picture of current and historical operations of organizations [5]. Since it provides a coherent picture of the business conditions at a particular point of time, it is used for the efficient decision making process. it involves the development of system that helps the extraction of data in flexible ways. Data Mining describes the process of designing how the data is stored in order to improve the reporting and analysis. Data Warehouse experts consider that the various stores of data are connected and related to each other conceptually as well as physically. A business's data is usually stored across a number of Databases. However, to be able to analyze the broadest range of data, each of these databases needs to be connected in some way. This means that the data within them need a way of being related to other relevant data and that the physical databases themselves have a connection so their data can be looked at together for reporting purposes.

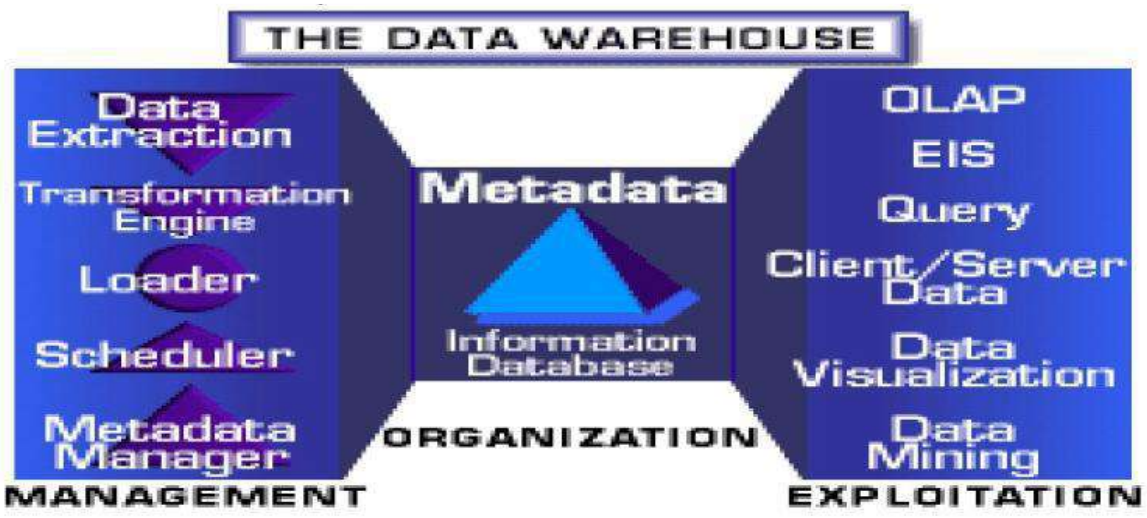


Fig 1: Data Warehouse [6]

Multiple data stores are integrated by the Data Warehouses and this information is used by the managers for better decision making. Data warehousing environment includes the Extraction

of relational database, Transformation, Loading (ETL process), Online Analytical Processing (OLAP) engine and client analysis tools. As a business grows globally, the parameters and complexities involved in analysis and decision making become more complex. Data access portion which is available in the form of products is the most visible part of a Data Warehouse project. Data warehousing process involves transformation of data from original format to a dimensional data store which consumes a greater percentage of effort, time and expenses. Since implementation of a data warehousing is expensive and critical, there are a number of data extraction and data cleaning tools and load and fresh utilities are available for the same.

Example of Data warehousing – Facebook :

A great example of data warehousing is what Facebook does. Facebook gathers al your data such as your friends, your likes, your groups etc. All these data are stored into one central repository. Although Facebook is storing all these information into separate databases, they store the most relevant and significant information into one central aggregated database. This is because of many reasons like to make sure that you see the most relevant ads that you are most likely to click on or the friends that they suggest are the most relevant to you.

Relevance of Data Warehouse :

Data Warehouse is a subject oriented, time variant, integrated and non-volatile collection of data. Data cleansing, data integration and Online Analytical Processing (OLAP) are a part of the data warehousing technology. It provides a complete and consistent data store from multiple sources which can be easily understood and used in business applications. Some of the application areas include:

- Integration of data across the enterprise.
- Quick decisions on current & historical data
- Provide ad-hoc information for loosely-defined system
- Manage & control businesses
- Solving what-if analysis.

Data Warehousing: Process :

Data warehousing is the process of centralizing or aggregating data from multiple sources into one common repository. Data warehousing occurs before Data Mining takes place. Data warehousing involves a strict engineering phase, where no business users are involved. In data warehousing, data stored in different databases are combined into one comprehensive and easily accessible database. This is available to business professionals or managers who use the data for Data Mining and to create forecasts. Data is fed from a variety of disparate sources into the Data Warehouse which is again converted, reformatted, summarized and used for managerial decision making. The process of data warehousing acts as a guideline to identify the business requirements, develop the business plan and create Data Warehouse also includes project management, startup and wrap-up activities.

Data Warehouse: Architecture :

Data Warehouse architecture is based on the various business processes associated with an organization. Some other considerations while going for the architecture of a Data Warehouse include data modeling, adequate security, metadata management, extent of query requirement and utilization of full technology. Metadata is data about data which is stored either as a unstructured or semi-structured form. These summary data are very useful in Data Warehouses. For example simple Data Warehouse query can be used to retrieve January sales. Data Warehouse architecture can be shown with the materialized view in Oracle 9i as below.

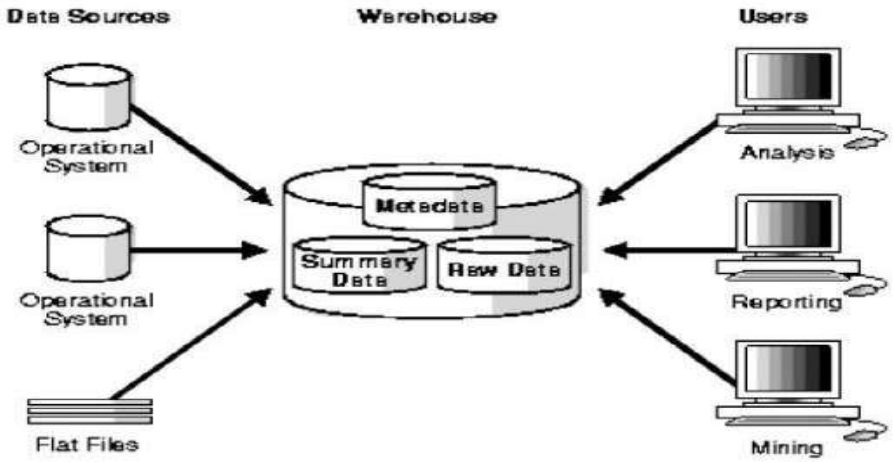


Fig 2: Data Warehouse Architecture [7]

From Data Warehouse To Data Mining :

It is necessary to choose adequate Data Mining algorithms for making Data Warehouse more useful. Data Mining algorithms are used for transforming data into business information and thereby improving decision making process. Data Mining is a set of methods used for data analysis, created with the aim to find out specific dependence, relations and rules related to data and making them out in the new higher level quality information [8]. Data Mining gives results that show the interdependence and relations of data. These dependences are mainly based on various mathematical and statistical relations [9]. Data are collected from internal database and converted into various documents, reports, list etc. which can be further used in decision making processes. After selecting the data for analysis, Data Mining is applied to the appropriate rules of behavior and patterns. That is the reasons why Data Mining is also known as “extraction of knowledge”, “data archeology” or “pattern analysis”.

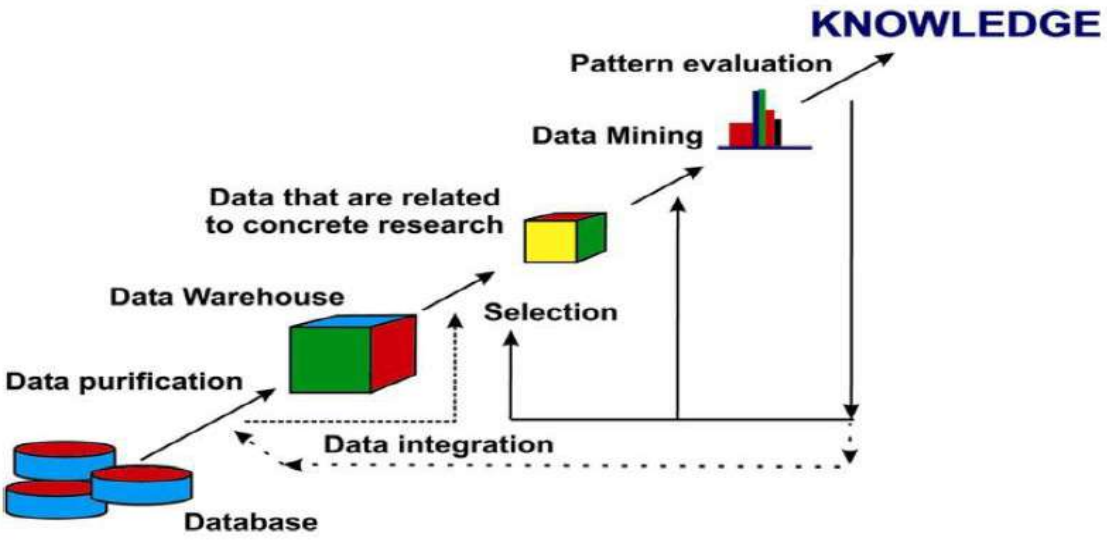


Fig 3: **The process of knowledge recovery from database by using Data Warehousing and DataMining technologies. [10].**

Example of Data Mining: Fraud detection of credit card usage :

Credit card companies will alert you when they think your credit card is fraudulently used by someone other than you. Companies will have a history of the customer's purchases and know geographically where the purchases have been made. If a purchase is made in a city far away from where you live, the companies will put an alert to possible fraud since their Data Mining shows that you don't normally make purchases in that city. Companies can either disable the card for that transaction or put a flag for suspicious activity.

Data Mining Process :

The process of Data Mining provides ways to make best use of data through rapid computerization [11]. Data Mining software uses modeling techniques to make a model that is a set of examples or a mathematical relationship based on data from situations where the answer is known and then applying the same model to other situations where answers are hidden. [12]

The 3 main stages involved in the process of Data Mining are:

1) **Exploration:** data preparation, cleaning and transformations are involved in this stage. A subset of records will be selected to reduce the number of variables to a manageable range. This depends on the complexity of analysis of graphical and statistical data.

2) **Model building and validation**: in this stage the best model will be taken based on their predictive performance. Various techniques used for comparison of models include bagging, boosting, stacking and Meta learning.

3) **Dependent:** in this final stage the best model is selected and it is applied to the new data sets to generate predictions of the expected outcome. One simple example for this is the online shopping site doing e-commerce transactions through credit card deploys neuralnetworks and Meta learner to identify fraud.

Data Mining process involves use of various techniques and methods. Most common techniques are:

1) **Classification:** stored data will be grouped into different classes. This allows locating data into pre-determined groups.

2) **Clustering:** Data items are grouped into clusters of similar groups. It may be of It may be of hierarchical or non-hierarchical.

3) **Regression:** this method uses a numerical data set to develop a best fit mathematical formula. This formula can be used to feed new data sets and get a better prediction. This is suitable for continuous quantitative data.

4) **Association:** it is a rule X->Y such that X and Y are data items sets.

5) **Sequential pattern matching:** it allows predicting behavior patterns and trends based on the sequential rule A->B which implies that event B will always be followed by A.

Next Generation Data Mining Techniques :

Data Mining uses black box approach to explore data and discovered knowledge using Exploratory Data Analysis (EDA) techniques. The techniques used in Data Mining are a blend of statistics, database research and artificial intelligence [13].

Next generation Data Mining techniques include artificial neural networks, decision trees, induction rules and genetic algorithms.

1) **Artificial neural networks:** This technique uses non-linear predictive models to enable learning through training. Computers are trained to think, act and take decision similar to humans. These models are quite complex to use even by the experts because it is packed as a complete solution[14]. It determines relevant prediction for a model.

2) **Rule induction:** This technique enables knowledge discovery and unsupervised learning. It extracts useful patterns from database based on accuracy and statistical significance. Prediction will be more correct and has better logic by neural network. It creates a certain confusions to select the best rule from a pool of rules. Normally rule induction is used on databases with many columns of binary fields or fields with higher cardinality in order to collect the suitable patterns for making a better prediction, a bottom – to – top approach is chosen.

3) **Decision trees:** Decision tree is a Data Mining technique where tree shapes structures are representing the set if decision generating rules for a data set classifications. The starting node or the top node is known as the root. Depending results of test, the root partitioned into two or more nodes. It is a fast Data Mining technique since its required less or no pre-processing of business data. It is used for both exploration and prediction using Classification And Regression Trees (CART) and Chi Square Automatic Interactions detection (CHAID). CART generates two way splits from data set segmentation which needs less preparation of data than

CHAID which generates a multi-way split. Rules are mutually exclusive and relatively exhaustive.

4) **Genetic algorithms:** This optimized technique of Data Mining is based on genetics and natural selections, combination and mutation [15]. Genetic algorithms are used in patterns recognition either as classifier or as an optimization tool. According to Chuck Kelly (2002), genetic algorithms support the survival of the fittest using heuristic functions even by posing the problems [16].

Infrastructure For Implementing Data Warehouse And Data Mining :

Data Warehouse and Data Mining application are quite divorced in size and storage capacities. Enterprise applications range from 10 GBs to higher. Data Warehouse is a very flexible solution that can explore database more efficiently than any other Online Transaction Processing (OLTP) environment. The major advantage of this is that the user does not have to possess knowledge of relational model and complex query languages.

Data ware house implementation phases.

According to Barry D & Addison – Wesley, 1997 Data Warehouse implementation phases include [17]:

1) Analysis of current situations: this is a very important phase in the Data Warehouse design, since at this phase a possibility of realization and solution of the problems can be seen. Since the users will have a better knowledge about the problems than the designers, their opinion is very crucial for a good warehouse design.
2) Selecting the most appropriate data for analysis from the existing data: instead of using the entire OLTP database, the data subset which includes all the interesting data related to the subject will be chosen.
3) Filtering data interesting for analysis: data analysis does not need all the data. Because of this the filtering of data will be done related to certain time period or some specific area.
4) Extracting data in staging database: after reducing and filtering of data, data are being extracted in staging database from which the Data Warehouse is being built. Data Transformation Services (DTS) package is written in SQL server 2000. Package writing is very significant in Data Warehouse implementation because packages can be arranged to function automatically so that the users can fresh and prompted data.
5) Selecting fact table, dimensional tables and appropriate schemas: entity-relationship model commonly used in the design of relational databases. This is suitable for OLTP. A Data Warehouse requires a concise, subject oriented schema that facilitates online data analysis. The simplest scheme is a single table scheme which consists of redundant fact table. Data Warehouse contains a large central fact table containing the bulk of data with no redundancy and a set of smaller dimension tables.
6) Selecting measurement, percentage of aggregations and warehouse models: the next step in designing Data Warehouse is selecting measurements. It needs calculated

measurements that are attained from various arithmetic operations with other measurements. Data Warehouse solutions also use aggregations through which they solve the queries very fast. The increasing of the percentage of aggregated data speeds up the user defined queries.

7) Creating and using the cube: the cube is being created on either client or server computer. Basic factors for selecting the place for cube's storehouse are size of the cube, performance of the client's and server's computers, number of the cube users and throughput of the system. The cube created can be used by the support of various client tools.

Data Mining Implementations

Microsoft Decision Tree (MDT) algorithms are based on possibility of various attributes and it is when prediction is necessary. These algorithms also generate rules. MDT also enables the user to analyze a large number of Data Mining problems.

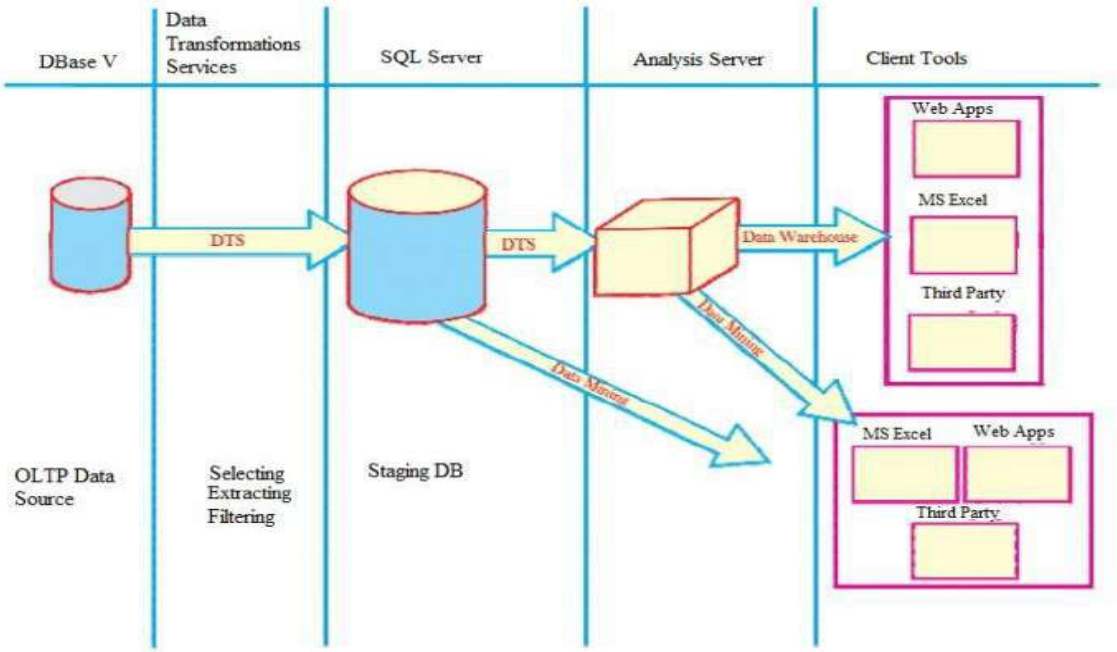


Fig 4: Scheme of Data Warehouse and Data Mining implementation [18].

Database size and query complexity are the 2 critical technological drivers for Data Mining. New hardware architectures like Massively Parallel Processors (MPP) are used which can link hundreds of speed processors to achieve better performance. Data Mining is now aggressively used in various industries [19]. All the major database vendors are using various Data Mining techniques in their platforms.

Some of them are:

1) SQL server: it is Microsoft database platform that allows Data Mining through the use of clustering and classification algorithms.

2) SAS, SPSS and S-PLUS are advanced statistical packages for implementing Data Mining algorithms.

3) Darwin: is an Oracle Data Mining suite for implementing classification and decision trees, K-nearest neighbors, regression analysis, clustering algorithms and neural networks.

Data Warehouse And Data Mining: Application Areas In Business :

Data warehousing and Data Mining has gained improved popularity in multiple areas of business to analyze the large databases quickly which would be too complex and time consuming. Some of these application areas are listed below.

Government: for searching terrorist profile and threat assessments.

- Finance: analysis and forecasting of business performance, for stock and bond analysis.
- Banking: to learn underwriting, mortgage approval etc.
- Direct marketing: for identifying prospects that are included in mailing list so as to obtain highest response time.
- Medicine: for drug analysis, diagnosis, quality control and epidemiological studies.
- Manufacturing: for improved quality control and maintenance.
- Churn analysis: to predict customers who are likely to quit the company and move to a competitor company.
- Market segmentation: to identify customer's common characteristics and behavior that purchases the same products of a company [20].
- Trend analysis: to analyze the difference between the customer's behavior over consecutive months.
- Fraud detection: to identify the fraud users in telecommunication industry as well as credit card usage.
- Web marketing: for advertisements and personalization opportunities.

Conclusion :

Data Warehouse and Data Mining technologies have bright future in business applications as it helps to generate new possibilities by automated prediction of trends and behaviors in a large database. Data Mining techniques help to automatically discover the unknown patterns like identifying anomalous data that highlight errors generated during the data entry. Data Warehouse & Data Mining technologies have become a hit with various industries like sales & marketing, healthcare organization, financial institutions and many more.

These technologies have a lot of benefits in varying fields. It can be said with pleasure that these technologies help the quick analysis of data and thereby improving the quality of decision making process. Both Data Mining and Data Warehousing are business intelligence tools that are used to turn information data into actionable knowledge. Data Warehouse experts design data storage system that connects relevant data in different databases where as a Data miner run more meaningful and efficient queries to improve business.

The immense data volumes and extremely complex knowledge discovery procedures associated with business organizations make the Data Warehouse with its OLAP and Data Mining tools a very significant technology supporting decision making. Thus Data Warehouse & Data Mining are very essential components in business operations to gain competitive intelligence. These technologies allow statistical multidimensional analysis of data to evaluate relationships, correlations and trends in business.

References :

- Inmon W.H., "*Building the Data Warehouse"*, Second Edition, JWiley and Sons, New York, 1996.
- P. Bergeron, C. A. Hiller, (2002), "Competitive intelligence", in B. Cronin, Annual Review of Information Science and Technology, zedford, N.J.: Information Today, vol. 36, chapter 8
- B. de Ville, (2001), *"Microsoft Data Mining: Integrated Business Intelligence for e-Commerce and Knowledge Management",* Boston: Digital press.
- Frawley W., Piatetsky – Shapiro G. and Matheus C., "Knowledge Discovery in Databases: An Overview", Al Magazine, Fall 1992, pgs 213-228.
- C. Date, (2003), *"Introduction to Database Systems",* 8th ed., Upper Saddle River, N.J.: Pearson Addison Wesley.
- Han Jiawei, Kamber Micheline, "*Data Mining: Concepts and Techniques"*, 2nd edition, Morgan Kaufman Publishers, March 2006. ISBN 1-55860-901-6.
- Oracle9i Data Warehousing Guide Release 2 (9.2), Part No. A96520-01, March 2002.
- Berry, M.J.A., and Linoff, G., *"Mastering data mining*", The Art and Science of Customer Relationship Management, 1999.
- Bhavani, T., *Data Mining: Technologies, Techniques, Tools and Trends*, 1999.
- Jiwei, H., and Micheline, K., *Data Mining: Concepts and Techniques*, Simon Fraser.
- D. Pyle, (2003), *"Business Modeling and Data Mining",* Morgan Kaufmann, San
- Francisco, CA.
- M.H. Dunham, (2005), "Data *Mining – Introductory and Advanced Topics"*, Prentice Hall.
- Berson Alex, Smith J. Stephen, Thearling Kurt, (1999), *"Building Data Mining Applications for CRM"*, McGraw-Hill Companies.
- Gilman Michael, (2004), "*Nuggets and Data Mining*", Data Mining Technologies Inc. Melville, NY 11714, (631) 692-4400
- Krulj, D., "*Design and implementation of data warehouse systems*", M Sc. Thesis, Faculty of Organizational Sciences, Belgrade, 2003.
- Chapple Mike, "*Data Mining: An Introduction*", (2011), http:/ /databases.about. com/od/datamining/ a/ datamining.htm.
- Alexander Doug, "*Data Mining*", (2000), http:// www.laits.utexas.edu/ norman/BUS.FOR /course.mat / Alex/, electronic articl

IMPACT FACTOR 5.473(SJIF)
UPA NATIONAL E-JOURNAL
Interdisciplinary Peer-Reviewed Indexed Journal
Volume -8 : Issue-1 (February-2022)
ISSN 2455-4375

SUMMARIZATION OF AUTOMATIC TEXT SIMPLIFICATION USING NATURAL LANGUAGE PROCESSING

Dr. Pankaj V. Nimbalkar
Assistant Professor,
Department of Computer Science
Dr. Ambedkar College,
Deekshabhoomi, Nagpur-10
Email:pankajnimbalkar3@gmail.com
Mobile No:9011095977

Abstract : *The world of internet is getting* ***exploded*** *with a bulk amount of data every day, being able to automatically summarize is big challenge. Summaries of long documents articles in news, or even conversations can help us consume content faster and more efficiently. Automatic Text Summarization is a growing field in NLP and has been getting more attention in the last few years.*

Keywords: NLP,Text simplification.

---

1. Types of Text Summarization

Two types of text summarization methods are extractive and abstractive. **Extractive summarization** is necessarily picking out sentences from the text that can best represent its summary. Extractive summarization techniques have been common for quite some time now, owing to its origin in 1951. It's more about learning to understand the importance of each sentence and their relations with each other rather than trying to understand the content of the text.

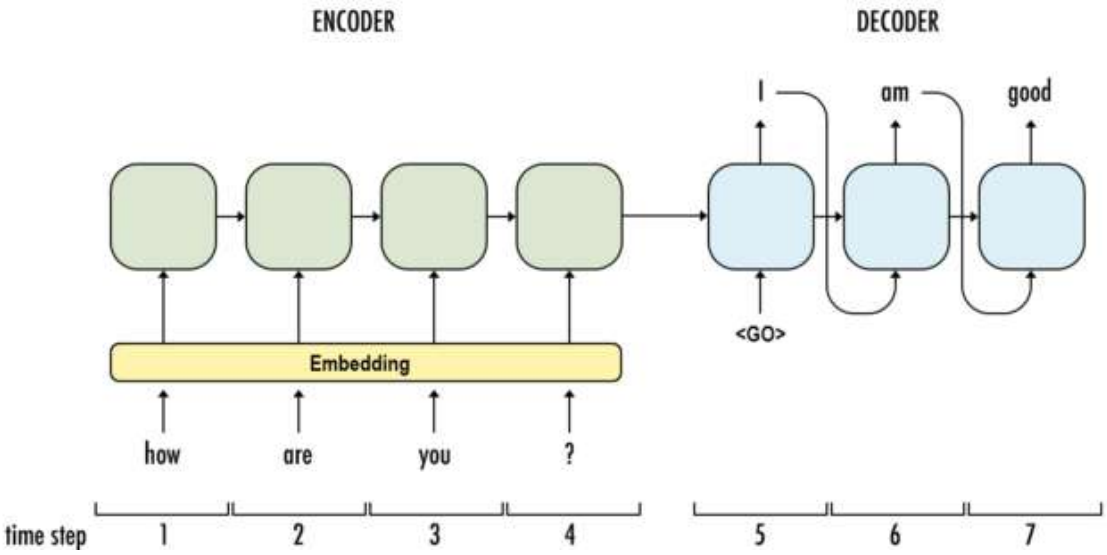
1.1 Abstractive summarization, on the other hand, is all about trying to understand the content of the text and then providing a summary based on that, which may or may not have the same sentences as present in the original text. Abstractive summarization tries to create its own sentences and is definitely a step towards more human-like summaries.

The techniques working to do extractive and abstractive summarization are different from each other. Extractive summarization is, crudely speaking, a sentence ranking problem while abstractive summarization involves more complex linguistic models as it generates new sentences.

1.2 Encoding and decoding Techniques:

since the arrival of Deep Learning and Abstractive Summarization, Interaction with machines through natural language and Machine Translation have all been getting a lot of success. Due to parallelism *Machine Translation and interaction* follows with Abstractive

Summarization. All of these techniques **encode** an input sentence into features and then tries to generate a different sentence i.e. **decode** these features.



A commonly used Deep Learning based Machine Translation model is an LSTM based Encoder Decoder network with Attention. The model starts with an LSTM based Encoder which converts the sentence into a vector of features. The decoder, also made up of an LSTM, is responsible for creating the output, one word at a time. The decoder starts with the vector of features provided by the encoder and then each word is predicted based on the previous word prediction and LSTM output. Attention is placed on the encoder features to make them even more specific to the current word.

Creation of new sentences is a complex process that the machines have not mastered yet. An issue with Abstractive Summarization is also the length of sentences to be encoded. While LSTMs have the ability to capture both long term and short term contexts, even they have a limit for long term. This makes summarizing really long documents difficult.

Another astronomically important issue for summaries is that it should never contain facts that contradict the input text. Extractive summarization can never face this problem since they pick up sentences directly from the text. But abstractive summarization is prone to such factual incoherence.

1.3 Benefits

The benefits of Automatic Text Summarization go beyond solving perceptible problems. Some other advantages of Text Summarization include:

Saves Time:

By generating automatic summaries, text summarization helps content editors save time and effort, which otherwise is invested in creating summaries of articles manually.

Instant Response:

It reduces the user's effort involved in exacting the relevant information. With automatic text summarization, the user can summarise an article in just a few seconds by using the software, thereby decreasing their reading time.

Increases Productivity Level:

Test Summarization enables the user to scan through the contents of a text for accurate, brief, and specific information. Therefore, the tool saves the user from the workload by reducing the size of the text and increasing the productivity level as the user can channel their energy to other critical things.

2. **AUTOMATIC MACHINE RECOGNITION OF FEATURES AND SENTIMENTS FROM ONLINE REVIEWS :**

E-commerce websites provide customers with the needed product information by giving a variety of services to choose from. One such service is to allow the customer to read the end user online reviews. Online reviews contain features which are helpful for the analysis in belief mining. Most of the systems work with the summarization of the features by taking the average features and their sentiments which leads to structured review information. Most of the times while classifying the sentiment of the review, the context of surrounding feature is undermined. In machine interpretable framework called Resource Description Framework (RDF) was introduce which helps in structuring these unstructured reviews in the form of features and sentiments obtained from traditional preprocessing and extraction techniques. The context data also supports for future ontology based analysis by taking the support of lexical database for word sense disambiguation. The Sentiments WordNet scores are used for sentiment word orientation. Many popular RDF vocabularies are helpful in the creation of such machine processable data. SQL queries are carried out on RDF data to learn the possibility for categorizing the reviews using feature information. This way to engineer the OWL Ontology for reasoning the RDF data. These results were processed by the interface as a feature, sentiment pair so that reviews are filtered clearly and help in satisfying the customer centric feature set.

3. **Data-driven Paradigm in Simplification** :

With the appearance of Simple English Wikipedia and its (comparable) alliance with English Wikipedia, which offered a large parallel dataset for training, It created opportunity for stronger NLP component of the systems and new challenges in text/sentence generation, but at the cost of blurring the final goal of those ATS systems, as there was no clear target population in mind anymore. The release of Newsela dataset (Xu et al., 2015) for English and Spanish in 2015, created opportunities for better modelling of simplification operations, given its well-controlled quality of manual simplifications at five different text complexity levels. Following the previously proposed idea of approaching ATS as a monolingual machine translation (MT) task (Specia, 2010; Coster and Kauchak, 2011), Xu et al. (2016) proposed an MT-based ATS system for English built upon Newsela and the large paraphrase database

(Pavlick and Callison-Burch, 2016). The manual sentence alignment of English Newsela (Xu et al., 2015), improved automatic alignment of EW-SEW corpus (Hwang et al., 2015), and the recently released free tools for sentence alignment (Paetzold et al., 2017; Stajner et al., ˇ 2017; Stajner et al., 2018), offered new opportunities for data-driven ATS. ˇ In 2017, several ATS systems explore various deep learning architectures appeared, using the new alignments of Wikipedia and Newsela for training. Sequence-to-sequence neural models (Nisioi et al., 2017; Stajner and Nisioi, 2018), and the neural model based on reinforcement learning techniques (Zhang ˇ and Lapata, 2017) showed a dominance of neural ATS approaches over the previous data-driven approaches in terms of quality of generated output (better grammaticality and meaning preservation). The question of simplicity of the generated output and the compliance of those models to different text genres and languages other than English, is still present. While solving the problems of grammaticality and meaning preservation, the neural TS systems introduced a new challenge, showing problems in dealing with abundance of name entities present both in news articles and Wikipedia articles.

Conclusion and Future work :

This method is good method for generating an automatic text generation. Since no model gives accurate result but our model provides better output and maximum output is accurate. Using our proposed model we have easily generated a fixed length and meaning full Bengali text.

There are some limitations this paper such as can not generate text without given the length of the text and n-gram sequence defined needed which is a lengthy process. Sometimes the order of the sentence is not correct in giving output. There are some defects in our proposed methodology such as can not generate random length text. We need to define the generating text length. Another defect is we need to define cushion token for predict next words. In our future work, we will make an automatic text generator which provides a random length hindi text without using any token or sequence.

References:

- Banko, Michele, Vibhu O. Mittal & Michael J.Witbrock. 2000. Headline generation based on statistical translation. Em Proceedings of the Annual Meeting of the Association for Compu-tational Linguistics, 318–325.
- Barzilay, Regina, Kathleen R McKeown & Mi-chael Elhadad. 1999. Information fusion in the context of multi-document summarization. EmProceedings of the Annual Meeting of the Association for Computer Linguistics, 550–557!
- Baxendale, Phyllis B. 1958. Machine-made index for technical literature: An experiment. IBM Journal of Research and Development 2(4).
- Berg-Kirkpatrick, Taylor, Dan Gillick & DanKlein. 2011. Jointly learning to extract and compress. Em Proceedings of the Annual Mee-ting of the Association for Computational Lin-guistics, 481–490.
- Carbonell, Jaime & Jade Goldstein. 1998. The use of MMR, diversity-based reranking for re-ordering documents and producing summaries.Em Proceedings of the Annual

International ACM SIGIR Conference on Research and Development in Information Retrieval, 335–336.

- Conroy, John M & Dianne P O'Leary. 2001.Text summarization via Hidden Markov Models. Em Proceedings of the Annual International ACM SIGIR Conference on Research and Development in Information Retrieval, 406–407.
- Coster, William & David Kauchak. 2011. Learning to simplify sentences using Wikipedia.Em Proceedings of the Workshop on Monolin-gual Text-To-Text Generation, 1–9.
- Dorr, Bonnie, David Zajic & Richard Schwartz.2003. Hedge trimmer: a parse-and-trim approach to headline generation. Em Proceedings of the Conference of the North American Chapter of the Association for Computational Linguis-tics, 1–8.
- Edmundson, Harold P. 1969. New methods in au-tomatic extracting. Journal of the ACM 16(2).Erkan, G¨unes & Dragomir R Radev. 2004. Lex-Rank: Graph-based lexical centrality as sali-ence in text summarization. Journal of Artifi-cial Intelligence Research 2(1).Franceschet, Massimo. 2011. PageRank: standing on the shoulders of giants. Communications of the ACM 54(6).
- Fung, Pascale & Grace Ngai. 2006. One story, one flow: Hidden Markov story models for multilingual multidocument summarization. ACM Transactions on Speech and Language roces-sing 3(2).

International Journal of Scientific Research in Computer Science, Engineering and Information Technology
ISSN : 2456-3307 (www.ijsrcseit.com)
doi : https://doi.org/10.32628/CSEIT21753

Classification and Performance of Biometric Authentication

Dr. Vijeet H. Meshram[*1], Dr. Ashish B. Sasankar[2]

[*1]Assistant Professor, Department of Computer Science, Dr. Ambedkar College, Nagpur, Maharashtra, India

[2] Principal, New Arts, Commerce and Science College, Wardha, Maharashtra, India

Article Info

Volume 7, Issue 5
Page Number : 16-20
Publication Issue :
September-October-2021
Article History
Accepted : 07 Sep 2021
Published : 14 Sep 2021

ABSTRACT

Out of the many authentication schemes in this paper we are trying to focus on the performance and classification of one of the techniques of authentication that is the biometric authentication. Although efforts of the entire international biometric community, the measurement of accuracy of a biometric system is far to be completely investigated and, eventually, standardized. The paper presents a critical analysis of the measurement of an accuracy and performance of a biometric system.

Keywords : Biometrics, Authentication, Performance.

I. INTRODUCTION

A. Classification

If the system has a large number of users, it might be a good idea to make some sort of classification of the sample before starting to compare it to the actual templates in the database. That way the number of necessary templates to be tested can be greatly reduced and therefore also the processing time.

Figure shows the classical fingerprint classification system that has been used by law enforcement agencies for decades. When a fingerprint was printed on card to be put into an archive, an expert first examined it to classify it. That way it was a lot easier to find a matching template when a new fingerprint arrived. Today the classification is done automatically and the method depends on the type of biometrics system used.

Figure 1. An example of biometric classification

B. Matching:

The matching procedure is the part of the verification process where the system tries to find a template in its database that is "sufficiently" alike the sample provided by the user. Due to the analog nature of the user sample, the system will probably not find a perfect match in its database, but rather a list of possible matches. If the system accepts the user or not, depends on some sort of security threshold set by the system administrator.

Copyright: © the author(s), publisher and licensee Technoscience Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited

How the matching procedure actually is performed depend much on what type of biometrics system we are talking about. Generally, the system would try to find some key features in the user sample to match against the templates.

C. Transaction Completion and Storage

Depending on if the system is designed for verification or identification the result of the transaction can be to accept, to reject or to list possible matches. In the case of a verification system, it might be a good idea to keep a log of attempted verifications for security reasons and statistical reasons. Some systems might also update the template upon a successful transaction, this way the template quality will constantly improve and the system will be able to handle small natural changes to the biometric. For example scars in fingerprints, aging etc.

D. System Performance

System performance is a vague term and what it means depends much on what type of system it refers to. When talking about biometrics system performance, one usually means the probability that the system will accept authorized users and reject unauthorized users. As mentioned earlier a biometrics system usually has some security threshold setting that enables the system administrator to adjust the system to optimal performance.

The False Reject Rate (FRR) and the False Accept Rate (FAR) are often mentioned when describing biometrics systems. The FRR is, as one would guess from the name, the percentage of times the system refuses to accept an authorized user, and the FAR is the percentage of times that the system will accept an unauthorized user. The FAR and the FRR are closely connected. If the system administrator rises the security threshold, the false accepts will drop. Unfortunately, at the same time the FAR will increase since it also will be harder for the live samples of authorized users to match the higher demands. The reverse is also true, if the threshold is lowered the FRR will drop but the FAR will rise.

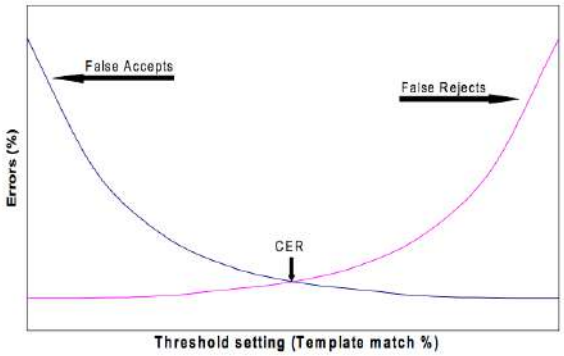


Figure 2. A typical performance curve

The Crossover Error Rate (CER), or as it is sometimes referred to, the Equal Error Rate (EER) is the point where the FRR and the FAR curves meet. Figure shows an example how these terms are linked together. When trying to set the security threshold to get optimal performance out of a biometrics system, it has been shown that the CER point is usually the best choice [1]. Of course this is not always the case, it depends on the type of security levels that are needed. If the system is intended to verify the identity of authorized personnel at Fort Knox, a few false rejects are probably to prefer compared to the risk of giving unauthorized personnel access to the facilities. On the other hand, if the biometrics system is used in an ATM the risk of a few false accepts are probably to prefer compared to the annoyance of the customers waiting in line if the system keep rejecting authorized users.

Another important term when talking about system performance, though often not mentioned by vendors, is Failure To Acquire biometric (FTA). The reason vendors donot mention this number is that it is usually a lot higher then the FAR and FRR. Say for example that the vendors of a fingerprint verification system claim their system has a CER of 0.0001%. That could be true in theory, but depending on the scanning device and the competence of user group, the FRR could actually be 20%. This is due to the fact

that the system might only be able to capture a good enough sample four times out of five.

II. ISSUES

There are also several other issues to consider when evaluating a biometrics system's performance, such as speed, user acceptance etc. You can, for example, not use a biometrics system in an ATM if it takes the system a couple of minutes to verify a user. And also, if the users do not trust the biometrics system to be accurate they will not be using the system to start with. Discussions over issues like these are usually collected together with the FAR, FRR, CER etc. into something called the Total System Performance (TSP).[2]

The fundamental barriers in biometrics can be divided into four main categories: (i) accuracy, (ii) scale, (iii) security, and (iv) privacy.

The critical promise of the ideal biometrics is that when a biometric identifier sample is presented to the biometric system, it will offer the correct decision. Unlike password or token-based system, a practical biometric system does not make perfect match decisions and can make two basic types of errors: i) false Match and ii) False non match.

1. False Match:

In the false match type of error the biometric system incorrectly declares a successful match between the input pattern and a non-matching pattern in the database (in the case of identification/screening) or the pattern associated with an incorrectly claimed identity (in the case of verification).

2. False Non-match:

In the false non-matched type of error the biometric system incorrectly declares failure of match between the input pattern and a matching pattern in the database (identification/screening) or the pattern associated with the correctly claimed identity (verification). It is more informative to report the system accuracy in terms of a Receiver Operating Characteristic (ROC) curve. Even ignoring the requirements of complete automation and assuming possibility of good biometric signal acquisition from a distance, it is easy to note that there is a need to bridge the gap between the current technology and performance requirements.

It is important to realize when compared to other pattern recognition systems, the false rejection of a user's claim by a biometric system is not a desirable outcome since a manual identification which is usually neither effective (e.g. to verify enrollment) nor feasible (e.g., large scale identification) has to be carried out. Practical biometric systems also have significant failures both in terms of failure to acquire (FTA) and failure to enroll (FTE).

III.REASONS FOR IMPERFECT ACCURACY

There are three primary reasons for the imperfect accuracy performance of a biometric system. They are i) Information Limitation ii) Representation Limitation and iii) Invariance Limitation. [3]

A. Information limitation:

The invariant and distinctive information content in the pattern samples may be inherently limited due to the intrinsic signal capacity (e.g.,individuality information limitationof the biometric identifier. For instance, the distinctive information extracted from the geometry is less than that of the fingerprints. Consequently, hand geometry measurements can differentiate fewer identities than the fingerprint signal even under ideal conditions. Information limitation may also be due to poorly controlled biometric presentation by the users or inconsistent signal acquisition. The measurements of a biometric identifier acquired through various means limit the invariance across different samples of the pattern. For example, information limitation occurs when there is

very little overlap between the enrolled and sample images in different poses and expressions. In such situation, even a perfect matcher fails to offer a correct matching decision. An extreme example of information limitation is when the person does not possess or cannot present exact biometric measurement needed by the identification system.

B. Representation limitation

An ideal representation scheme has to be designed to retain all invariance and discriminatory information in the sensed measurements. A typical practical feature extraction system based on simplistic models of biometric signal, fails to capture the richness of information in a realistic biometric signal, subsequently resulting in the inclusion of erroneous features and exclusion of true features. Consequently, a significant fraction of legitimate pattern space cannot be handled by the biometric system resulting in high FTA, FTE, FMR, and FNMR. For example, the individuality information contained in minutia-based representation of templates illustrates typical "poor quality" prints that cannot be processed by traditional minutiae-based identification systems, although the experts routinely use such smudged prints to make a reliable match decision. So, conventional representations and feature extraction methods are limiting the effective discrimination among the prints.

C. Invariance limitation

Finally, in a representation scheme, the design of an ideal matcher should perfectly model the invariance relationship in different patterns from the same class, even when imaged under varied presentation conditions. Again, in practice (e.g., due to non-availability of sufficient number of training samples, uncontrolled or unexpected variance in the collection conditions) a matcher may not correctly model the invariance relationship resulting in poor matcher accuracy.

IV. CONCLUSION

The user authentication, an essential part of a DRM system, determines whether the user is authorized to access the content. In a generic cryptographic system possession of the decrypting key is a sufficient evidence to establish user authenticity. Cryptographic keys are long and random, (e.g., 128 bits for the advanced encryption standard (AES)) and they are difficult to memorize. So, the cryptographic keys are stored somewhere (for example, on a computer or a smart card) and released on the basis to any alternative authentication (e.g., password) mechanism, that is, upon assuring that they are released to the authorized users. Most passwords are so simple that they can be easily guessed (especially based on social engineering methods) or broken by simple dictionary attacks. Many of these limitations of the traditional passwords can be ameliorated by incorporating better methods of user authentication.

Biometric authentication is one such method which eliminates most of the limitations other systems have. In Biometric authentication individuals are verified on the basis of their physiological and behavioral characteristics such as face, fingerprint, hand geometry, iris, keystroke, signature, voice, etc. It is inherently more reliable than password-based authentication, because biometric characteristics cannot be lost or forgotten (ex: passwords being lost or forgotten); Biometric characteristics are extremely difficult to copy, share, and distribute (ex: passwords being announced in hacker websites) and require the person at the time and point of authentication (ex: conniving users denying having shared the password). Biometric gives no scope for forgery since it requires more time, money, experience, and access privileges and it is unlikely for a user to repudiate a person, the digital content using biometrics. Finally, the biometrics is no easier to break than another's; that is, all users have a relatively equal security level, hence "easy to guess" biometrics, that can be used to mount

an attack against them, are relatively absent. Thus, biometrics-based authentication is a potential contender to replace password-based authentication, either by establishing the complete authentication mechanism or by securing the traditional cryptographic keys that contain the multimedia file in a DRM system.

Multiple biometric characteristics have been in use in various applications. Each biometric has its strengths and weaknesses, and the choice of the biometric depends on the application. A single biometric can not be expected to effectively meet all the requirements (e.g., accuracy, practicality, cost) of all the applications (e.g., DRM, access control, welfare distribution). In other words, no biometric is "optimal." The match between a specific biometric and an application is determined on the basis of the requirements of the application and the properties of the biometric characteristics.

Table 1. Comparison of Various Biometric Technologies Based on the Perception of the Authors. High, Medium, and Low are Denoted by H, M, and L, Respectively [4]

Biometric Identifier	Universality	Distinctiveness	Permanence	Collectability	Performance	Acceptability	Circumvention
Face	H	L	M	H	L	H	H
Finger Print	M	H	H	M	H	M	M
Hand Geometry	M	M	M	H	M	M	M
Iris	H	H	H	M	H	L	L
Keystroke	L	L	L	M	L	M	M
Signature	L	L	L	H	L	H	H
Voice	M	L	L	M	L	H	H

V. REFERENCES

[1]. Whalberg M., "Biometric Security – Integration of Biometric Devices inSolaris", University of Umea, 2000

[2]. Anil K. Jain, Sharath Pankanti, Salil Prabhakar, Lin Hong, and Arun Ross Michigan "Biometrics: A Grand Challenge", State University, IBM T. J. Watson Research Center,

[3]. Nazeer Unnisa Nazima, Shahana Tanveer ,Abdul Majeed, "Secure Public Key Protocol for Ad-Hoc Wireless Networks", International Journal of Computer Science and Network (IJCSN) Volume 1, Issue 6, Decembers 2012 www.ijcsn.org ISSN 2277-5420.

[4]. Soutar, Biometric System Security White Paper, Bioscrypt [Online]. Available: http://www.bioscrypt.com

Cite this article as :

Dr. Vijeet Meshram, Dr. A.B. Sasankar, "Classification and Performance of Biometric Authentication", International Journal of Scientific Research in Computer Science, Engineering and Information Technology (IJSRCSEIT), ISSN : 2456-3307, Volume 7 Issue 5, pp. 16-20, September-October 2021. Available at doi : https://doi.org/10.32628/CSEIT21753
Journal URL : https://ijsrcseit.com/CSEIT21753

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Study of Deep Reinforcement Learning

Avinash H. Hedaoo

Dept. of Computer Science, Prerna College of Commerce, Nagpur -44009, (M.S.) India

A B S T R A C T

Deep reinforcement learning is poised to revolutionise the field of AI and represents a step towards building autonomous systems with a higher level understanding of the visual world. The study of generalisation in deep Reinforcement Learning (RL) aims to produce RL algorithms whose policies generalise well to novel unseen situations at deployment time, avoiding overfitting to their training environments. Tackling this is vital if we are to deploy reinforcement learning algorithms in real world scenarios, where the environment will be diverse, dynamic and unpredictable. In this survey, we systematically categorize the deep RL algorithms and applications, and provide a detailed review over existing deep RL algorithms by dividing them into modelbased methods and model-free methods. Finally, we outline the current representative applications

Keywords: Reinforcement learning, Deep reinforcement learning, Reinforcement learning applications Generalisation, Reinforcement Learning Survey Review

1. Introduction

Although RL had some successes in the past (Nate Kohl and Peter Stone, 2004, Andrew Y Ng et. A.,2006, Satinder Singh et.al., 2002, Gerald Tesauro, 1995), previous approaches lacked scalability and were inherently limited to fairly low-dimensional problems. These limitations exist because RL algorithms share the same complexity issues as other algorithms: memory complexity, computational complexity, and in the case of machine learning algorithms, sample complexity (Alexander L Strehl et. al., 2006) . What we have witnessed in recent years - the rise of deep learning, relying on the powerful function approximation and representation learning properties of deep neural networks - has provided us with new tools to overcoming these problems. The advent of deep learning has had a significant impact on many areas in machine learning, dramatically improving the state-of-the-art in tasks such as object detection, speech recognition, and language translation (Yann LeCun et. al.,2015). The most important property of deep learning is that deep neural networks can automatically find compact low-dimensional representations (features) of high-dimensional data (e.g., images, text and audio). Through crafting inductive biases into neural network architectures, particularly that of hierarchical representations, machine learning practitioners have made effective progress in addressing the curse of dimensionality(Yoshua Bengio et. al., 2013). Deep learning has similarly accelerated progress in RL, with the use of deep learning algorithms within RL defining the field of "deep reinforcement learning" (DRL) (Kai Arulkumaran, et. al., 2017 AA).

Why has deep learning been helping reinforcement learning make so many and so enormous achievements? Representation learning with deep learning enables automatic feature engineering and end-to- end learning through gradient descent, so that reliance on domain knowledge is significantly reduced or even removed. Feature engineering used to be done manually and is usually time consuming, over-specified, and incomplete. Deep, distributed representations exploit the hierarchical composition of factors in data to combat the exponential challenges of the curse of dimensionality. Generality, expressiveness and flexibility of deep neural networks make some tasks easier or possible, e.g., in the breakthroughs and novel architectures and applications. Deep learning, as a specific class of machine learning, is not without limitations, e.g., as a black-box lacking interpretability, as an "alchemy" without clear and sufficient scientific principles to work with, and without human intelligence not able to competing with a baby in some tasks. However, there are lots of works to improve deep learning, machine learning, and AI in general. Deep learning and reinforcement learning, being selected as one of the MIT Technology Review 10 Breakthrough Technologies in 2013 and 2017 respectively, will play their crucial role in achieving artificial general intelligence. David Silver, the major contributor of AlphaGo (Silver et al., 2016a; 2017), even made a formula: artificial intelligence = reinforcement learning + deep learning (Silver, 2016) (Yuxi Li , 2018).

The aim of this study is to outline and critically review all significant research done to date in the context of combining reinforcement learning algorithms and deep learning methods. The research will review both supervised and unsupervised deep models that have been combined with RL methods for environments which might be partially observable MDPs or not. This study will also present recent outstanding success stories of the combined RL and deep learning paradigms, which led to the introduction of a novel research route called deep reinforcement learning, to overcome the challenges in learning control policies from high-dimensional raw input data in complex RL environment (Seyed Sajad Mousavi et. al., 2018).

I endeavour to provide as much relevant information as possible. For reinforcement learning experts, as well as new comers, I hope this overview would be helpful as a reference. In this overview, I mainly focus on contemporary work in recent couple of years, by no means complete . In this version, I

endeavour to provide a wide coverage of fundamental and contemporary RL issues, about core elements, important mechanisms, and applications. Rest of the paper composition is as follows. Section II defines the background of RL . Section III describes the reinforcement learning algorithms, section IV illustrates applications and section V concludes the paper.

2. Background

2.1 Reinforcement Learning

Reinforcement learning (RL) is one of the machine learning areas in which an agent has to interact with its environment in order to achieve a goal. RL based on the structure of Markov Decision Processes (MDPs); a reliable structure for the agent learning while interacting with its environment in order to receive rewards and drawbacks. The essential elements of RL are the states, actions and reinforcements (Maia, T. V. 2009). Via the agent's sensors, the agent recognizes the environment and implements actions (according to a policy) in which leads to changes in the environment. According to these changes, the agent obtains rewards based on the taken actions. RL improves strategy through the learning via trial and error by interacting with the environment and recognize the best actions at each state in order to reach the goal and gain the best rewards (Ming, G. F., et. al. 2010, Gil, P., 2013). RL tries to find the best policy that increases the total reward. (Barto, A. G, 2003) indicated that RL algorithms work on how the agent can learn to estimate an optimal strategy while to interact with its environment (Mostafa Al-Emran, 2015).

2.1.1. Reinforcement in Learning Classifier System

To better understand how reinforcement learning is applied in the artificial intelligent system, we have to know how a learning classifier system works. A learning classifiers system (LCS) works by interacting with the real world from which it attains feedback in the form of mostly numerical reward (R). Learning is driven by trying to maximize the amount of reward received. Usually, the LCS consists of four components : a finite population of condition-action rules, called classifiers, that represents the current knowledge of the system; the performance component, which governs the interaction with the environment; the reinforcement component (also called credit assignment component), which distributes the reward received from the environment to the classifiers accountable for the rewards obtained; the discovery component, which is responsible for discovering better rules and improving existing ones through a genetic algorithm. Therefore, reinforcement learning is essential for capturing the diachronic behaviours of an intelligent system (Amit Kumar Mondal,2021). Conventionally used RL algorithms are Markov decision process, Q learning, Temporal difference and Monte Carlo.

2.1.2. Challenges with reinforcement learning

Safety is an important parameter while considering system operations during the learning phase. In RL, due to the limited availability of data in the real world, algorithms are trained with a limited number of patterns during the learning phase. RL algorithms have many practical real-world problems with large and continuous state and action spaces. In many cases of RL direct training is not possible. In this case, an off-policy and off-line training system is used where training is done by the recent iterations of the algorithms (Pamina, J. et. al.,2019) (Surjeet Balhara et. al., 2022).

2.2 Hierarchical Reinforcement Learning

A larger goal is sub-divided into a hierarchy of sub-goals. Each subtask could still be decomposed to sub- tasks, and the lowest level of tasks, typically, are primitive actions (Jose JFR et. al. , 2011). This approach shifts the focus of RL problem from being a state-to-state or action-to-action oriented towards subgoals to larger-goal oriented. HRL can be summarized as an approach that abstracts and divides the state space into key landmarks, from start to the final goal. Thus tackling large dimensions of state-space could be easier. This algorithm can be drawn as parallel to Work Breakdown Structure, which is followed in many of the software project management processes and elsewhere(Chapman JR, 2004) (N. R. Ravishankar et. Al., 2017).

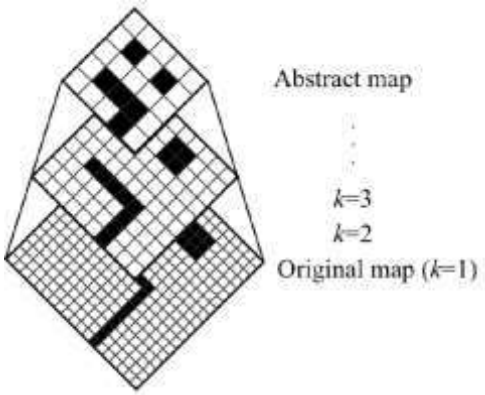


Figure 1. Multi-scale Value Functions. Courtesy19.

2.3 Q-Learning

Q-learning is one of the RL algorithms that has been successfully used in many domains such as: face recognition, simple toys, web-based education and many others (Rodrigues Gomes, E., 2009). Q-learning tries to find an optimal action policy by estimating the optimal state-action function Q(s, a) where s -> state from the set of the possible states S, a -> action from the set of the possible actions A. The Q function described the maximum reward achieved when an action a is executed over the states. The Q-learning equation is described as follows:

$$Q(s,a) \leftarrow (1-\alpha)Q(s,a) + \alpha(r+\gamma \max_{a'} Q(s',a'))$$

Where α refers to the learning rate, γ refers to the discount factor and r refers to the reward of executing the action a over the states (Mostafa Al-Emran, 2015).

3. Reinforcement Learning Algorithms

In the following, I will distinguish between different classes of RL algorithms. Reinforcement learning algorithms are categorized as model-free and model-based reinforcement learning algorithms. "Fig. 2," illustrates the difference between model free and model based algorithm (Eisha Akanksha, 2021).

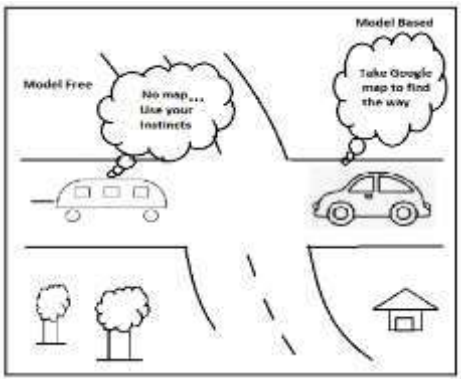


Fig.2. Illustration of model free and model based reinforcement learning algorithms

3.1 Model-free RL

Model-free RLs do not have any knowledge about the environment in which the agent acts(Quentin JM, 2014).The agent only acts in any given state, but doesn't know where it leads to. So they rely on the instantaneous reward obtained by taking an action in a state, and then evaluate the utility of that state. Utility is defined as the expected total reward from the current state to the goal-state. Once all the paths are traversed they then evaluate the utilities of each of the states experienced. As always, the action sequence that yields the maximum utility is considered as the optimal policy. So they learn the utilities by trial-and error method. Some of the most popular, legacy model-free RL algorithms are Q-learning, SARSA, Dyna-Q, and Temporal Difference (TD) (N. R. Ravishankar et. Al., 2017).

Model-free RL further divided into two scenarios: 3.1.1 RL based on the value function 3.1.2 RL based on policy gradient.

3.1.1 RL based on the value function

3.1.1.1 Deep Q-Learning [DQN]

Researchers in DeepMind technologies have developed an approach called Deep Q learning Network (DQN)(Mnih, V. et. al., 2013) , DQN combine a deep convolutional neural network with the simplest reinforcement learning method (Q-learning) to play several Atari 2600 computer games only by watching the screen. For the correlated states issue DQN provides approach named experience replay. In the process of learning, DQN store agent's experience (st,at,rt,rt+1)at each time step into a date set D, where st, at and rt, respectively the state, selected action and received reward at time step t and st+1 is state at the next time step. For updating Q-values, it uses stochastic minibatch updates with uniformly random sampling from experience replay memory (previous transitions) at training time. This work break strong correlations between consecutive samples, And for instability in the policy, the network is trained with a target Q-network to obtain consistent Q-learning targets by fixing weight parameters used in Q-learning target and updating them periodically. In some games its strategy outperformed the human player and achieved state of the art performance on many Atari games with the same network architecture or hyperparameters. However, using deep neural networks need sufficient data to be fed into network to learn better representations and as a result getting good performance. Hence, applying this approach in real environment such as robotics is very challenging and difficult since performing a large number of episodes to collect samples is source consuming and even not possible (Seyed Sajad Mousavi et. al., 2018).

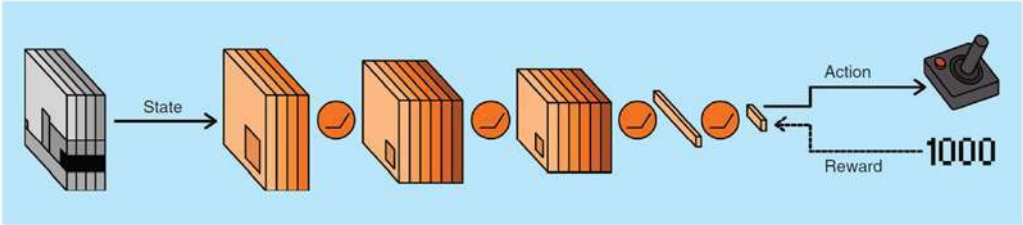


Fig. 3. The DQN. The network takes the state—a stack of gray-scale frames from the video game—and processes it with convolutional and fully connected layers, with ReLU nonlinearities in between each layer. At the final layer, the network outputs a discrete action, which corresponds to one of the possible control inputs for the game. Given the current state and chosen action, the game returns a new score. The DQN uses the reward—the difference between the new score and the previous one—to learn from its decision. More precisely, the reward is used to update its estimate of Q, and the error between its previous estimate and its new estimate is backpropagated through the network (Kai Arulkumaran, et. al., 2017).

3.1.1.2 Temporal difference

TD learning (Sutton, 1988) learns value function V (s) directly from experience with TD error, with bootstrapping, in a model-free, online, and fully incremental way. TD learning is a prediction problem. The update rule is V (s) <- V (s) + α[r + γ V (s') - V(s)], where α is a learning rate, and r + γ V (s') - V(s) is called TD error(Yuxi Li , 2018).

TD learning is a model-free RL algorithm which is the combination of both Monte Carlo (MC) algorithm and dynamic programming technology that is used for solving forecast problems in RL, which are in time series. In the TD algorithm, the learning process uses the current action and immediate state to estimate the current state. It aims to maximize the reward by adjusting the strategy continuously while interacting with the environment (Surjeet Balhara et. al., 2022).

3.1.1.3 Q-learning

"Q" stands for quality. The algorithm represents how fruitful a given action would be in gaining the best future reward. The Q table is a reference matrix that makes the agent to locate the best activity for each state. It assists with augmenting the expected rewards by choosing the most ideal of all actions (state, activity) restores the normal potential compensation of that activity at that state. The Q (s, a) is iteratively refreshed utilizing the Bellman equation (Eisha Akanksha, 2021).

Q-learning is a typical type of off_policy learning that updates a target policy π using samples generated by any stochastic behaviour policy in an environment. Following the Bellman equation and temporal difference (TD) for the action-value function, the Q-learning algorithm is recursively updated using the following equation:

$$Q(s_t, a_t) = Q(s_t, a_t) + \alpha[r_t + \gamma \max_{a' \in A} Q(s_{t+1}, a') - Q(s_t, a_t)].$$

where a' follows the target policy a' ~ π (. | st) and α is the learning rate. While updating Q-learning, the next actions at+1 are sampled from the behaviour policy which follows an ϵ-greedy exploration strategy, and among them, the action that makes the largest Q-value, a' is selected. (Pawel Ladosz et. al., 2022)

3.1.1.4 State-Action-Reward-State-Action (SARSA)

The algorithm learns the Q- value dependent on the activity performed by the current arrangement rather than the greedy approach(Eisha Akanksha, 2021).The name Sarsa comes from (s_t, a_t, r_{t+1}, s_{t+1}, a_{t+1}) which is in essence the description of the backup diagram of Sarsa. Sarsa uses the current action-value, the reward and the action-value belonging to the next state and action to backup the current action-value. An exploring policy has to be followed e.g. ϵ-greedy. A combination of the Bellman-equation and the incremental average is used to derive the following equation (Victor Dolk,2010).

$$Q(s_t, a_t) \leftarrow Q(s_t, a_t) + \alpha\,[r_{t+1} + \gamma Q(s_{t+1}, a_{t+1}) - Q(s_t, a_t)]$$

3.1.2 RL based on policy gradient

REINFORCE (Williams, 1992) is the prototype of policy gradient (PG) algorithms. Compared with value-based RL, policy-based RL not only avoids the policy degradation caused by the value function error, but also is easier to apply in the continuous action space problem. Specifically, value based methods, such as Q-learning and SARSA, require a one-step operation to calculate the maximum value, which can hardly be found in the continuous space or high-dimensional space. In addition, value-based methods learn implicit policies but policy-based RL methods can learn stochastic policies. That is, in the value-based method, the policies obtained through policy improvement are all deterministic policies, and will encounter some problems that

cannot be resolved in some tasks like Rock-Paper-Scissors. Policy-based methods also have some common shortcomings: (1) data efficiency or sample utilization is low; (2) the variance is large, which makes it difficult to converge (Hao-nan Wang et. al.,2020).

3.1.2.1 Policy gradient

There are two sorts of policies: deterministic and stochastic. Deterministic strategy that maps state to activity with no ambiguity. The stochastic approach yields a probability distribution over activities in a given state. It is called the Partially Observable Markov Decision Process. The software programs which are considered as learner and decision-maker are called as an agent. The agent interacts with the environment, the environment provides rewards in return and the probability distribution of the future state based on the actions of the agent. The reward can be positive or negative based on the actions. Hence the algorithm consists of the policy π having parameter θ where the π yields a probability distribution of activities(Zhang, J. et. al.,2021) (Eisha Akanksha, 2021).

3.1.2.2 Proximal Policy Optimization (PPO)

Proximal policy optimization (PPO) algorithm performs unconstrained optimization, requiring only first-order gradient information (Pieter Abbeel et. al. ,2016). The two main variants include an adaptive penalty on the KL divergence, and a heuristic clipped objective which is independent of the KL divergence. Being less expensive whilst retaining the performance of TRPO means that PPO (with or without GAE) is gaining popularity for a range of RL tasks (Kai Arulkumaran, et. al., 2017).

3.1.2.3 Trust Region Policy Optimization (TRPO)

Trust region policy optimization (TRPO), has been shown to be relatively robust and applicable to domains with high-dimensional inputs . To achieve this, TRPO optimizes a surrogate objective function—specifically, it optimizes an (importance sampled) advantage estimate, constrained using a quadratic approximation of the KL divergence. The constrained optimization of TRPO requires calculating second order gradients, limiting its applicability (Kai Arulkumaran, et. al., 2017).

3.1.2.4 Asynchronous Advantage Actor-Critic (A3C)

Asynchronous Advantage Actor-Critic Algorithm is policy-based RL algorithms. Policy-based algorithms output policies rather than the q values and each policy distribution has different exploration estimations. Policy-based methods can handle continuous action spaces easily as it represents parameters of the distribution as output which is finite. In training a policy-based algorithm, instead of minimizing error and finding optimal policy, the concept of gradient is used (Deepanshu Mehta, 2019).

3.2 Model-based RL

The algorithm makes a simulated model for every condition. The agent learns from the environment by taking actions and observing the outcomes. The various types of model-based reinforcement learning algorithms are:

3.2.1 Imagination-Augmented Agents (I2A)

A hybrid approach, which combines model-based elements with a model-free algorithm, is Imagination-Augmented Agents (I2A). This particular method incorporates an imagination core module used for producing possible future trajectories (i.e. rollouts) from past experience and through action-conditional next-step predictors. Imagined rollouts are then encoded using LSTM encoders . At the same time, a model-free agent is trained naturally at each time step, only to feed both their output and the concatenated model-based encoded rollouts into a policy network which undertakes the task of producing the final action to be executed. I2A solved 85% of the Sokoban puzzles (Aristotelis Lazaridis et al., 2020).

3.2.2 Imagination-Augmented Agents (I2A)

The model-based value expansion (MBVE) algorithm learns a policy π and a critic Q, to solve some well known control tasks. The way the critic is updated is by using rollouts done with the model up to a fixed horizon H. The horizon length represents a measure of trust in the model, and controlling it helps controlling the uncertainty of the model without the need of more complex uncertainty estimation techniques (Constantin-Valentin Pal, 2020).

3.2.3 Model-based policy optimization (MBPO)

Model-based policy optimization (MBPO) uses a probabilistic model ensemble and performs a large amount of short model rollouts that start from a state distribution with states from the real environment dynamics. This state distribution contains states collected in a buffer D constructed with the previous policy in the iterative algorithm, and the rollouts are used to perform policy optimization using a model-free optimizer ((Constantin-Valentin Pal, 2020).

There is a performance gap between puremodel- based and model-free methods. Compared with model-free methods that require 10 days, model-based methods enable a complete training process using only 10 min in real time. However, model-free methods can achieve much better performance, differing by at most three orders of magnitude (Nagabandi et al., 2018) (Hao-nan Wang et. al.,2020). The "Fig. 4," gives an overview of reinforcement learning agent taxonomy (Eisha Akanksha, 2021).

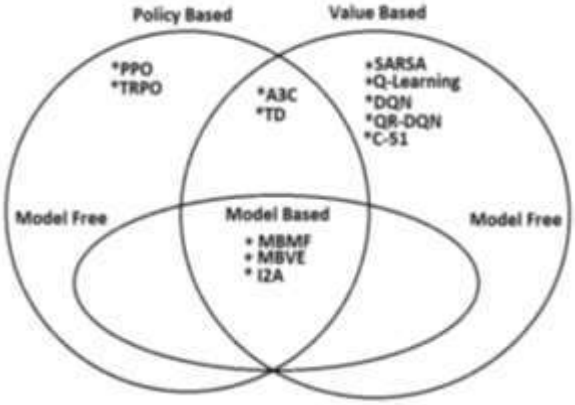


Fig.4. Illustration of RL agent taxonomy

4. Applications

Deep RL has achieved significant success in various fields. I outline current representative RL applications including robotics, natural language processing (NLP), and computer systems etc. in this section as follows :

4.1 Energy

Our mankind is facing issues of sustainable and green energy. It is critical to consume energy efficiently. I discuss data center cooling and smart grid in the following.

4.1.1 Data Center Cooling

RL is one approach to data center cooling. I discuss how to control fan speeds and water flow in air handling units (AHUs) to regulate the airflow and temperature inside server floors, using model-predictive control (MPC). In MPC, the controller (agent) learns a linear model of the data center dynamics with random, safe exploration, with little or no prior knowledge. It then optimizes the cost (reward) of a trajectory based on the predicted model, and generates actions at each step, to mitigate the effect of model error and unexpected disturbances, at the cost of extra computation. The controls or actions are variables to manipulate, including fan speed to control air flow and valve opening to regulate the amount of water. States refer to the process variables to predict and regulate, including differential air pressure (DP), cold-aisle temperature (CAT), entering air temperature(EAT) to each AHU, leaving air temperature (LAT) from each AHU.

The method is compared with a local proportional integral derivative (PID) controller and a certainty-equivalent controller, which updates parameters of the dynamics model assuming the estimated model were accurate. Experiments show that the method can achieve data center cooling in a large-scale commercial system in a safe, effective, and cost-efficient way (Yuxi Li, 2019).

4.1.2 Smart Grid

A smart grid is a power grid utilizing modern information technologies to create an intelligent electricity delivery network for electricity generation, transmission, distribution, consumption, and control (Fang et al., 2012). An important aspect is adaptive control (Anderson et al., 2011). Application of RL for electric power system decision and control is reviewed. Here demand response discussed briefly. Demand response systems motivate users to dynamically adapt electrical demands in response to changes in grid signals, like electricity price, temperature, and weather, etc. With suitable electricity prices, load of peak consumption may be rescheduled/lessened, to improve efficiency, reduce costs, and reduce risks. Design of a fully automated energy management system with model-free reinforcement learning is proposed , so that it doesn't need to specify a disutility function to model users' dissatisfaction with job rescheduling. The authors decomposed the RL formulation over devices, so that the computational complexity grows linearly with the number of devices, and conducted simulations using Q-learning. The demand response problem is tackled with batch RL. The exogenous prices is taken as states, and the average as feature extractor to construct states is utilized. (Yuxi Li , 2018)

4.2 Finance

RL is a natural solution to some finance and economics problems (Hull, 2014), like option pricing, and multi-period portfolio optimization, where value function based RL methods were used. To utilize policy search to learn to trade is proposed; it is extended with deep neural networks. Deep (reinforcement) learning would provide better solutions in some issues in risk management. The market efficiency hypothesis is fundamental in finance. However, there are well-known behavioural biases in human decision-making under uncertainty, in particular, prospect theory. A reconciliation is the adaptive markets hypothesis, which may be approached by reinforcement learning. It is nontrivial for finance and economics academia to accept blackbox methods like neural networks. However, there is a lecture in AFA 2017 annual meeting: Machine Learning and Prediction in Economics and Finance. We may also be aware that financial firms would probably hold state-of-the-art research/application results. FinTech has been attracting attention, especially after the notion of big data. FinTech employs machine learning techniques to deal with issues like fraud detection, consumer credit risk, etc. (Yuxi Li , 2018).

4.3 Healthcare

AI technologies are realistically altering and empowering the healthcare system. At present RL and DL have been extensively used to determine and discover innovative healthcare applications and services namely, medical imaging. DRL also focuses on lung cancer as much of the global population is suffering from lung tumours; and on providing solutions to computer-aided diagnosis. Value-based DL models including DQN and hierarchical DRL models are used in the treatment of lung cancer and its diagnosis (Surjeet Balhara et. al., 2022).

Dynamic treatment regimes (DTRs) or adaptive treatment strategies are sequential decision making problems. I discuss an approach to optimal treatment strategies for sepsis in intensive care. A state is constructed from the multidimensional discrete time series composed of 48 variables. An action, or a medical treatment, is defined by the total volume of intravenous fluids and maximum dose of vasopressors over each 4 hour period. A reward and a penalty is associated with survival and death, respectively, to optimize patient mortality. Experiments show that the policy learned by RL has larger value, or lower mortality, than those from human clinicians, and that the patients have the lowest mortality when they receive treatments similar to those recommended by the policy learned by RL (Yuxi Li, 2019).

Q-learning is the RL method in DTRs(Dynamic treatment regimes). Deep RL is applied to the problem of inferring patient phenotypes (Yuxi Li, 2018).

Medical image report is generated by following a hybrid retrieval-generation approach trained by RL, to integrate human prior knowledge and neural networks. A convolutional neutral network (CNN) extract visual features of a set of images of a sample, and an image encoder transforms the visual features into a context vector, then a sentence decoder generates latent topics recurrently (Yuxi Li, 2019).

4.4 Robotics

Robotics is a classic area for RL. RL can implement behavioral control of complex robots in the simulation environment, thus enabling realistic responses to perturbations and environmental variation. Apart from Atari and simple agents in Mujoco (e.g., half-cheetah, ant, and spider), DeepMimic (Peng et al., 2018a) further develops challenging multiskilled agents including multiple characters (e.g., human, Atlas robot, bipedal dinosaur, and dragon) and a large variety of skills (e.g., locomotion, acrobatics, and martial arts). In addition, RL has obtained numerous research results in robot control tasks in real situations. A range of real-world tasks are contact-rich and require close coordination between vision and control, such as stacking tight-fitting Lego blocks and screwing bottle caps onto a bottle. The improvements (Levine et al., 2015) control manipulation to complete these tasks by reducing the sample count and automating parameter selection in GPS. An RNN with LSTM (Rahmatizadeh et al., 2016) helps the controller learn from virtual demonstrations and successfully performs the manipulation tasks on a physical robot By closed-loop vision-based control (Kalashnikov et al., 2018), re-grasping strategies are automatically learned, probing an object and repositioning objects to find the most effective grasps and perform other non-prehensile pre-grasp manipulations. However, training data of real robots is scarce for real scenarios. The method which combines knowledge from previous tasks with online adaptation of the dynamics model (Fu et al., 2016) helps solve a variety of complex robotic manipulation tasks in a single attempt. Multiple robots (Gu SX et al., 2017a; Yahya et al., 2017) learn collaboratively to sample and train in parallel. Manipulating the source domain (Peng et al., 2018b) narrows the gap between simulation and real physical systems. Al- Nima et al. (2019) produced suitable road tracking actions based on RL by collecting input states from forward car facing views. Based on transfer learning (Devin et al., 2017), robots can share task-specific modules across robots and robot-specific modules across all tasks. The improved methods of meta-RL (Finn et al., 2017b; Yu TH et al., 2018) enable the agents to learn rapidly from little data in new environments. Learning to adapt to dynamic real-world environments (Nagabandi et al., 2019) further alleviates the problem of missing training data and has better generalization ability in dealing with robotic manipulation tasks [WW].

DRL is applied in robotics for navigation of the mobile robot in an unfamiliar environment by avoiding the obstacles to reach the desired destination autonomously with an RGB-D camera by using a DDQN algorithm. Navigation of the mobile robot to the desired destination without using any maps is done by asynchronous deterministic policy gradients with light detection and ranging (LIDAR) and the commands will be provided to the mobile robot for avoiding obstacles by estimating the Q value from the DQN to know the depth of the image by using RGBD sensor. DRL is also used in solving flocking control problems in multi robotic systems in complex environments using an algorithm called multi-agent DDPG, which helps the multi-robot system in performing a flocking task with greater convergence speed (Surjeet Balhara et. al., 2022).

Following points are discussed in (Yuxi Li, 2018) : See Kober et al. (2013) for a survey of RL in robotics, Deisenroth et al. (2013) for a survey on policy search for robotics, and Argall et al. (2009) for a survey of robot learning from demonstration. See the journal Science Robotics. It is interesting to note that from NIPS 2016 invited talk, Boston Dynamics robots did not use machine learning. In the following, I discuss guided policy search (Levine et al., 2016a) and learn to navigate (Mirowski et al., 2017). See more recent robotics papers, e.g., Chebotar et al. (2016; 2017); Duan et al. (2017); Finn and Levine (2016); Gu et al. (2016a); Lee et al. (2017); Levine et al. (2016b); Mahler et al. (2017); P´erez-D'Arpino and Shah (2017); Popov et al. (2017); Yahya et al. (2016); Zhu et al. (2017b). I recommend Pieter Abbeel's NIPS 2017 Keynote Speech, Deep Learning for Robotics, slides at, https://www.dropbox.com /s/fdw7q8mx3x4wr0c/.

4.5 Transportation

Today traffic congestion is a serious issue in many metropolitan cities. DQN is used to optimize the real-time traffic control policies. To solve many real-time problems and to provide better navigation when compared with some traditional routing algorithms, DRL-based real-time navigation and vehicle routing method is proposed by using simulation of urban mobility (SUMO) for training DNN to reroute vehicles to the destination in the real-time complex environment (Surjeet Balhara et. al., 2022).

Hierarchical RL is an approach to knowledge representation with temporal abstraction at multiple levels, and to learn and plan. Transfer learning techniques can help adapt a learned policy to multiple cities. The learned policy show promising performance results w.r.t. metrics about total driver income and user experience on the platform of Didi Chuxing.

I next discuss the problem formulation for ride-sharing order dispatching. A high-fidelity simulator is helpful for RL, e.g., generating synthetic data to evaluate or optimize a policy. At the beginning of the simulation, drivers' status and order information are initialized with historical real data. After that, the simulator determines drivers' status, following an order-driver matching algorithm, with the help of an order dispatching policy learned with RL. A busy driver will fulfill an order. An idle driver follows a random walk, according to a driver movement model, and be in an online/offline mode, according to an online/offline model. These two models are learned from the historical real data (Yuxi Li, 2019).

4.6 Games

DRL has significant applications in games. After applying DRL to games like cart pole and mountain car, the masters have tested the gaming strategy and they found that it repeatedly won the game. In this case, the designers faced the challenges that came across during the gaming process and analysed every possible scenario of gaming by learning from wins, losses and draw over sometimes. The designer feeds the neural network with thousands of rules and scenarios. The game itself starts with random play. After each play, the system analyses the result and sets the parameters of the neural network to become the strongest player. With the help of deep neurons, it makes its move very dynamically by increasing its gaming power (Surjeet Balhara et. al., 2022). Games provide excellent testbeds for RL/AI algorithms. In the following sections I discuss achievements and applications of RL in different categories of games.

4.6.1. Perfect Information Board Games

Board games like Backgammon, Go, chess, checker and Othello, are classical testbeds for RL/AI algorithms. In such games, players reveal perfect information. AlphaGo (Silver et al., 2016a and Sutton and Barto (2018), a computer Go program, won the human European Go champion, 5 games to 0, in October 2015, in March 2016, AlphaGo defeated Lee Sedol, an 18-time world champion Go player, defeated Ke Jie 3:0 in May 2017. AlphaGo Zero (Silver et al., 2017) further improved previous versions by learning a superhuman computer Go program without human knowledge. AlphaGo was built with techniques of deep convolutional neural networks, supervised learning, reinforcement learning, and Monte Carlo tree search (MCTS) (Browne et al., 2012; Gelly and Silver,

2007; Gelly et al., 2012).

4.6.2 Imperfect Information Board Games

Imperfect information games, or game theory in general, have many applications, e.g., security and medical decision support. Heinrich and Silver (2016) proposed Neural Fictitious Self-Play (NFSP). NFSP was evaluated on two-player zero-sum games. In Leduc poker, NFSP approached a Nash equilibrium, while common RL methods diverged. In Limit Texas Hold'em, a real-world scale imperfect-information game, NFSP performed similarly to state-of-the-art, superhuman algorithms which are based on significant domain expertise. Heads-up Limit Hold'em Poker was essentially solved (Bowling et al., 2015) with counterfactual regret minimization (CFR).

4.6.3 Video Games

Video games would be great testbeds for artificial general intelligence. A3C won the champion in Track 1 of ViZDoom Competition by a large margin. The problem of sensorimotor control in immersive environments is approached with supervised learning, and won the Full Deathmatch track of the Visual Doom AI Competition. It is also discussed how to tackle Doom. Multiagent actor-critic framework is proposed , used StarCraft as the testbed. Without human demonstration or labelled data as supervision, the proposed approach learned strategies for coordination similar to the level of experienced

human players, like move without collision, hit and run, cover attack, and focus fire without overkill. Usunier et al. (2017); Justesen and Risi (2017) also studied StarCraft. Oh et al. (2016) and Tessler et al. (2017) studied Minecraft, Chen and Yi (2017); Firoiu et al. (2017) studied Super Smash Bros, and Kansky et al. (2017) proposed Schema Networks and empirically studied variants of Breakout in Atari games (Yuxi Li, 2018).

4.7. Natural language processing

RL methods have broad application prospects in the domain of NLP and have been successfully applied in the fields of neural machine translation (NMT), dialog systems, and speech generation. Benefitting from the development of transfer learning and deep meta-RL, universal NMT (GuJT et al., 2018a) uses a transfer-learning approach to share lexical and sentence representations across multiple source languages into one target language. This enables the low-resource language to use the lexical and sentence representations of the higher resource languages. Further, Gu JT et al. (2018b) first extended a deep meta-RL algorithm (e.g., MAML) into low-resource NMT. The model can learn to adapt to low-resource languages based on multilingual high-resource language tasks. The task of chatbots in dialogue systems is to mimic human-human interactions with extended conversations. A modified version of the episodic REINFORCE algorithm explores and learns the policy and the posterior probability over the knowledge base entries for correct retrievals to select dialogue acts An adaptive TTS approach is presented based on MAML to highly restore the speaker's voice in new scenes using very few speech samples. Similarly, the DeepVoice model is improved by predicting the embedding with an encoding network and fitting the embedding based on a small amount of adaptation data (Hao-nan Wang et. al.,2020).

4.8. Computer Vision

Computer vision is about how computers gain understanding from digital images or videos. In the following, after presenting background in computer vision, we discuss recognition, motion analysis, scene understanding, integration with NLP, and visual control. Reinforcement learning would be an important ingredient for interactive perception (Bohg et al., 2017), where perception and interaction with the environment would be helpful to each other, in tasks like object segmentation, articulation model estimation, etc.

4.8.1 Recognition

RL can improve efficiency for image classification by focusing only on salient parts. For visual object localization and detection, RL can improve efficiency over approaches with exhaustive spatial hypothesis search and sliding windows, and strikes a balance between sampling more regions for better accuracy and stopping the search when sufficient confidence is obtained about the target's location. Mnih et al. (2014) introduced the recurrent attention model (RAM) to focus on selected sequence of regions or locations from an image or video for image classification and object detection. Caicedo and Lazebnik (2015) proposed an active detection model for object localization with DQN. Jie et al. (2016) proposed a tree-structure RL approach to search for objects sequentially. Mathe et al. (2016) proposed to use policy search for visual object detection. Kong et al. (2017) deployed collaborative multi-agent RL with inter-agent communication for joint object search. Welleck et al. (2017) proposed a hierarchical visual architecture with an attention mechanism for multi-label image classification. Rao et al. (2017) proposed an attention-aware deep RL method for video face recognition. Krull et al. (2017) for 6D object pose estimation.

4.8.2. Motion Analysis

In tracking, an agent needs to follow a moving object. Supancic and Ramanan (2017) proposed online decision-making process for tracking, formulated it as a partially observable decision-making process (POMDP). Yun et al. (2017) also studied visual tracking with deep RL. Rhinehart and Kitani (2017) proposed Discovering Agent Rewards for K-futures Online (DARKO).

4.8.3. Scene Understanding

Wu et al. (2017b) studied the problem of scene understanding, and attempted to obtain a compact, expressive, and interpretable representation to encode scene information like objects, their categories, poses, positions, etc, in a semi-supervised way. The authors deployed a variant of REINFORCE algorithm to overcome the non-differentiability issue of graphics rendering engines. Wu et al. (2017a) proposed a paradigm with three major components, a convolutional perception module, a physics engine, and a graphics engine, to understand physical scenes without human annotations. There are recent works about physics learning, e.g., Agrawal et al. (2016); Battaglia et al. (2016); Denil et al. (2017); Watters et al. (2017); Wu et al. (2015).

4.8.4. Integration With NLP

Some are integrating computer vision with natural language processing. Xu et al. (2015) integrated attention to image captioning, trained the hard version attention with REINFORCE, and showed the effectiveness of attention on Flickr8k, Flickr30k, and MS COCO datasets. Rennie et al. (2017) introduced self-critical sequence training, using the output of test-time inference algorithm as the baseline in REINFORCE to normalize the rewards it experiences, for image captioning. Strub et al. (2017) proposed end-to-end optimization with deep RL for goal-driven and visually grounded dialogue systems for GuessWhat?! game. Das et al. (2017) proposed to learn cooperative Visual Dialog agents with deep RL. See also Kottur et al. (2017). See Pasunuru and Bansal (2017) for video captioning. See Liang et al. (2017d) for visual relationship and attribute detection.

4.8.5. Visual Control

Visual control is about deriving a policy from visual inputs, e.g., in games (Mnih et al., 2015; Silver et al., 2016a; 2017; Oh et al., 2015; Wu and Tian, 2017; Dosovitskiy and Koltun, 2017; Lample and Chaplot, 2017; Jaderberg et al., 2017), robotics (Finn and Levine, 2016; Gupta et al., 2017b; Lee et al., 2017; Levine et al., 2016a; Mirowski et al., 2017; Zhu et al., 2017b), and self-driving vehicles (Bojarski et al., 2016; Bojarski et al., 2017; Zhou and Tuzel, 2017).

4.8.6. Business Management

Reinforcement learning has many applications in business management, like ads, recommendation, customer management, and marketing. Li et al. (2010) formulated personalized news articles recommendation. Theocharous et al. (2015) formulated a personalized ads recommendation systems as a RL problem to maximize life-time value (LTV) with theoretical guarantees. Li et al. (2015) also attempted to maximize lifetime value of customers. Silver et al. (2013) proposed concurrent reinforcement learning for the customer interaction problem.

4.8.7. Industry

The era of Industry 4.0 is approaching, e.g., see O'Donovan et al. (2015), and Preuveneers and Ilie-Zudor (2017). Reinforcement learning in particular, artificial intelligence in general, will be critical enabling techniques for many aspects of Industry 4.0, e.g., predictive maintenance, realtime diagnostics, and management of manufacturing activities and processes. Robots will prevail in Industry 4.0.

4.9. Computer systems

Computer systems present many challenging problems for RL, including time-varying state or action, structured data sources , and highly stochastic environments. Here, I summarize some typical RL methods used in computer systems and show that RL could provide significant real-world benefits in this domain. Tackling multi-resource cluster scheduling with a PG algorithm optimizes various objectives like average job slowdown or completion time in an online manner with dynamic job arrivals, and validates the approach via simulation. Chen L et. al. (2018) proposed a two-level system called "automatic traffic optimization (AuTO)" to solve the scalability problem in data center traffic. Motivated by prior applications, a scalable RL model with the graph embedding technique is trained by the PG algorithm to deal with the issue of continuous stochastic job arrivals. Further, inspired by much potential for RL to improve the performance, an open extensible platform Park defines the MDP formulation (e.g., state, action space, and reward function). Park connects to a suite of real-world computer systems and lowers the barrier of entry for machine learning researchers to innovate based on deep RL in computer systems (Hao-nan Wang et. al.,2020).

4.10. Resource Allocation

Mao et al. (2016) studied resource management in systems and networking with deep RL. The authors proposed to tackle multi-resource cluster scheduling with policy gradient, in an online manner with dynamic job arrivals, optimizing various objectives like average job slowdown or completion time. The authors validated their proposed approach with simulation. Liu et al. (2017) proposed a hierarchical framework to tackle resource allocation and power management in cloud computing with deep RL. Google deployed machine learning for data centre power management, reducing energy consumption by 40%.

4.10.1 Performance Optimization

To optimize device placement for Tensorflow computational graphs with RL is proposed . The authors deployed a seuqence-to-sequence model to predict how to place subsets of operations in a Tensorflow graph on available devices, using the execution time of the predicted placement as reward signal for REINFORCE algorithm(Yuxi Li, 2018).

5. Conclusion

Over the past few years, deep RL has become increasingly powerful and important in handling complex problems. Deep learning models with great power of automatically extracting complex data representations from high-dimensional input data could outperform other state of the art of traditional machine learning methods. A major challenge in reinforcement learning is to learn optimal control policies in problems with raw visual input. Hierarchical feature extraction and learning abstracted representations of deep architectures, not only made the deep learning become a valuable tool for classification, but it has made it to be a great solution for the mentioned challenge in RL tasks as well. Despite of the significant works done to data in combining RL and DL, research on deep reinforcement learning is at its first steps and there are still many unexplored aspects of this combination. Also, their challenges in real application such as robotics, are yet unsolved and need more exploration to be done. Especially, developing those mechanisms which make the end to end learning can be practical in real world application, those which doing a large number of actions is impossible. Furthermore, an open problem that has not yet been addressed is how deep architectures can help deep reinforcement learning models to transfer knowledge (transfer learning). Indeed, how to use learned features by the deep networks for different tasks, without changing the network architectures. There is an immense scope for DRL

due to its learning behaviour and hence, the possibilities of its application are immeasurable. The study also concludes that a larger skill force will be required to cater to these applications with specific knowledge in different industrial sectors, especially in healthcare, automotive, smart city and intelligent transportation.

In this study , I present a comprehensive study of deep RL algorithms. I have presented recent advances in combing reinforcement learning framework and deep leaning models for both deep supervised and unsupervised learning networks. In particular, the deep architectures that have been most used in combination with RL such as deep convolutional networks, deep autoencoders and deep recurrent networks. In addition, appropriate deep networks for the problems with partially observable MDPs (POMDPs) environment, have been discussed. First, I introduce background theory of RL then I performed a clear and novel dissection of model-free and model-based deep RL algorithms. Finally in terms of applications, I discuss deep RL in robotics, NLP, and computer systems etc.

References

Kai Arulkumaran, Marc Peter Deisenroth, Miles Brundage, Anil Anthony Bharath, A Brief Survey of Deep Reinforcement Learning, IEEE signal processing magazine, special issue on deep learning for image understanding (arxiv extended version), 2017

Nate Kohl and Peter Stone. Policy Gradient Reinforcement Learning for Fast Quadrupedal Locomotion. In ICRA, volume 3, 2004.

Andrew Y Ng, Adam Coates, Mark Diel, Varun Ganapathi, Jamie Schulte, Ben Tse, Eric Berger, and Eric Liang. Autonomous Inverted Helicopter Flight via Reinforcement Learning. Experimental Robotics, pages 363–372, 2006.

Satinder Singh, Diane Litman, Michael Kearns, and Marilyn Walker. Optimizing Dialogue Management with Reinforcement Learning: Experiments with the NJFun System. JAIR, 16:105–133, 2002.

Gerald Tesauro. Temporal Difference Learning and TD-Gammon. Communications of the ACM, 38(3):58–68, 1995

Yann LeCun, Yoshua Bengio, and Geoffrey Hinton. Deep Learning. Nature, 521(7553):436–444, 2015.

Yoshua Bengio, Aaron Courville, and Pascal Vincent. Representation Learning: A Review and New Perspectives. IEEE Trans. on Pattern Analysis and Machine Intelligence, 35(8):1798–1828, 2013.

Silver, D., Huang, A., Maddison, C. J., Guez, A., Sifre, L., Van Den Driessche, G., Schrittwieser, J., Antonoglou, I., Panneershelvam, V., Lanctot, M., et al. (2016a). Mastering the game of go with deep neural networks and tree search. Nature, 529(7587):484–489.

Silver, D. (2016). Deep reinforcement learning, a tutorial at ICML 2016. http://icml.cc/ 2016/tutorials/deep_rl_tutorial.pdf.

Silver, D., Schrittwieser, J., Simonyan, K., Antonoglou, I., Huang, A., Guez, A., Hubert, T., Baker, L., Lai, M., Bolton, A., Chen, Y., Lillicrap, T., Hui, F., Sifre, L., van den Driessche, G., Graepel, T., and Hassabis, D. (2017). Mastering the game of go without human knowledge. Nature, 550:354–359.

Pieter Abbeel and John Schulman. Deep Reinforcement Learning through Policy Optimization, 2016. Tutorial at NIPS 2016.

Yuxi Li, Deep Reinforcement Learning: An Overview, arXiv:1701.07274v6 [cs.LG] 26 Nov 2018

Fang, X., Misra, S., Xue, G., and Yang, D. (2012). Smart grid - the new and improved power grid: A survey. IEEE Communications Surveys Tutorials, 14(4):944–980.

Anderson, R. N., Boulanger, A., Powell, W. B., and Scott, W. (2011). Adaptive stochastic control for the smart grid. Proceedings of the IEEE, 99(6):1098–1115.

Hull, J. C. (2014). Options, Futures and Other Derivatives (9th edition). Prentice Hall.

Seyed Sajad Mousavi(&), Michael Schukat, and Enda Howley, Deep Reinforcement Learning: An Overview, Springer International Publishing AG

Mostafa Al-Emran, Hierarchical Reinforcement Learning: A Survey, International Journal of Computing and Digital Systems, Int. J. Com. Dig. Sys. 4, No.2 , http://dx.doi.org/10.12785/ijcds/040207 (Apr-2015)

Maia, T. V. (2009). Reinforcement learning, conditioning, and the brain: Successes and challenges. Cognitive, Affective, & Behavioral Neuroscience,9(4), 343-364.

Surjeet Balhara, Nishu Gupta, Ahmed Alkhayyat, Isha Bharti, Rami Q. Malik, Sarmad Nozad Mahmood, Firas Abedi, A survey on deep reinforcement learning architectures, applications and emerging trends, IET Commun., IET Commun. 2022;1–16.

Ming, G. F., & Hua, S. (2010). Course-scheduling algorithm of option-based hierarchical reinforcement learning. In 2010 Second International Workshop on Education Technology and Computer Science, Vol. 1, pp. 288-291.

Gil, P., & Nunes, L. (2013, June). Hierarchical reinforcement learning using path clustering. In Information Systems and Technologies (CISTI), 2013 8th Iberian Conference on (pp. 1-6). IEEE.

Barto, A. G., & Mahadevan, S. (2003). Recent advances in hierarchical reinforcement learning. Discrete Event Dynamic Systems, 13(4), 341-379

Pamina, J., Raja, B.: Survey on deep learning algorihms. Int. J. Emerging Technol. Innovative Eng. 5(1), 6 (2019) N. R. Ravishankar and M. V. Vijayakumar, Reinforcement Learning Algorithms: Survey and Classification, Indian Journal of Science and Technology, Vol 10(1), DOI: 10.17485/ijst/2017/v10i1/109385 January 2017

Jose JFR. Solway A, Diuk C, McGuire JT, Barto AG, Niv Y.A Neural Signature of Hierarchical Reinforcement Learning. Neuron. 2011 Jul; 71(2): 370–379.

Amit Kumar Mondal, A Survey of Reinforcement Learning Techniques: Strategies, Recent Development, and Future Directions, Reasearchgate, 2021

Chapman JR. Work Breakdown Structures, ver. 2.01, [Online]. 2004. Available: http://www.hyperthot.com/pm_wbs.htm

Quentin JM, Huysa B, Anthony C, Peggy S. Reward-Based Learning, Model-Based and Model-Free. Encyclopedia of Comput. Neurosci. 2014

Eisha Akanksha, Jyoti, Neeraj Sharma, Dr. Kamal Gulati, Review on Reinforcement Learning, Research Evolution and Scope of Application, Proceedings of the Fifth International Conference on Computing Methodologies and Communication (ICCMC 2021) DVD Part Number: CFP21K25-DVD: ISBN: 978-0-7381-1203-9

Pawel Ladosz, Lilian Weng, Minwoo Kim, Hyondong Oh, Exploration in Deep Reinforcement Learning: A Survey, arXiv:2205.00824v1 [cs.LG] 2 May 2022.

Victor Dolk, Survey Reinforcement Learning, 2010

Hao-nan Wang‡, Ning LIU, Yi-yun Zhang, Da-wei Feng, Feng Huang, Dong-sheng LI, Yi-ming Zhang, Deep reinforcement learning: a survey, Frontiers of Information Technology & Electronic Engineering www.jzus.zju.edu.cn; engineering.cae.cn; www.springerlink.com, 2020.

Williams RJ, 1992. Simple statistical gradient-following algorithms for connectionist reinforcement learning. Mach Learn, 8(3-4):229-256.

Nagabandi A, Kahn G, Fearing RS, et al., 2018. Neural network dynamics for model-based deep reinforcement learning with model-free fine-tuning. IEEE Int Conf on Robotics and Automation, p.7559-7566. https://doi.org/10.1109/ICRA.2018.8463189

Gu JT, Hassan H, Devlin J, et al., 2018a. Universal neural machine translation for extremely low resource languages. Proc 16th Conf of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, p.344-354. https://doi.org/10.18653/v1/N18-1032

Gu JT, Wang Y, Chen Y, et al., 2018b. Meta-learning for low-resource neural machine translation. Proc Conf on Empirical Methods in Natural Language Processing, p.3622-3631.https://doi.org/10.18653/v1/D18-1398

Chen L, Lingys J, Chen K, et al., 2018. AuTO: scaling deep reinforcement learning for datacenter-scale automatic traffic optimization. Proc Conf of the ACM Special Interest Group on Data Communication, p.191-205. https://doi.org/10.1145/3230543.3230551

Deepanshu Mehta ,State-of-the-Art Reinforcement Learning Algorithms, International Journal of Engineering Research & Technology, http://www.ijert.org ISSN: 2278-0181, Vol. 8 Issue 12, December-2019

Aristotelis Lazaridis et al., Deep Reinforcement Learning: A State-of-the-Art Walkthrough, Journal of Artificial Intelligence Research (2020)

Constantin-Valentin Pal, Florin Leon, A Brief Survey of Model-Based Reinforcement Learning Techniques, 24th International Conference on System Theory, Control and Computing, 2020.

Generative Adversarial Networks : A Review

Avinash H. Hedaoo
Dept of Computer Science
Prerna College of Commerce, Nagpur, (MS) – India

Abstract- *GANs have gained much attention from the research community in recent years in terms of generating quality images and data augmentation. Generative adversarial networks (GANs) present a way to learn deep representations without extensively annotated training data. . The goal of GANs is to estimate the potential distribution of real data samples and generate new samples from that distribution. The representations that can be learned by GANs may be used in several applications. However, generating naturalistic images containing ginormous subjects for different tasks like image classification, segmentation, object detection, reconstruction, etc., is continued to be a difficult task. Generative modelling has the potential to learn any kind of data distribution in an unsupervised manner. In this paper, the background of the GAN, theoretic models and extensional variants of GANs are introduced, where the variants can further optimize the original GAN or change the basic structures. Then the typical applications of GANs are explained.*

Keywords- Generative adversarial networks, Supervised learning, Unsupervised learning, adversarial learning, generative models, zero-sum game, machine learning.

I. INTRODUCTION

Generating quality images is a challenging task in the field of computer vision and artificial intelligence, having numerous applications and research scope. Supervised machine learning and deep learning models require large and labelled datasets to generalize the decision making process. However, the availability of large and labelled databases is questioned in many domains like medical diagnosis, fault detection, intrusion detection, etc. Hence, the research community heavily depends on unsupervised learning. In unsupervised learning, the model strives to learn the structure and extracts the useful features of the data. However existing models do not fit the data distributions completely. Goodfellow et al. introduced GANs, an unsupervised generative model, worked on the principle of maximum likelihood, and used adversarial training. Right from the inception of generative adversarial networks (GANs), they have been the most discussed and most researched domains not only in the field of computer science but also in other domains. GANs have gained much popularity in generating high-quality realistic data.

It is now possible using GANs to generate photorealistic object images such as birds and faces, generate indoor or outdoor scenes, translate images from a source domain to the target domain, generate high definition images from low-definition images, and so on [5]. Besides, GANs have been introduced into the study of other artificial intelligence subfields, including speech and language processing [1], [2], malware detection [3], and chess game program [4],[5]. Recently, media interest in generative modelling projects has increased. The StyleGAN introduced by NVIDIA generates an authentic face image. GPT-3 from open artificial intelligence generates a complete sentence by providing a short introduction syntax. As of 2021, GAN and attention-based methods have evolved significantly, generating video, text, speech, and music that even experts cannot distinguish[10].

The goal of this survey is to provide a broad understanding of the progression of GANs and to summarize the current state-of-the-art. In this paper, the author presents an overview of GANs, its different variants, and potential applications in different domains. The paper attempts to identify GANs' advantages, disadvantages and major challenges for successful implementation of GAN in different application areas. Rest of the article is organized as follows. Section II provides basics of GANs, different objective functions of GANs and the variants of GANs. Section III highlights the most significant applications of GAN in real life. Sect. IV concludes the paper at the end[17].

II. BASIC THEORY AND TYPES OF GANs

A. Basic Theory of GAN

The generative models can be thought of as a group of thieves trying to generate counterfeit currency whereas the discriminative model can be thought of as police trying to detect the counterfeit currency. Thus, the entire framework resembles a two-player minimax game where the generator tries minimize its objective function and the discriminator tries to maximize its objective function[14].

Goodfellow et al. [18] introduced the adversarial process to learn generative models. The fundamental aspect of GAN is the min-max two-person zero-sum game. In this game, one player takes the advantages at the equivalent loss of the other player. Here, the players correspond to different

networks of GAN called discriminator and generator. The main objective of the discriminator consists of determining whether a sample belongs to a fake distribution or real distribution. Whereas, generator aims to deceive the discriminator by generating fake sample distribution. Discriminator produces the chances or probability of a given sample to be a real sample. A higher value of probability shows that the sample is likely to be a real sample. The value close to zero indicates that the sample is a fake sample. The probability value near 0.5 indicates the generation of an optimal solution, such that discriminator is unable to differentiate fake and real sample[17].

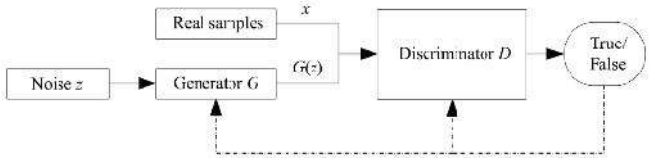


Fig. 1. Computation procedure and structure of GAN

In Fig. 1. Any differentiable function can be used as the generator and the discriminator. Here, differentiable functions D and G is used to represent the discriminator and the generator, and their inputs are real data x and random variables z, respectively. G(z) represents the sample generated by G and obeying the distribution pdata of real data. If the input of discriminator D is from the real data x, D should classify it to be true and label it as 1. If the input is from G(z), D should classify it to be false and label it as 0. The purpose of D is to achieve correct classification of the data source, while the purpose of G is to make performance of the generated data G(z) on D (i.e., D(G(z)) consistent with the performance of real data x on D (i.e., D(x)). The adversarial optimization process improves the performance of D and G gradually. Eventually, when the discrimination ability of D has been improved to a high level but cannot discriminate the data source correctly, it is thought that the generator G has captured the distribution of real data [5].

The loss function that G seeks to minimize and D attempts to maximize is as follows:

$$min_G max_D V(D,G) = \mathbb{E}_{x\sim p_{data(x)}}[logD(x)] + \mathbb{E}_{x\sim p_z(z)}[log(1-D(G(z)))] \quad (1)$$

where x is a sample from the real dataset distribution pdata(x)and z is sampled from a latent space distribution pz(z). Eq.1shows the two networks playing a Mini-Max Game, each trying to improve their own loss function [23].

B. Types of GANs

With the passage of time, several developments have been made to the original architecture of GAN. In this subsection, we will introduce GANs' representative variants.

1) InfoGAN

Information maximizing GANs (InfoGANs) [15] are an information-theoretic extension of GANs that are able to learn disentangled features in a completely unsupervised manner. Here, InfoGANs modify the objective of GANs to learn meaningful representations by maximizing the mutual information between a fixed small subset of GAN's noise variables and observations. InfoGANs use approach of semantically decomposing a domain according to the semantic features of the data under consideration and thus decompose the input noise vector into two parts: (i)z which is treated as a source of noise, (ii) c called the latent code and targeted at the salient structured semantic features of the data distribution. Thus, the generator network becomes the generator G(z, c). In order to avoid the latent code c being ignored, information-theoretic regularization is done and the information I(c; G(z, c)) is maximized[14].

InfoGAN [22] aims to solve :

$$\min_G \max_D V_I(D,G) = V(D,G) - \lambda I(c, G(z,c)), \quad (2)$$

where V(D, G) is the objective function of original GAN,G(z, c) is the generated sample, I is the mutual information,and λ is the tunable regularization parameter. The final objective function of InfoGAN is

$$\min_G \max_D VI(D,G) = V(D,G) - \lambda L_I(c,Q), \quad (3)$$

where LI (c,Q) is the lower bound of I(c,G(z, c)). InfoGAN has several variants such as causal InfoGAN and semisupervised InfoGAN (ss-InfoGAN) [21].

The uniqueness of the InfoGAN compared to the standard GAN is the introduction of a regularization term (I) that captures the shared information among the interpretable variables (c) and the generator output [24].

Figure 2 shows the structure of InfoGAN[10].

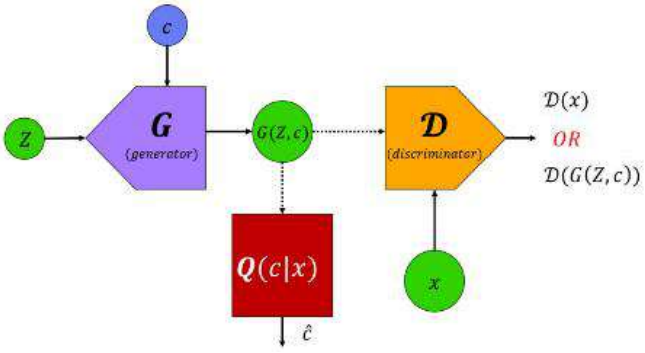


Figure 2. Structure and principle of InfoGAN (Information maximizing Generative Adversarial Networks).

2)Conditional GANs (cGANs)

GANs can be extended to a conditional model if both the G and D networks are conditioned on some extra information yto address the limitation of dependence only on random variables in original model [80]. y could be any kind of auxiliary information, such as class labels or data from other modalities. The conditional information can be added by feeding y into the both the D and G network as an additional input layer as depicted in Fig. 3[17].

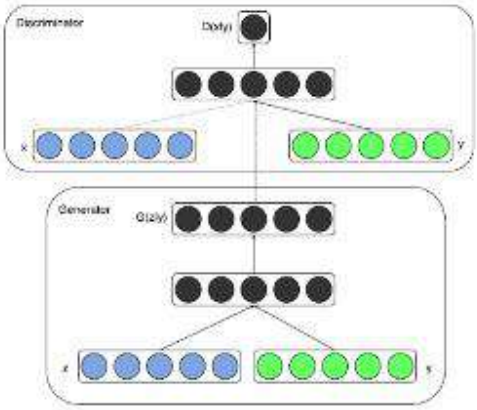


Figure 3. The structure of a Conditional Generative Adversarial Network (CGAN)

In the generator for CGANs, the prior input noise pz(z) and the auxiliary information yare combined in joint hidden representations. In the discriminator, x and y are presented as inputs to the discriminative function. Here, the objective function is similar to that of vanilla GAN except that the data distributions are now conditioned on y. This modified objective function is given as follows:

$$\min_G \max_D V(D,G) = E_{x\sim p_{data}(x)}[logD(x|y)] + E_{z\sim p_z(z)}[log(1-D(G(z|y)))] \quad (4)$$

The architectural diagram of CGAN can be seen in Figure 3. Both, the generator and the discriminator are multilayer perceptrons with Rectified Linear Units (ReLU) as the activation for hidden layers and sigmoid for the output layer. [16] also demonstrate the use of CGANs for automated tagging of images with multi-label predictions. This allows them to generate a distribution of tag-vectors conditional on image features [14].

3) WGAN-GP (Wasserstein GAN-Gradient Penalty)

WGAN-GP[11] solves problems such as mode collapse and unstable training, and makes GAN training predictable and reliable. WGAN-GP included a gradient penalty term in the critic loss function [12]. Critics' weights are not clipped. Moreover, the batch normalization layer should not be used for critics. Batch normalization generates a correlation between images in the same batch, so gradient penalty loss has less effect [13]. WGAN-GP suggests another way to enforce the Lipchitz constraint on critics: adding a term to the loss function that penalizes when the gradient norm of critic deviates significantly from "1". As a result, the training process was greatly stabilized. Gradient penalty loss is the squared difference between the gradient norm of the output and one. This model naturally finds weights that minimize the gradient penalty term. In other words, the model is made to follow the Lipchitz constraint. It is difficult to calculate the gradient everywhere during the training process. WGAN-GP only calculates the gradient at some point. In order not to be biased on one side, the real image-synthetic image pair are connected as shown in Figure 4, and the images interpolated using randomly selected points along a straight line are used [10].

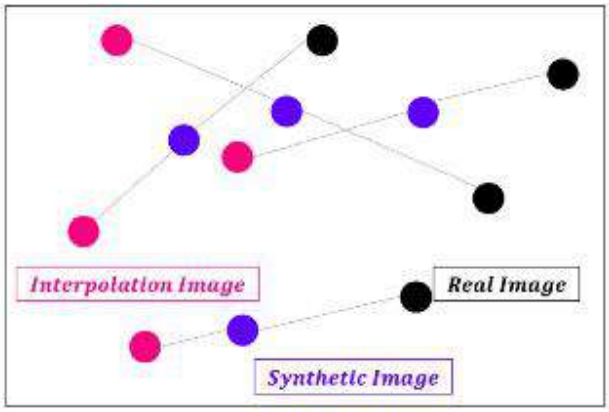


Figure 4. Interpolation between images

4) Laplacian Pyramid of Adversarial Networks(LAPGAN)

A sequential image generation framework Laplacian GAN (LapGAN) proposed by combining the CGAN model

with the framework of the Laplacian pyramid (LP) . LapGAN requires the multiscale generation process in which a series of the GAN generates particular levels of details of an image in an LP representation. The GAN at each generation step of the LP can be different. The LP was built from a Gaussian pyramid (GP) using up-sampling u (.) and down-sampling d (.) functions explained as:[24] Let G(I) = [I0, I1,....,IK] be the Gaussian pyramid where I0 = I and IK is k repeated applications of d(:) to I. Then, the coefficient hk at level k of the Laplacian pyramid is given by the difference between the adjacent levels in Gaussian pyramid, upsampling the smaller one with u(:).

$h_k = L_k(I) = G_k(I) - u(G_{k+1}(I) = I_k - (I_{k+1}))$(5)

Modified reconstruction of the Laplacian pyramid coefficients[h_1,…., h_K] can be performed through backward recurrenceas follows:

$$\widetilde{I}_k = u(\widetilde{I}_{k+1}) + \widetilde{h}_k = u(\widetilde{I}_{k+1}) + G_k(z_k, u(\widetilde{I}_{k+1}))$$

(6)

LAPGANs also take advantage of the CGAN model by adding a low-pass image l_k to the generator as well as the discriminator[25].

5) Deep Convolutional Generative Adversarial Networks (DCGAN)

A new class of convolutional neural networks (CNN) called Deep Convolutional GAN (DCGAN). DCGAN was the first structure that practiced de-convolutional neural networks (de-CNN) structural design that significantly stabilizes GAN training. These frameworks consist of two networks; one network works as a CNN called the generator, and the other network works as a de-CNN called discriminator. A newly proposed class of architectural constraints included in the CNN architecture is:

- Remove all levels of pooling layers with stride convolutions.
- Both G and D must use Batch Normalization (BN) .
- Use ReLU and Leaky-ReLU in the generator and the discriminator networks, respectively[24].

The DCGAN models performance was evaluated against LSUN, Imagenet1k, CIFAR10 and SVHN datasets. The quality of unsupervised representation learning was evaluated by first using DCGAN as a feature extractor and then the performance accuracy was calculated by fitting a linear model on top of those features. The authors also demonstrated feature learning by the generator show casing how the generator could learn to forget scene components such as bed, windows, lamps and other furniture. They also performed vector arithmetic on face samples leading to good results [17].

6) Adversarial Autoencoders (AAE)

Makhzani et al. [19] proposed adversarial autoencoder which is a probabilistic autoencoder which makes use of GAN to perform variational inference by matching the aggregated posterior of the hidden code vector of the autoencoder with an arbitrary prior distribution. After training, the encoder learns to convert the data distribution to the prior distribution, while the decoder learns a deep generative model that maps the imposed prior to the data distribution. The architectural diagram of an adversarial autoencoder is shown in Fig.5.

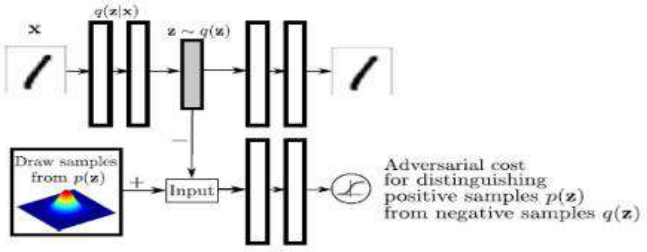


Fig. 5 The architecture of AAE

Let x be the input and z be the latent code vector of an autoencoder. Let p(z) be the prior distribution we want to impose, q(z | x) be the encoding distribution and p(x | z) be the decoding distribution. Also, let $p_d(x)$ be the data distribution and p(x) be the model distribution. The encoding function of the autoencoder $q(z|x)$ defines an aggregated posterior distribution of q(z) on the hidden code vector of the autoencoder as follows:

$$q(z) = \int_x q(z \mid x) p_d(x) dx$$

(7)

In adversarial autoencoder, the autoencoder is regularized by matching the aggregated posterior q(z) to an arbitrary priorp(z). The generator of the adversarial network is alsothe encoder of the autoencoder q(z | x) . Both, the adversarial network and the autoencoder are trained jointly with stochastic gradient descent in two phases—the reconstruction phase and the regularization phase. Labels can also be incorporated in AAEs in the adversarial training phase in order to better shape distribution of the hidden code. A one-hot vector is added to the input of the discriminative network to associate the label with the mode of distribution. Here, the one-hot vector acts as a switch that selects the corresponding

decision boundary in the discriminative network given the class label. The one hot vector also contains one point corresponding to an extra class which in turn corresponds to unlabelled examples. When an unlabelled example is encountered, the extra class is turned on and the decision boundary for the full mixture of Gaussian distribution is selected [17].

The performance of adversarial autoencoders is evaluated on MNIST and Toronto Face datasets using log likelihood analysis in supervised, semi-supervised and unsupervised settings.

$$p(y) = Cat(y) \qquad p(z) = N(z \mid 0 , I) \qquad (8)$$

Here, the adversarial network and the autoencoder are trained in three phases viz. the reconstruction phase, regularization phase and the semi-supervised classification phase. Moreover, the inference network q(y|x) predicts a one-hot vector whose dimension is the number of categories that the data can be clustered into. It is also showed how adversarial autoencoders can be used for dimensionality reduction [25].

7) Generative Recurrent Adversarial Networks(GRAN)

Im et al. (2016) proposed recurrent generative model showing that unrolling the gradient based optimization yields a recurrent computation that creates images by incrementally adding to a visual "canvas". Here, the "encoder" convolutional network extracts images of current "canvas". The resulting code and the code for the reference image get fed to a "decoder" which decides on an update to the "canvas". Figure 6 depicts an abstraction of how a Generative Recurrent Adversarial Network works. The function f serves as the decoder and the function g serves as encoder in GRAN.

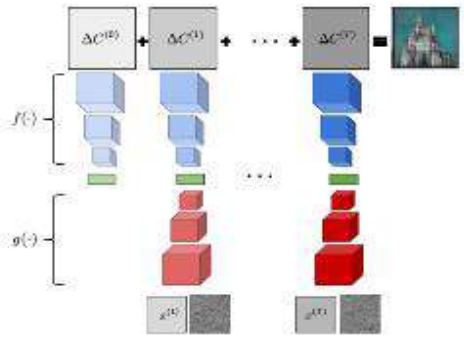


Figure 6. The structure of a Generative Recurrent Adversarial Network (GRAN)

In GRAN, the generator G consists of a recurrent feedback loop that takes a sequence of noise samples drawn from the prior distribution z ~ p(z) and draws the output at different time steps C_1, C_2,….,C_T . At each time step t, a sample z from the prior distribution is passed onto a function f(.)with the hidden state $h_{c,t}$ where $h_{c,t}$ represents the current encoded status of the previous drawing C_{t-1}. C_t is what is drawn to the canvas at time t and it contains the output of the function f(.). Moreover, the function g(.) is used to mimic the inverse of the function f(.). Accumulating the samples at each time step yields the final sample drawn to the canvas C. Ultimately, the function f(.) acts as adecoder and receives the input from the previous hidden state $h_{c,t}$ and noise sample z and the function g(.) acts as anencoder that provides a hidden representation of the outputC_{t-1} for time step t. The authors propose a new evaluation metric for generative models called Generative Adversarial Metric (GAM). The GRAN model's performance was evaluated against MNIST, CIFAR10 and LSUN datasets with time steps T =1, 3, 5. It was found that GRAN with time steps T = 3and T = 5 performed better than GRAN with time step T = 1. Also, GRAN was compared against other generative models such as denoising VAE and DRAW on the MNIST dataset. It was also found that the samples generated by GRAN were discernible and did not overfit on the training data[14].

8) Bidirectional Generative Adversarial Networks(BiGAN)

Donahue et al. [20] proposed a method for learning the semantics in data distribution as well as its inverse mapping using these learnt feature representations for projecting data back into the latent space. The structure of a Bidirectional Generative Adversarial Network is shown in Fig. 7. As it can be seen from the Fig. 7, in addition to the generator G from the standard GAN framework, BiGAN includes an encoder E which maps the data x to latent representations z. The BiGAN discriminator D discriminates not only in the data space (x versus G(z)), but jointly in data and latent spaces (tuples (x,E(x)) versus (G(z), z)), where the latent component is either the encoder output E(x) or generator input z. Here, according to the objective of GANs, the BiGAN encoder E should learn to invert the generator G. The BiGAN training objective is defined as follows:[17]

$$\min_{G,E} \max_{D,E,G} V(D,E,G) = E_{x\sim p(x)} \underbrace{E_{z\sim PE(.|x)}[logD(x,z)]}_{logD(x,E(x))} + E_{z\sim p(z)} \underbrace{E_{z\sim PG(.|z)}[1-logD(x,z)]}_{(1-logD(G(z),z))} \qquad (9)$$

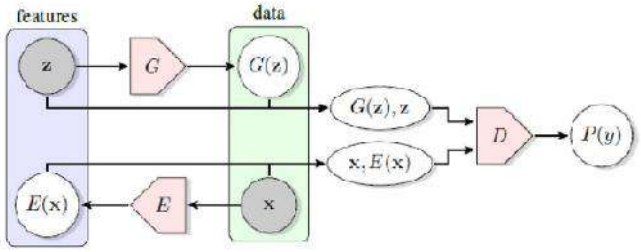


Fig. 7The architecture of BiGAN

9) SAGAN (Self-Attention Generative Adversarial Networks)

Attention is an algorithm used in sequence models, such as transformers [3]. SAGAN is a model that applies the attention algorithm to GAN [9]. The self-attention algorithm is shown in Figure 8..

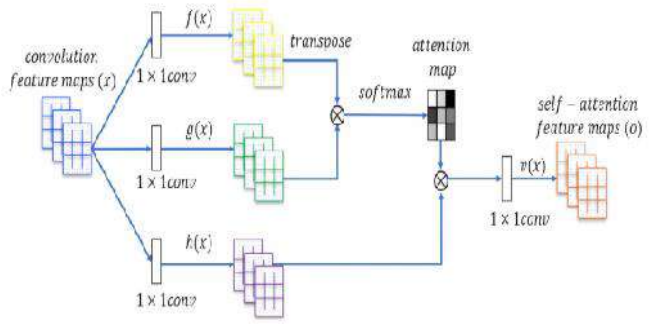


Figure 8. Self-attention algorithm of SAGAN (Self-Attention Generative Adversarial Networks) [9].

In a GAN without attention, the convolution feature map can process only local information. In order to connect pixel information on one side of the image to the other side, the channel must be increased to several convolutional layers, and the dimension of the image space must be reduced. This process, on the other hand, loses accurate location information instead of capturing high-level features. As such, it is inefficient for the model to learn the dependence between distant pixels. SAGAN solved the problem above by applying the attention algorithm to GAN. The outline of the proposed method is shown in Figure 4. As shown in Figure 8, attention focuses on different types of areas. SAGAN made a significant advancement using an attention mechanism that works similar to human perception.

10) Boundary Equilibrium GAN (BEGAN)

Boundary equilibrium GAN (BEGAN) keep-up an equilibrium that manages the trade-off between variety and superiority. The main goal behind BEGAN is to change the loss function. The Wasserstein distance between reconstruction loss of actual and synthesized images gives the real loss. In BEGAN, the discriminator works during training as autoencoder balances the process optimizing of G and D. The idea of making the discriminator as an autoencoder first proposed in BEGAN . BEGAN cost function is:

$$\begin{aligned} L_D(x, z) &= D(x) - k_t D(G(z)) \text{ for } \theta_D \\ L_G(z) &= D(G(z)) \text{ for } \theta_{DG} \\ L_{k+1} &= k_t + \alpha\ (\gamma D(x) - D(G(z))) \text{ for k training} \end{aligned} \quad (10)$$

where L_G represents the loss of the generator, L_D represents the loss of the discriminator, L(x), L (G (z))represents the auto-encoder L1 loss of real, fake data, and equilibrium hyper-parameter "γ" respectively [24].

The added layer does not freeze but continues training. This algorithm was applied tothe LSUN (large scale scene understanding) dataset image [10].

11) Style GAN

StyleGAN uses a mixture of Progressive Growing of Generative Adversarial Networks and neural-style transfer technologies [8,11,49]. StyleGAN has been in the spotlight by creating full high definition-level results with several steps of control from the details of the image to the whole. StyleGAN solved the problem of latent space entanglement by proposing a method called AdaIN (Adaptive Instance Normalization) , which uses reference style bias and scale are used to adjust the mean and variance of feature map outputted from the layers within the synthesis network. The AdaIN layer prevents style information from leaking between layers. The style vector injected into each layer makes it affect only the features of that layer. This latent vector is better than the original vector.

The synthesis network is based on the PGGAN structure, and the style vector of the front layer of the synthesis network affects features larger than the style vector of the back layer. StyleGAN had full control over the image generated using latent vector and changed the style to various levels by changing the position of the vector in the synthesis network. To merge the two images, a vector is passed through the synthesis network and is converted . When deformation occurs early, styles such as posture, appearance, and glasses are transferred. When deformation occurs later, styles such as color and fine shape of the face are transferred. Both features of the image are maintained.

Finally, the StyleGAN structure adds noise behind each convolutional layer to capture areas such as hair position or face background. The noise injection location determines the fineness and roughness in the image [10].

StyleGAN2 comes with various improvements to image quality, efficiency, diversity, and disentanglement, and the results are incredibly improved. StyleGAN2 simply redesigns the normalization used in the generator of StyleGAN, which removes the artifacts such as blob-shaped artifacts that resemble water droplets. The StyleGAN2 achieves excellent results in face image synthesis and quality than StyleGAN [24].

III. APPLICATIONS OF GANS

In this section diverse applications of GANs are discussed like, medical diagnosis, text generation, hyperspectral image classification, etc., in detail.

A. Clinical diagnosis

In [27], a cycleGAN-based unified framework is discussed to standardize the intensity distribution of MRI images with different parameters coming from multiple groups. The effectiveness of the proposed method is investigated on T2-FLAIR image datasets. Qi et al. [28] developed a model using cascaded conditional GAN (C-cGANs) for automatic bi-ventricle segmentation of magnetic resonance images of the heart. In [29], the authors have addressed two issues while dealing with clinical data for cardiac disease diagnosis using ECG signals. First, they extracted the global features and then increased the stability of training to extract high-quality diverse samples. In [30], the authors used a GAN model as a data augmentation tool to generate synthetic data to tackle the imbalanced classification of multi-class ECG data. In [31] the authors developed a finger veinGAN(FV-GAN) framework that consists of two generators: an image generator that generates vein images from vein patterns and a pattern generator that maps vein images to vein patterns. Another useful resource for clinical diagnosis is ultrasound imaging. A two-stage GAN structure is devised to increase the image quality of hand-held or portable ultrasound devices. MRI and PET images are fused , the authors have proposed an algorithm based on Wasserstein GAN (MWGAN) to surmount the challenges involved in fusing images from multiple sources. A GAN-based unsupervised approach is proposed on the principles of anomaly detection for the diagnosis of lung cancer. The GAN (MDGAN) consists of a generator network and multiple discriminator networks. Ghassemi et al. [32] discussed a GAN-based model as a novel data augmentation method for multi-class classification of MR images. Conditional GAN (CGAN)-based denoising method that removes the noise in reduced radiation chest images and enhances the image quality for clinical diagnosis. Label smoothing GAN (LSGAN) for the classification of optical coherence tomography (OCT) images that can help in detecting and avoiding blindness at early stages. From the above discussion, it is observed that image reconstruction, image synthesis , segmentation, classification, abnormality detection, denoising, data augmentation, etc., are the novel tasks that were solved using GANs [26].

B. Image Generation

Recently, GANs has gained more and more momentum for generating naturalistic images through adversarial training. A novel Geometry-Aware GANs modelcalled GAGAN is proposed which incorporates geometric information into the image generation process. Adversarial image generation model, called LR-GAN is proposed to generate sharp images by considering both scene structure and context. LR-GAN combines foregrounds on the background in a contextually relevant style for generating more realistic images. Results have shown that LR-GAN outperforms DCGAN. Style and Structure GAN (S2-GAN) model is proposed in which a GANs is used to produce the image structure and then output is fed into the second GANs for considering the image style. Generation of realistic images has wide range of practical applications, such as anime character generation, image synthesis, super resolution, image editing and blending, inpainting, etc [38].

C. Intrusion detection

Yuan et al. [33] developed a randomized nonlinear image transformation method to alter and ruin the advanced patterns of attacking noise partly in the adversarial images. They employed a generative cleaning network to retrieve the lost content of the original image during the image transformation phase. The discriminator network is used to defend the classification process and trained not to detect any leftover noise patterns in the images. Extended Monte Carlo tree search (MTCS) algorithm using a GAN model that produces adversarial examples of cross-site scripting (XSS) attack traffic data. They added adversarial examples to an original dataset during the training phase. Also, they assigned a probability value that bypasses the adversarial image from the detector. Imbalance GAN (IGAN) framework to enhance the process of intrusion detection in adhoc networks. The architecture consists of a feed forward network to extract the features, an IGAN with a filter to synthesize the abnormal class samples and a deep neural network to perform the classification task.

D. Fault diagnosis

Fault detection is an important task in the field of control engineering to capture the malfunctioning of machine to avoid machine failure and human loss. A paper discussed in [26] devised a model for monitoring of machine condition and fault diagnosis using sensor data. The model design is based on ACGAN. They also used a novel quantitative method for the evaluation of generated sensor signal data and used time domain and frequency domain characteristics for assessing the diversity of generated samples. A paper discussed in [26] addressed the automated detection and diagnosis (AFDD) of fault training data using an unsupervised framework. A support vector machine (SVM) is trained as a binary classifier on the augmented dataset. In the detection phase, it identifies the faulty state, and in the diagnosis phase, it classifies the type of fault. Another GAN-based framework (CVAE-GAN) using the conditional variational autoencoder (CVAE) for imbalanced fault diagnosis in a planetary gear box. A framework that works in two stages for imbalanced fault diagnosis of rotating machines is also discussed in this paper [26]. Investigations on CWRU and Bogie datasets proved the effectiveness of the proposed model. [26].

E. Applications to Speech and Language Processing

Recently, there are some GANs based applications for speech and language processing. Li et al. [1] use GANs to capture the relevance of dialogue and generate corresponding text. Zhang et al. [6] propose to generate realistic sentence with GANs, by using long short-term memory and convolutional neural networks for adversarial training. SeqGAN [2] employs reinforcement learning to generate speech and language, poem, and music. Pascual et al. [7] propose the use of GANs for speech enhancement, called SEGAN. Reed et al. [8] present a GANs-based method for generating images from the text. Text encoding is used by both the generator and the discriminator. Zhang et al. [9] propose StackGAN for text to photorealistic image synthesis. Given text descriptions, Stage-I of StackGAN sketches rough shapes and basic colors of objects, yielding low resolution images. Stage-II of StackGAN takes Stage-I results and text descriptions as inputs, and generates high resolution images with photorealistic details [5].

F. Geoscience and remote sensing

The remote sensing community suffers from the problem of limited samples. Due to this, the training process end up with over-fitting problem. In Shi et al. automatically generated building footprints from the satellite images using a conditional GAN. Zhu et al. presented two schemes for the classification of 1D and 3D hyperspectral images. First, a spectral classifier is modelled using a 1D GAN. Second, a spectral-spatial classifier is designed using a 3D GAN. The authors have used the GAN model as a regularization unit to alleviate the effect of overfitting due to limited samples. Cloud obstruction is a conventional problem in remote sensing object detection field. To overcome this problem, a deep convolutional-based GAN model is proposed with a novel in painting loss function. spatial-spectral GAN model discussed, that performs a multi-class classification of hyperspectral images. This model addresses two issues of the classification process. First, it addresses the inability of the discriminator in multi-class classification and Second, consideration of spatial and spectral information in the classification of hyperspectral images. Variational GAN is proposed using a semi-supervised method to classify hyperspectral images with limited labels. Multibranch conditional GAN (MCGAN) model is devised to increase data for objection in remote sensing images. The MCGAN architecture consists of one generator, three discriminators, and a classifier that build using deep CNNs [26].

G. Video Generation

Vondrick et al.[35] have made great progress in the video field, 32-frame resolution 64×64 realistic video can be generated, depicting golf courses, beaches, train stations and newborns. After testing, 20 of the markers did not recognize the authenticity of these videos. MD-GAN(Multistage Dynamic GAN) predicts future video frames with the proposed model through a given first frame image. In its two-stage model, the first stage a time-lapse video with realistic content can be generated; the second stage the results of the first stage is optimized. By using this model, realistic time-lapse photographic video with a resolution of 128×128 up to 32 frames can be generated [34].

H. Auxiliary Automatic Driving

Santana et al.[36] implemented the assisted autonomous driving with GAN. First, an image is generated, that is consistent with the distribution of the official traffic scene image, and then a transition model is trained based on the cyclic neural network to predict the next traffic scene[34].

I. Drug Discovery

Researchers from Insilico Medicine [37] proposed an approach of artificially intelligent drug discovery using GANs. They attempt to train the Generator to sample drug candidates for a given disease as precisely as possible to existing drugs from a Drug Database. After training, it's possible to generate a drug for a previously incurable disease using the Generator,

and using the Discriminator to determine whether the sampled drug actually cures the given disease.

J. Molecule Development in Oncology

Insilico Medicine showed the pipeline of generating new anticancer molecules with a defined set of parameters. Researchers proposed an Adversarial Autoencoder (AAE) model for identification and generation of new compounds based on available biochemical data. AAE was trained using Growth Inhibition percentage data, drug concentrations, and fingerprints as inputs [17].

K. Deepfakes

GANs generates high-quality data (text, image, video, speech) which can be used to generate fake information, i.e., deepfakes. Deepfakes algorithms generate fake images and videos whose authenticity cannot be distinguished from the real data. Deepfakes mainly have been explored for facial manipulation which can be classified into three categories, (1) face synthesis is about creating non-existent realistic faces using GANs ; (2) face swap is about swapping faces; (3) facial attributes and expressionis about manipulating attributes of the face, such as color tone, age, gender, etc. There is a need of algorithms that can detect fake content automatically.A novel solution is proposed to detect deepfakes by identifying subtle visual artifacts in the image.

L. Handling privacy issues in data generation

GANs has also been used for generating synthetic data which can be made available publicly instead of real data. However, an adversary can get the training set membership through the GANs model and generated synthetic data. A model memorizes the training samples which leads the issue of privacy and makes the GANs model vulnerable. It is easy to identify the training samples through the observation that D is more likely to classify training samples as real rather than samples not present in the training data. To achieve the privacy, records in the data can be de-identified, but now de-identified records can be re-identified by relating them to other identifiable datasets. Differentially Private Generative Adversarial Network (DP-GAN) is proposed to guarantee differential privacy of D by introducing noise during the model optimization. But, proposed model does not maintain trade-off between sample quality and diversity while supporting differential privacy. Hence, model is not useful for practical applications. An architecture design is proposed maintaining trade-off between privacy and sample quality.

M. Fairness

Recently, achieving fairness in learning models have gained momentum in machine learning for several applications, such as granting loan, shortlisting candidate for interview, etc. A GANs-based approach is proposed to generate fair dataset w.r.to sensitive attributes in allocative decision making from the real dataset for model training. Reinforcement learning based race balance network is proposed to handle the bias in the data. Existing deep learning models are pointed out for face recognition encode gender information implicitly. A new direction introduced for handling the issue of missing fairness in the outcome. It is identified that existing deep learning classifiers trained to generate diagnostic labels from X-ray images are biased w.r.to sensitive attributes[38].

IV. CONCLUSION

This paper summarizes the background of GANs, expounds its basic principles, and introduces its derived model and its application in various fields. Despite being a relatively newly-proposed approach, GANs have been widely accepted in the machine learning community, with the quantity of research carried out in respect of them increasing at a significant pace. The ability of GAN to generate “infinite” new samples from potential distribution has great application value in many fields such as image and vision computing, speech and language processing, and information security. The author also investigate the development trends of GANs, there are many opportunities for the developments in both theory and algorithms, and by using deep networks, there are vast opportunities for new applications.

REFERENCES

[1] J. W. Li, W. Monroe, T. L. Shi, S. Jean, A. Ritter, and D. Jurafsky, “Adversariallearning for neural dialogue generation,” arXiv: 1701.06547,2017.
[2] L. T. Yu, W. N. Zhang, J. Wang, and Y. Yu, “SeqGAN: sequencegenerative adversarial nets with policy gradient,” arXiv: 1609.05473,2016.
[3] W. W. Hu and Y. Tan, “Generating adversarial malware examples forblack-box attacks based on GAN,” arXiv: 1702.05983, 2017.
[4] M. Chidambaram and Y. J. Qi, “Style transfer generative adversarialnetworks: Learning to play chess differently,” arXiv: 1702.06762, 2017.
[5] X. Kunfeng Wang, Chao Gou, Yanjie Duan, Yilun Lin, Xinhu Zheng,and Fei-Yue Wang,. ieee/caa Journal Of Automatica Sinica, vol. 4, no. 4, 2017
[6] Y. Z. Zhang, Z. Gan, and L. Carin, “Generating text via adversarialtraining,” Proc. Workshop on Adversarial Training, Barcelona, Spain,2016.

[7] S. Pascual, A. Bonafonte, and J. Serr´a, "SEGAN: speech enhancementgenerative adversarial network," arXiv: 1703.09452, 2017.

[8] S. Reed, Z. Akata, X. C. Yan, L. Logeswaran, B. Schiele, and H. Lee,"Generative adversarial text to image synthesis," in Proc. 33rd Int. Conf.Machine Learning, New York, NY, USA, vol. 48, pp. 1060¡1069, 2016.

[9] H. Zhang, T. Xu, H. S. Li, S. T. Zhang, X. L. Huang, X. G. Wang, andD. Metaxas, "StackGAN: text to photo-realistic image synthesis withstacked generative adversarial networks," arXiv: 1612.03242, 2016

[10] Sung-Wook Park, Jae-Sub Ko, Jun-Ho Huh, and Jong-Chan Kim, Review on Generative Adversarial Networks: Focusing on Computer Vision and Its Applications, https://www .mdpi.com/ journal/electronics Electronics 2021, 10, 1216

[11] Gouk, H.; Frank, E.; Pfahringer, B.; Cree, M. Regularisation of Neural Networks by Enforcing Lipschitz Continuity. arXiv 2020,arXiv:1804.04368. Available online: https://arxiv.org/abs/1804.04368 (accessed on 26 May 2020).

[12] Gulrajani, I.; Ahmed, F.; Arjovsky, M.; Dumoulin, V.; Courville, A.C. Improved training of wasserstein gans. In Proceedings of theAdvances in Neural Information Processing Systems, Long Beach, CA, USA, 4–9 December 2017; Curran Associates Inc.: Red Hook, NY,USA, 2018; pp. 5767–5777.

[13] Ioffe, S.; Szegedy, C. Batch normalization: Accelerating Deep Network Training by Reducing Internal Covariate Shift. arXiv 2020,arXiv:1502.03167. Available online: https://arxiv.org/abs/1502.03167 (accessed on 28 May 2020).

[14] Saifuddin Hitawala,Comparative Study on Generative Adversarial Networks, arXiv:1801.04271v1 [cs.LG]

[15] Chen, Xi, Duan, Yan, Houthooft, Rein, Schulman, John, Sutskever, Ilya, and Abbeel, Pieter. Infogan: Interpretable representation learning by information maximizing generative adversarial nets. In Advances inNeural Information Processing Systems, pp. 2172–2180,2016.

[16] Mirza, Mehdi and Osindero, Simon. Conditional generative adversarial nets. arXiv preprint arXiv:1411.1784, 2014.

[17] Hamed Alqahtani, Manolya Kavakli Thorne, Gulshan Kumar, Applications of Generative Adversarial Networks (GANs): An UpdatedReview, Archives of Computational Methods in Engineering, https://doi.org/ 10.1007/ s11831-019-09388-y, 2019

[18] Goodfellow I, Pouget-Abadie J, Mirza M, Xu B, Warde-FarleyD, Ozair S, Courville A, Bengio Y (2014) Generative adversarialnets. In: Advances in neural information processing systems, pp2672–2680

[19] Makhzani A, Shlens J, Jaitly N, Goodfellow I, Frey B (2015)Adversarial autoencoders. arXiv preprint arXiv :1511.05644

[20] Donahue J, Krahenbuhl P, Darrell T (2016) Adversarial featurelearning. arXiv preprint arXiv :1605.09782

[21] Jie Gui, Zhenan Sun, Yonggang Wen, Dacheng Tao, Jieping Ye, A Review on Generative Adversarial Networks:
Algorithms, Theory, and Applications, Journal Of Latex Class Files, Vol. 14, NO. 8, 2015, arXiv:2001.06937v1 [cs.LG] 2020

[22] X. Chen, Y. Duan, R. Houthooft, J. Schulman, I.Sutskever, andP. Abbeel, "Infogan: Interpretable representation learning byinformation maximizing generative adversarial nets," in NeuralInformation Processing Systems, pp. 2172–2180, 2016.

[23] Bhaskar Ghosh, Indira Kalyan Dutta, Michael Totaro, Magdy Bayoumi, A Survey on the Progression and Performance ofGenerative Adversarial Networks, DOI: 10.1109/ICCCNT49239.2020.9225510, 2020

[24] Abdul Jabbar, Xi Li*, and Bourahla Omar, A Survey on Generative Adversarial Networks:Variants, Applications, and Training

[25] Comparative Study on Generative Adversarial Networks, Saifuddin Hitawala

[26] M. R. Pavan Kumar, Prabhu Jayagopal, Generative adversarial networks: a survey on applicationsand challenges, Springer, International Journal of Multimedia Information Retrievalhttps://doi.org/10.1007/s13735-020-00196-w, 2020

[27] Gao Y, Liu Y, Wang Y, Shi Z, Yu J (2019) A universal intensity standardization method based on a many-to-one weak-paired cycle generative adversarial network for magnetic resonance images. IEEE Trans Med Imaging 38(9):2059–2069

[28] Qi L, Zhang H, Tan W, Qi S, Xu L, Yao Y, Qian W (2019) Cascaded conditional generative adversarial networks with multiscale attention fusion for automated bi-ventricle segmentation in cardiac mri. IEEE Access 7:172305–172320

[29] Ye F, Zhu F, Fu Y, Shen B (2019) Ecg generation with sequencegenerative adversarial nets optimized by policy gradient. IEEEAccess 7:159369–159378

[30] Shaker AM, Tantawi M, Shedeed HA, Tolba MF (2020) Generalization of convolutional neural networks for ecg classification using generative adversarial networks. IEEE Access 8:35592– 35605

[31] Yang W, Hui C, Chen Z, Xue JH, Liao Q (2019a) Fv-gan: fingervein representation using generative adversarialnetworks. IEEETrans Inf Forensics Secur 14(9):2512–2524

[32] He K, Zhang X, Ren S, Sun J (2016) Deep residuallearning forimage recognition. In: Proceedings of the IEEE conference oncomputer vision and pattern recognition, pp 770–778
[33] Yuan J, He Z (2020) Adversarial dual network learning with randomizedimage transform for restoring attackedimages. IEEEAccess 8:22617–22624
[34] Liang Gonog1,2 and Yimin Zhou, A Review: Generative Adversarial Networks, 978-1-5386-9490-9/19/$31.00_c 2019 IEEE
[35] C. Vondrick, H. Pirsiavash, and A. Torralba, "Generating videos withscene dynamics," in Advances In NeuralInformation Processing Systems,2016, pp. 613–621.
[36] E. Santana and G. Hotz, "Learning a driving simulator," arXiv preprintarXiv:1608.01230, 2016.
[37] Medicine I (2019) Artificial intelligence for drug discovery, biomarkerdevelopment and aging research. URL https ://insil ico.com/
[38] Divya Saxena, Generative Adversarial Networks (GANs): Challenges, Solutions, and Future Directions

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

Study of Convolutional Neural Network

Avinash H. Hedaoo
Assistant Professor, Department of Computer Science
Prerna College of Commerce, Nagpur, Maharashtra, India

Abstract: *The success of traditional methods for solving computer vision problems heavily depends on the feature extraction process. But Convolutional Neural Networks (CNN)have provided an alternative for automatically learning the domain specific features. Now every problem in the broader domain of computer vision is re-examined from the perspective of this new methodology. In deep learning, Convolutional Neural Networks (CNN) are found to give the most accurate results in solving real world problems such as several engineering fields, including array processing, wireless communications, medical signal processing, speech processing and biomedical engineering. The availability of a large amount of data and improvement in the hardware technology has accelerated the research in CNNs. This paper intends to provide a detail study over basic concepts of CNN and its applications.*

Keywords: Convolutional Neural Networks, Machine Learning, computer vision, deep leaning, Machine learning

I. INTRODUCTION

The term artificial intelligence (AI) was first coined by John McCarthy in 1956[2].In recent years, AI based applications have rapidly been developed in all fields[3].Machine learning is defined by TM Mitchell:"Machine learning is the study of computer algorithms that allow computer programs to automatically improve through experience."[4].Deep learning algorithms are a subset of Machine Learning algorithms [5][1].

With the recent advancement in digital technologies, the size of data sets has become too large in which traditional data processing and machine learning techniques are not able to cope with effectively [10,11]. However, analyzing complex, high dimensional, and noise-contaminated data sets is a huge challenge [12-14]. To undertake these problems, in recent years, various deep architectures with different learning paradigm are quickly introduced to develop machines that can perform similar to human or even better [15][9].

A convolutional neural network, symbolled as CNN, or ConvNet, most commonly applied to analyse visual imagery [16]. Such networks are characterised by being multi-layered, and so they are large and they are consequently complex. [17]. These networks are also called "shift invariant" type of artificial neural networks and symbolled as SIANN [18][19].

The concept of neural network has already existed since 1950s whenFrank Rosenblatt created the perceptron. Even convolutional neural network itself is not a new conceptat all [20].In 1959, Hubel & Wiesel [28] found that cells in animal visual cortex are responsible for detecting light in receptive fields. Inspired by this discovery, Kunihiko Fukushima proposed the neocognitron in 1980 [29], which could be regarded as the predecessor of CNN. In 1990, LeCun et al . [30] published the seminal paper establishing the modern framework of CNN, and later improved it in [31]. Like other neural networks, LeNet-5 has multiple layers and can be trained with the back propagation algorithm [32][27].The convolutional neural network was firstly introduced in [21] to recognize handwritten ZIP code in1989, and later extended to recognition and classification of various objects such as hand-written digits (MNIST) [22],house numbers [23], traffic signs [24], Caltech-101 [25] and more recently 1000-category ImageNet dataset [26][20].Initially CNN had been widely used for object recognition tasks but now it is being examined in other domains as well like object tracking [48], pose estimation [49], text detection and recognition [50], visual saliency detection [51], action recognition [52], scene labelling [53] and many more [54].[47]

CNNs saw extensive use in the 90s of 20th century, butfell out of fashion with the emergence of SVM and Bayesian models. One important reason is, small datasets in 1990s and early 2000s such has MNISTandCaltech-101[20].However with the availability of big data and advancements in hardware are the main reasons for the recent

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

success of deep CNNs. Recently, it is shown that different levels of features, including both low and high-level, can be transferred to a generic recognition task by exploiting the concept of Transfer Learning (TL)[73][74][75]. Different architectural designs such as Wide ResNet, ResNeXt, Pyramidal Net, Xception, PolyNet, and many others explore the effect of multilevel transformations on CNNs learning capacity by introducing cardinality or increasing the width [76][77][78][79]. Therefore, the focus of research shifted from parameter optimization and connections readjustment towards the improved architectural design of the network. This shift resulted in many new architectural ideas such as channel boosting, spatial and feature-map wise exploitation and attention-based information processing etc.,[80][81][82][72]. In industry, companies such as Google, Microsoft, AT&T, NEC, and Facebook have developed active research groups for exploring new architectures of CNN [6] [7][1].

This review gives an insight into the basic structure of CNN as well as its historical perspective. This survey will help the readers to develop the theoretical insight into the design principles of CNN and thus may further accelerate the architectural innovations in CNN. The rest of the paper is organized in the following order: Section I develops the systematic understanding of CNN, discusses its resemblance with primate's visual cortex, as well as its contribution to MV. Section II provides history of CNN, Section III discusses about various layers of CNN. Whereas, Section IV discusses the recent innovations in CNN architectures. Section V discusses on applications of CNNs. Finally, the last section concludes.

II. HISTORY OF CNN

With the discovery of concepts such as convolution and back propagation applied to neural networks, NN got better. With the power of GPUs and more efficient algorithms, CNNs can be applied to real life applications[8].

In 1959, Hubel & Wiesel [28] found that cells in animal visual cortex are responsible for detecting light in receptive fields[27].In 1959, an apparatus was developed by Russell Kirsch along with his colleagues for transforming images into grids of numbers so that the machine can understand the images[110]. The evolutionary history of deep CNN architectures is pictorially represented in Fig. 1. Improvements in CNN architectures can be categorized into five different area that are discussed below.

2.1 Origin of CNN: Late 1980s-1999

In 1998, LeCuN proposed an improved version of ConvNet, which was famously known as LeNet-5 [83][84]. Due to the good performance of CNN in optical character and fingerprint recognition, its commercial use in ATM and Banks started in 1993 and 1996, respectively.

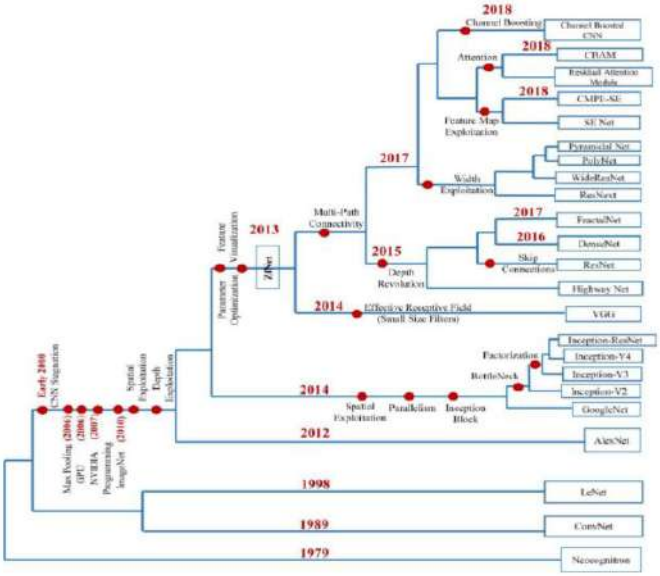


Fig. 1 Evolutionary history of deep CNNs showing architectural innovations from ConvNet till to date architectures.

A. Stagnation of CNN: Early 2000

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

As CNN was not effective in converging to the global minima of the error surface it was considered as a less effective feature extractor compared to handcrafted features [85]. In 2003, [86] improved CNN architecture and showed good results compared to SVM on a hand digit benchmark dataset.

2.2 Revival of CNN: 2006-2011

Hinton reported the concept of greedy layer-wise pre-training in 2006. Experimental studies showed that both supervised and unsupervised pre-training could initialize a network in a better way than random initialization. The observation of Bengio and other researchers started the use of activation functions other than sigmoid such as ReLU, tanh etc., [87]. [88]used max-pooling instead of subsampling, which showed good results by learning invariant features [89]. In late 2006, researchers started using graphics processing units (GPUs) to accelerate the training of deep NN and CNN architectures [90][91][92][93]. In 2007, NVIDIA launched the CUDA programming platform, which allows exploitation of parallel processing capabilities of GPU with a greater degree [94] [95]. ImageNet Large Scale Visual Recognition Challenge (ILSVRC)and Neural Information Processing Systems Conference (NIPS) are the two platforms that play a dominant role in strengthening research and increasing the use of CNN and thus making it popular.

2.3 Rise of CNN: 2012-2014

The main breakthrough in CNN performance was brought by AlexNet, which showed exemplary performance in 2012-ILSVRC [96]. The problems of determining filter dimensions, stride, padding, and other hyper-parameters for each layerresolved by the concept of modularity in CNNs made it easy to tailor them for different tasks effortlessly [97][98]. In this connection, a different idea of branching and block within a layer was introduced by the Google group [99].

2.4 Rapid Increase In Architectural Innovations And Applications of CNN: 2015-Present

In 2015, different ideas such as information gating mechanism across multiple layers, skip connections, and cross-layer channel connectivity was introduced [100][101][102]. Most of the famous object detection and segmentation architectures such as Single Shot Multibox Detector (SSD), Region-based CNN (R-CNN), Faster R-CNN, Mask R-CNN and Fully Convolutional Neural Network (FCN) are built on the lines of ResNet, VGG, Inception, etc. [103][104][105]. Applications of deep showed state-of-the-art results on MS COCO-2015 image captioning challenge.
Similarly, in 2016, it was observed that the stacking of multiple transformations not only depth-wise but also in parallel fashion showed good learning for complex problems [76][77]. Different researchers used a hybrid of the already proposed architectures to improve deep CNN performance [102]. In 2017, the focus was on designing of generic blocks In 2018, a new idea of channel boosting was introduced by [81].
The solutions to the problems of high computational cost and memory requirement are discussed in [106][107][108][109]. From 2012 up till now, many improvements have been reported in CNN architectures[72].

III. CNN LAYERS

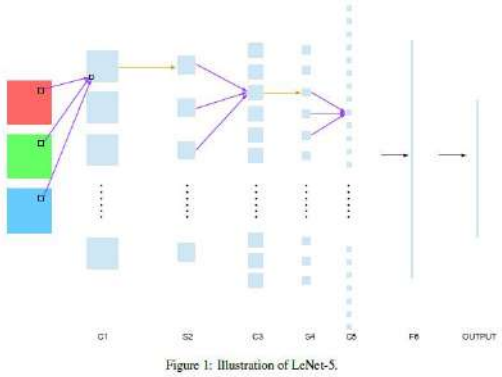


Figure 1: Illustration of LeNet-5.

Fig 2 : Illustration of LeNet-5

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

Convnets are very similar to normal neural networks which can be visualized as a collection of neurons arranged as an acyclic graph. The main difference from a neural network isthat a hidden layer neuron is only connected to a subset of neurons in the previous layer. Because of this sparse connectivity it is capable to learn features implicitly. The deep architecture of the network results in hierarchical feature extraction [47].

The modern convolutional neural networks proposed by LeCun [113] is a 7-layer (excluding the input layer)LeNet-5structure. It has the following structure C1,S2, C3, S4, C5, F6, OUTPUT as shown in Figure 2,where C indicates convolutional layer, S indicates sub sampling layer, and F indicates fully-connected layer.

Among different structures, they share fourkey features including weight sharing, local connection, pooling, and the use of many layers [112]. There are some commonly used layers such as convolutional layers, sub sampling layers (pooling layers), and fully connected layers. Usually, there is a convolutional layer after the input. The convolutional layer is often followed by a subsampling layer. This combination repeats several times to increase the depth of CNN. The fully connected layers are designed as the last few layers in order to map from extracted features to labels. [111]

As fundamental building blocks of CNNs, CNN layers have shown their variety and flexibility both in their designed structures and the connections. The efforts in modifying layer structures and connections have led to the possibility of training a CNN faster and of making it perform better. In following subsections, we will introduce common layers of modern CNNs and their functions.

3.1 Activation function

Activation function serves as a decision function and helps in learning of intricate patterns. The activation function for a convolved feature-map is defined in equation (3).

$$T_i^l = a(F_i^l) \quad (3)$$

In the above equation, F_i^l an output of a convolution, which is assigned to activation functiona(.) that adds non-linearity and returns a transformed output for lth laT_i^lr.[72]There are several types of activation functions[72][20][27] [47][111].

3.2 Pooling

Feature motifs, which result as an output of convolution operation, can occur at different locations in the image. Oncefeatures are extracted, its exact location becomes less important as long as its approximate position relative to others ispreserved. Pooling or down-sampling is an interesting local operation. It sums up similar information in theneighborhood of the receptive field and outputs the dominant response within this local region (Lee et al. 2016). [47]Pooling is an important step to further reduce thedimensions of the activation map, keeping only the importantfeatureswhile also reducing the spacial invariance. This inturn reduces the number of learnable features for the model.Thishelps to resolve the problem of overfitting. Poolingallows CNN to incorporate all the different dimensions of animageso that it successfully recognises the given object evenif its shape is skewed or is present at a different angle.[121]

3.3 Convolutional Layer

The convolutional layer is composed of a set of convolutional kernels where each neuron acts as a kernel. However, if the kernel is symmetric, the convolution operation becomes a correlation operation. Convolutional kernel works by dividing the image into small slices, commonly known as receptive fields. The division of an image into small blocks helps in extracting feature motifs. Kernel convolves with the images using a specific set of weights by multiplying its elements with the corresponding elements of the receptive field[72].

Convolution Layer basically convolves or multiplies the pixel matrix generated for the given image or object to produce an activation map for the given image. The main advantage of activation map is that it stores all the distinguishing features of a given image while at the same time reducing the amount of data to be processed. The matrix with which the data is convolved is a feature detector which basically is a set of values with which the machine is compatible. Different versions of image are generated using different values of feature detector. The convoluted model is also trained with back propagation in order to ascertain minimal error in each layer. According to the lowest error set, depth and padding is set.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

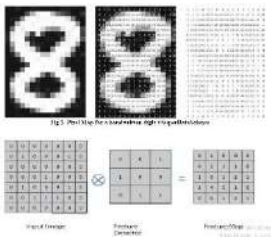


Fig 3. Convolution to produce an Activation Map ©SuperDataScience

Fig. 3 above shows how convolution works. This step involves convoluting the matrix containing the image data and then feature detector which gives us an activation map or a feature map. What happens in convolution is that the values on identical positions in the data and feature map i.e. values having value 1 or more than 1 are kept while rest areremoved. The matrix from the image data is compared 3x3 at a time. The size of feature detector varies with the type of CNN used. For example there are versions of CNN which use 5x5 or even7x7 scale filters for convolution. Convolution follows which aims to show how one function modifies the shape of the other [121].

The spatial extend of sparse connectivity between the neurons of two layers is a hyper paramter called receptive field. The hyper parameters that control the size of the output volume are the depth(number of filters at a layer), stride(for filter movement) and zero padding(to control spatial size of output). The ConvNets are trained with Back propagation and the backward pass as well involves convolution operation but with spatially flipped filters. One of the variants of the traditional CNN is "Network In Network"(NIN) proposed by Lin et al. [114] [115]. To alleviate saturation problem, many non-saturated activations are proposed such as Rectified Linear Unit (ReLU) [116], Leaky ReLU [117], Parametric ReLU (PReLU) [118], Randomized Leaky ReLU (RReLU) [119], and Exponential Linear Unit (ELU) [120][111].

Convolution filter in basic CNNs is a Generalized Linear Model (GLM) for the underlying local image patch. It works well for abstraction when instances of latent concepts are linearly separable. There are some types of convolution which can be sued to enhance CNN's representation abilitylike, Tiled Convolution, Transposed Convolution, Dilated Convolution, Network in Network, Inception Module[27].

3.4 Fully Connected (FC)

The fully connected layer is the last layer of CNN architecture. Neurons in this layer are fully connected to all neurons in the previous layer, as in a regular Neural Network. High level reasoning is done here. The neurons are not spatially arranged(one dimensional) so there cannot be a conv layer after a fully connected layer [47]. In a typical CNN, the feature maps of last convolutional layer are vectorized and fully connected with output units, which are followed by a softmax loss layer [122]. This FC layer takes input from other layers and transforms them into specific no. of classes which are already decided by the network. The output layer of the FC layer is computed for error calculation. Then, a loss function(SVM/Softmax) is defined to compute the gradient of error. These errors are propagated backwardly to update weights and bias in back propagation neural network. In one forward and backward pass, one cycle is completed for training[110].

3.5 Loss Layer

The last fully connected layer serves as the loss layer that computes the loss or error which is a penalty for discrepancy between desired and actual output. For predicting a single class out of K mutually exclusive classes Softmax loss isused. It is the commonly used loss function. Basically it is multinomial logistic regression. It maps the predictions tonon- negative values and also normalized to get probability distribution over classes. Large margin classifier, SupportVector Machine, is trained by calculating Hinge loss. For regressing to real-valued labels Euclidean loss can be used. [47]Four representative losses are Hinge loss, Softmax loss, Contrastive loss, Triplet loss.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

IV. CNN ARCHITECTURES

4.1 LeNet

This was one of the pioneering work in Convolutional Neural Networks by LeCun et al. In 1990 [56] and later improved it in 1998 [57]. Itfinds application in reading zip codes, digits, etc. [47]. LeNet exploited the underlying basis of the image that the neighboring pixels are correlated to each other and feature motifs are distributed across the entire image. Therefore, convolution with learnable parameters is an effective way to extract similar features at multiple locations with few parameters. Learning with sharable parameters changed the conventional view of training where each pixel was considered as a separate input feature from its neighborhood and ignored the correlation among them. LeNet was the first CNN architecture, which not only reduced the number of parameters but was able to learn features from raw pixels automatically [72].The final input that isprovided to the FCNis of dimension 120x1x1. No. of parameters taken into account are approximately 60,000[121].

4.2 AlexNet

This architecture developed by Alex Krizhevsky, Ilya Sutskever and Geoff Hinton [58] is credited as the first work in Convolutional Networks to popularize it in the field of computer vision and was published in 2012. The network was similar to LeNet but instead of alternating conv layers and pooling layers, AlexNet had all the conv layers stacked together [47]. Input provided was about 15million RGB image data of dimensions 3x224x224 image(which was later corrected to 227x227) from about 22,000categories. This Deep CNN consists of 7 layers and 60million parameters. The operations consists of 11x11,5x5,3x3 convolutions, 3x3 max pooling ending with 2 fully connected layers of 4096 layers each. AlexNet was able to win the ILSVRC-2012 competitions achieving top-1and top-5 error rates on test dataset[121].To address challenge of over fitting, Krizhevesky et al. (2012) exploited the idea of Hinton (Dahl et al. 2013; Srivastava et al. 2014)[72].

4.3 GoogleNet

This ConvNet architecture from Szegedy et al.[59] from Google won the ILSVRC 2014 competition. They have proposed a new architecture called Inception (v1) that gives more utilization of the computing resources in the network[47].The GoogLeNet also followed the block pattern as followed by VGG 16 and each block is called Inception Module. GoogLeNet uses total of 9 inception module. This network 22 layers deep but compensated by relatively much lesser no. of parameters of about 5 million compared to runner up VGG's 138 million parameters. [121] In GoogleNet, conventional convolutional layers are replaced in small blocks similar to the idea of substituting each layer with micro NN as proposed in Network in Network (NIN) architecture (Lin et al. 2013). The exploitation of the idea of split, transform, and merge by GoogleNet, helped in addressing a problem related to the learning of diverse types of variations present in the same category of images having different resolutions. GoogleNet regulates the computations by adding a bottleneck layer of 1x1 convolutional filter, before employing large size kernels. Other regulatory factors applied were batch normalization and the use of RmsProp as an optimizer (Dauphin et al. 2015). GoogleNet also introduced the concept of auxiliary learners to speed up the convergence rate. However, the main drawback of the GoogleNet was its heterogeneous topology and a representation bottleneck[72].

4.4 VGG(16) Net

Karen Simonyan and Andrew Zisserman have done a thorough analysis of the depth factor in a ConvNet, keeping all other parameters fixed [47].VGG stands for Visual Geometric Group. This network contains about 138 million parameters. Thereare total 16 convolutional layers in VGG 16, distributed in 3blocks containing 2layers of 3x3 convolutions followed by2x2 max pooling and 2 blocks containing 3 layers of 3x3convolutions followed by 2x2 max pooling. The architecture isfinally finished by 2 fully connected layers of 4096 hidden layers each. [121] The use of the small size filters provides an additional benefit of low computational complexity by reducing the number of parameters. VGG regulates the complexity of a network by placing 1x1 convolutions in between the convolutional layers, which, besides, learn a linear combination of the resultant feature-maps. For the tuning of the network, max-pooling is placed after the convolutional layer, while padding was performed to maintain the spatial resolution (Ranzato et al. 2007)[123].VGG was at 2nd place in the 2014-ILSVRC competition but, got fame due to its simplicity, homogenous

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

topology, and increased depth. The main limitation associated with VGG was the use of 138 million parameters, which make it computationally expensive and difficult to deploy it on low resource systems. [72]

4.5 ResNet

Kaiminget. al. [60] have presented a residual learning framework where the layers learn residual functions with respect to the inputs received instead of learning unreferenced functions[47]. ResNet or Deep Residual Network was the winner for ImageNet challenge for 2015 surpassing the human accuracy error for the first time with an error rate of about 3.6%. The network is very very deep and the one presented at challenge was 152 layers deep. In order to counter Vanishing Gradient Problem, ResNet introduced a feature of skip connection. The concept behind resnet was that even if thenet work was deep, the training of the network was similar to that of shallow network by skipping after every 2 layer. In order to compute, the input and output both were copied to the next layer basically learning the residual of previous computation. No. of parameters computed were about 65 million. Some layers also have bottleneck starting and ending by 1x1convolution. Batch Normalization was used after each convolution.[121]In order to address the problems faced during training of deep networks, ResNet exploited the idea of bypass pathways used in Highway Networks (He et al. 2015a). Residual links (shortcut connections) speed up the convergence of deep networks, thus giving ResNet the ability to avoid gradient diminishing problems. [72]To overcome the problem of high depth in residual networks, authors Zagoruyko et al. [21] proposed wide residual networks (WRNs) used for mitosis detection in breast histology images [22]. Larsson et al. [23] proposed Fractalnet [123].

4.6 ResNeXt

ResNeXt, also known as Aggregated Residual Transform Network, is an improvement over the Inception Network (Xie et al. 2017). Cardinality is an additional dimension, which refers to the size of the set of transformations (Han et al. 2018; Sharma and Muttoo 2018). ResNeXt utilized the deep homogenous topology of VGG and simplified GoogleNet architecture. ResNeXt used multiple transformations within a split, transform and merge block and defined these transformations in terms of cardinality. The complexity of ResNeXt was regulated by applying low embedding's (1x1 filters) before 3x3 convolution, whereas training was optimized by using skip connections (Larsson et al. 2016).[72]

V. CNN APPLICATION

Because of CNN popularity, it has many applications and used in extensive manner. Some of them are discussed below:

5.1 Natural Language Processing (NLP)

Natural Language Processing (NLP) converts language into a presentation that can easily be exploited by any computer. CNNs have also been utilized in NLP based applications such as language modeling, and analysis, etc. Especially, language modelling or sentence modelling has taken a twist after the introduction of CNN as a new representation learning algorithm.[72] CNNs are usually utilized in natural language processing [61]. CNN models are useful for numerous natural language processing issues and achieved glorious results in text categorization, semantic parsing [62], search query retrieval [63], and classification [64], prediction [65], text categorization [66], diversified traditional natural language processing [61][47] , Statistical Language Modelling, Text Classification[27], Sentence Modelling, Twitter Sentiment Analysis and Semantic Role Labeling tasks[8].

5.2 Computer Vision and Related Applications

Computer vision (CV) focuses on developing an artificial system that can process visual data, including images and videos and can effectively understand, and extract useful information from it .Farfade, et al. proposed deep CNN for detecting faces from different poses as well as from occluded faces [67]. In another work, Zhang et al. performed face detection using a new type of multitasking cascaded CNN [68]. Zhang's technique showed good results when compared to state-of-the-art techniques [69].Experimental results have shown that Wang's technique outperforms other activity recognition based techniques [70, 71]. Similarly, another three dimensional CNN based action recognition system is proposed by Ji et al. [72]. [47] [72] Deep Pose is the first application of CNNs to human pose estimation problem [27].

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

5.3 Object Detection and Segmentation

Object detection focuses on identifying different objects in images. Recently, R-CNN has been widely used for object detection[47] . Recently, AE based CNN architectures have shown success in segmentation tasks. [72] One of the most famous object proposal based CNN detector is Region-based CNN (R-CNN) [33]. Spatial pyramid pooling network (SPP net) [34] is a pyramid-based version of R-CNN [33], which introduces an SPP layer to relax the constraint that input images must have a fixed size. Fast RCNN [35] improves SPP net by using an end-to-end training method. Later, Faster R-CNN [35] introduces a region proposal network (RPN) for object proposals generation and achieves further speed-up. More recently, YOLO [36] and SSD [37] allow single pipeline detection that directly predicts class labels.[27]

5.4 Image Classification

CNN has been widely used for image classification. One Recently, Spanhol et al. used CNN for the diagnosis of breast cancer images, and results are compared against a network trained on a dataset containing handcrafted descriptors [47], Wahab et al. 2017, Cireşan et al. 2012]. The different pixel neighborhoods can be evaluated with the help of spatial dependencies of cell and non-cell pixels. In (Su, Liu, Xie, et al. 2015), proposed method is used to segment a high resolution image (1000*1000) done in only 2.3 seconds[38].

Subcategory classification is another rapidly growing subfield of image classification. Along this way, Branson et al .[39] propose a method which detects parts and extracts CNN features from multiple pose-normalized regions. Zhanget al . [40] propose a part-based R-CNN which can learn whole-object and part detectors. Lin et al . [41] incorporate part localization, alignment, and classification into one recognition system which is called Deep LAC. Krause et al . [42] use the ensemble of localized learned feature representations for fine-grained classification.

5.5 Object Tracking

There are several attempts to employ CNNs for visual tracking. Fan et al . [43] use CNN as a base learner. In [43], the authors design a CNN tracker with a shift-variant architecture Li et al. [44] propose a target-specific CNN for object tracking, where the CNN is trained incrementally during tracking with new examples obtained online. Li et al . [44] use a relatively small number of filters in the CNN within a framework equipped with a temporal adaptation mechanism. In [45], a CNN object tracking method is proposed to address limitations of handcrafted features and shallow classifier structures in object tracking problem. In [46] propose a visual tracking algorithm based on a pre-trained CNN[27].

VI. CONCLUSION

CNN has made remarkable progress, especially in image processing and vision-related tasks, and has thus revived the interest of researchers in ANNs. In this context, several research works have been carried out to improve CNN's performance on such tasks. Due to the advantages of CNNs, such as local connection, weight sharing, and down sampling dimensionality reduction, CNN has been widely deployed in both research and industry projects. The advancements in CNNs can be categorized in different ways, including activation, loss function, optimization, regularization, learning algorithms, and innovations in architecture. This paper studies advancement in the CNN architectures, especially based on the design patterns of the processing units and thus has proposed the taxonomy for recent CNN architectures. In addition to the categorization of CNNs into different classes, this paper also covers the history of CNNs, its applications. The learning capacity of CNN is significantly improved over the years by exploiting depth and other structural modifications. It is observed in recent literature that the main boost in CNN performance has been achieved by replacing the conventional layer structure with blocks. Even though convolutions possess many benefits and have been widely used, we reckon that they can be refined further in terms of model size, and security. Moreover, there are lots of problems that convolution is hard to handle, such as low generalization ability, lack of equivariance, and poor crowded-scene results, so that several promising directions are pointed. Although CNNs have achieved great success in experimental evaluations, there are still lots of issues that deserve further investigation. Firstly, they require large-scale dataset and massive computing power for training. Manually collecting labeled dataset requires huge amounts of human efforts. Thus, it is desired to explore unsupervised learning of CNNs. Meanwhile ,to speed up training procedure, it is still worth to develop effective and scalable parallel training algorithms. It is important

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

to investigate how to reduce the complexity and obtain fast-to-execute models without loss of accuracy. Furthermore, one major barrier for applying CNN on a new task is that it requires considerable skill and experience to select suitable hyper parameters. These hyper-parameters have internal dependencies which make them particularly expensive for tuning. Finally, the solid theory of CNNs is still lacking. Meanwhile, it is also worth exploring how to leverage natural visual perception mechanism to further improve the design of CNN. I hope that this paper not only provides a better understanding of CNNs but also facilitates future research activities and application developments in the field of CNNs.

REFERENCES

[1]. S. Majid Rezaee, A Review On Convolutional Neural Networks And Its Applications, https://www.researchgate.net/publication/353922229, July 2021

[2]. John McCarthy. what is artificial intelligence? Computer Science Department Stanford University.www-formal.stanford.edu/jmc/. 2007 Nov 12.

[3]. RaffaeleCioffi, Marta Travaglioni, GiuseppinaPiscitelli, AntonellaPetrillo, andFabio De Felice . Artificial Intelligence and Machine Learning Applications in Smart production: Progress, Trends, and Directions. Sustainability 2020, 12, 492; doi:10.3390/su12020492.

[4]. Tom M. Mitchell. Machine Learning Definition, McGraw-Hill Science, Engineering, Math; (March 1, 1997), Page 1.

[5]. Adrian Carrio, Carlos Sampedro, Alejandro Rodriguez-Ramos, and PascualCampoy. Review Article A Review of Deep Learning Methods and Applications for Unmanned Aerial

[6]. Deng L, Yu D, Delft B— (2013) Deep Learning: Methods and Applications Foundations and Trends R in Signal Processing. Signal Processing 7:3–4. doi: 10.1561/2000000039.

[7]. Asifullah Khan, AnabiaSohailUmmeZahoora, and Aqsa Saeed Qureshi. A Survey of the Recent Architectures of Deep Convolutional Neural Networks. Published in Artificial Intelligence Review, DOI: https://doi.org/10.1007/s10462-020-09825-6.

[8]. D. T. Mane, SGGS IE&T, Nanded, India, U. V. Kulkarni, A Survey on Supervised Convolutional Neural Network and Its Major ApplicationsInternational Journal of Rough Sets and Data Analysis, Volume 4 , Issue 3, 2017

[9]. Xizhao Wang1 • Yanxia Zhao1 • Farhad Pourpanah2, Recent advances in deep learning, International Journal of Machine Learning and Cybernetics (2020) 11:747–750

[10]. Wang X, Joshua HZ (2015) Uncertainty in learning from big data. Fuzzy Sets Syst 258:1–4

[11]. Rezvani S, Wang X, Pourpanah F (2019) Intuitionistic fuzzy twin support vector machines. IEEE Trans Fuzzy Syst 27(11):2140–2151

[12]. Wang Z, Wang X (2018) A deep stochastic weight assignment network and its application to chess playing. J Parallel DistribComput 117:205–211

[13]. Wang Z, Wang X (2018) A deep stochastic weight assignment network and its application to chess playing. J Parallel DistribComput 117:205–211

[14]. Pourpanah F, Lim CP, Wang X, Tan CJ, Seera M, Shi Y (2019) A hybrid model of fuzzy minmax and brain storm optimization for feature selection and data classification. Neurocomputing 333:440–451

[15]. Sengupta S, Basak S, Saikia P, Paul S, Tsalavoutis V, Atiah F, Ravi V, Peters A (2020) A review of deep learning with special emphasis on architectures, applications and recent trends. Knowl-Based Syst https ://doi.org/10.1016/j.knosy s.2020.10559 6

[16]. I. Krizhevsk, Alex Sutskever and G. E. Hinton, "ImageNetClassificationWithDeepConvolutionalNeural Networks," Adv. Neural Inf. Process. Syst., 2012.

[17]. T. Chilimbi, Y. Suzue, J. Apacible, and K. Kalyanaraman "ProjectAdam: Building An Efficient And Scalable DeepLearning Training System," 11th USENIX Symp. Oper. Syst. Des. Implement., pp. 571–582, 2014.

[18]. W. Zhang, K. Itoh, J. Tanida, and Y. Ichioka, "Parallel distributed processing model with local spaceinvariant interconnections and its optical architecture," Appl. Opt., 1990.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[19]. Ali FadhilYaseen, A Survey on the Layers of Convolutional Neural Networks, IJCSMC Journal, Vol.7 Issue.12, December- 2018, pg. 191-196

[20]. Chenyou Fan Indiana University Bloomington, IN, Survey of Convolutional Neural Network

[21]. Y. LeCun, et al.,Backpropagation applied to handwritten zip code recognition. Neural computation, 1(4):541–551, 1989.

[22]. Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner. Gradientbased learning applied to document recognition. Proceedings of the IEEE, 86(11):2278–2324, 1998

[23]. P. Sermanet, S. Chintala, and Y. LeCun. Convolutional neural networks applied to house numbers digit classification. In Pattern Recognition (ICPR), 2012 21st International Conference on, pages 3288–3291. IEEE, 2012.

[24]. P. Sermanet and Y. LeCun. Traffic sign recognition with multi-scale convolutional networks. In Neural Networks (IJCNN), The 2011 International Joint Conference on, pages 2809–2813. IEEE, 2011

[25]. L. Fei-Fei, R. Fergus, and P. Perona. Learning generative visual models from few training examples: An incremental bayesian approach tested on 101 object categories. Computer Vision and Image Understanding, 106(1):59–70, 2007.

[26]. I. Krizhevsky, I. Sutskever, and G. E. Hinton. Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems, pages 1097–1105, 2012.

[27]. JiuxiangGu et al., Recent Advances in Convolutional Neural Networks, arXiv:1512.07108v6 [cs.CV] 19 Oct 2017

[28]. D. H. Hubel, T. N. Wiesel, Receptive fields and functional architecture of monkey striate cortex, The Journal of physiology (1968) 215–243.

[29]. K. Fukushima, S. Miyake, Neocognitron: A self-organizing neural network model for a mechanism of visual pattern recognition, in: Competition and cooperation in neural nets, 1982, pp. 267–285.

[30]. *B. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard, L. D. Jackel, Handwritten digit recognition with a back propagation network, in: Proceedings of the Advances in Neural Information Processing Systems (NIPS), 1989, pp. 396–404.*

[31]. Y. LeCun, et al., Gradient-based learning applied to document recognition, Proceedings of IEEE 86 (11) (1998) 2278–2324.

[32]. R. Hecht-Nielsen, Theory of the backpropagation neural network, Neural Networks 1 (Supplement-1) (1988) 445–448.

[33]. R. Girshick, J. Donahue, T. Darrell, J. Malik, Rich feature hierarchies for accurate object detection and semantic segmentation, in: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2014, pp. 580–587

[34]. K. He, X. Zhang, S. Ren, J. Sun, Spatial pyramid pooling in deep convolutional networks for visual recognition, IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI) 37 (9) (2015) 1904–1916.

[35]. S. Ren, K. He, R. Girshick, J. Sun, Faster r-cnn: Towards real-time object detection with region proposal networks, IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI) 39 (6) (2017) 1137–1149.

[36]. J. Redmon, S. Divvala, R. Girshick, A. Farhadi, You only look once: Unified, real-time object detection, in: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 779–788.

[37]. W. Liu, D. Anguelov, D. Erhan, C. Szegedy, S. Reed, Ssd: Single shot multibox detector, in: Proceedings of the European Conference on Computer Vision (ECCV), 2016, pp. 21–37.

[38]. O. Russakovsky, J. Deng, H. Su, J. Krause, S. Satheesh, S. Ma, Z. Huang, A. Karpathy, A. Khosla, M. Bernstein, et al., Imagenet large scale visual recognition challenge, International Journal of Conflict and Violence (IJCV) 115 (3) (2015) 211–252.

[39]. S. Branson, G. Van Horn, P. Perona, S. Belongie, Improved bird species recognition using pose normalized deep convolutional nets, in: Proceedings of the British Machine Vision Conference (BMVC), 2014.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[40]. N. Zhang, J. Donahue, R. Girshick, T. Darrell, Part-based r-cnns for fine-grained category detection, in: Proceedings of the European Conference on Computer Vision (ECCV), 2014, pp. 834–849.

[41]. Lin, X. Shen, C. Lu, J. Jia, Deep lac: Deep localization, alignment and classification for fine-grained recognition, in: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2015, pp. 1666–1674.

[42]. J. Krause, T. Gebru, J. Deng, L.-J. Li, L. Fei-Fei, Learning features and parts for fine-grained recognition, in: Proceedings of the International Conference on Pattern Recognition (ICPR), 2014, pp. 26–33.

[43]. J. Fan, W. Xu, Y. Wu, Y. Gong, Human tracking using convolutional neural networks, IEEE Trans. Neural Networks(TNN) 21 (10) (2010) 1610–1623.

[44]. H. Li, Y. Li, F. Porikli, Deeptrack: Learning discriminative feature representations by convolutional neural networks for visual tracking, in: Proceedings of the British Machine Vision Conference (BMVC), 2014.

[45]. Y. Chen, X. Yang, B. Zhong, S. Pan, D. Chen, H. Zhang, Cnntracker: Online discriminative object tracking via deep convolutional neural network, Appl. Soft Comput. 38 (2016) 1088–1098.

[46]. S. Hong, T. You, S. Kwak, B. Han, Online tracking by learning discriminative saliency map with convolutional neural network, in: Proceedings of the International Conference on Machine Learning (ICML), 2015, pp. 597–606.

[47]. Neena Aloysius and Geetha M, A Review on Deep Convolutional Neural Networks, International Conference on Communication and Signal Processing, April 6-8, 2017, India

[48]. J. Fan, W. Xu, Y. Wu, and Y. Gong, Human tracking using convolutionalneural networks, Neural Networks, IEEE Transactions, 2010.

[49]. I. Toshev and C. Szegedy, Deep -pose: Human pose estimation viadeepneural networks, in CVPR, 2014.

[50]. M. Jaderberg, A. Vedaldi, and A. Zisserman, Deep features for textspotting, in ECCV, 2014.

[51]. R. Zhao, W. Ouyang, H. Li, and X. Wang, Saliency detection by multicontextdeep learning, in CVPR, 2015.

[52]. J. Donahue, Y. Jia, O. Vinyals, J. Hoffman, N. Zhang, E. Tzeng, and T.Darrell, Decaf: A deep convolutional activation feature for generic, 2014

[53]. *Farabet, C. Couprie, L. Najman, and Y. LeCun, Learning hierarchicalfeatures for scene labeling, PAMI, 2013.*

[54]. Nithin, D Kanishka and Sivakumar, P Bagavathi, Generic Feature Learningin Computer Vision, Elsevier, Vol.58, Pages202-209, 2015.

[55]. Matthew D. Zeiler, Rob Fergus, Visualizing and Understanding Convolutional Networks, 13th European Conference, Zurich, Switzerland,2014, Proceedings, Part I, Volume 8689, pages:818-833.

[56]. B. B. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hub- bard, and L. D. Jackel, Handwritten digit recognition with a back- propagation network, in NIPS, 1990.

[57]. Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner, Gradient-based learning applied to document recognition, Proceedings of the IEEE,1998

[58]. Alex Krizhevsky, Sutskever I, and Hinton G.E. Imagenet classificationwith deep convolutional neural networks. In NIPS, 2012.

[59]. C. Szegedy, W. Liu, Y. Jia, P. Sermanet, S. Reed, Going deeper withconvolutions, CoRR, 2014.

[60]. K. He, X. Zhang, S. Ren, and J. Sun. Deep residual learning for imagerecognition, arXiv preprint arXiv:1512.03385, 2015.

[61]. B. B. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard, and L. D. Jackel, Handwritten digit recognition with a backpropagation network, in NIPS. Citeseer, 1990.

[62]. Y. LeCun, et al., Gradient-based learningapplied to document recognition, Proceedings of the IEEE, 1998.

[63]. Alex Krizhevsky, Sutskever I, and Hinton G.E, Imagenet classificationwith deep convolutional neural networks. In NIPS, 2012.

[64]. K. Jarrett, K. Kavukcuoglu, M. A. Ranzato, and Y. LeCun. What is the best multi-stage architecture for object recognition? In International Conference on Computer Vision, pages 21462153. IEEE, 2009.

[65]. I. Krizhevsky. Convolutional deep belief networks on cifar-10. Unpublished manuscript, 2010.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[66]. L. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hub- bard, and L. D. Jackel, Handwritten digit recognition with a backpropagationnetwork, in NIPS. Citeseer, 1990

[67]. Zeiler M., Taylor G., and Fergus R. Adaptive deconvolutional networks for mid and high level feature learning, In ICCV, 2011.

[68]. S. Hochreiter, Y. Bengio, P. Frasconi, and J. Schmidhuber. Gradient flow in recurrent nets: the difficulty of learning long-term dependencies,2001.

[69]. A. Krizhevsky. Convolutional deep belief networks on cifar-10. Unpublished manuscript, 2010. G.E. Hinton, N. Srivastava, A. Krizhevsky, I. Sutskever, and R. R.

[70]. Salakhutdinov, Improving neural networks by preventing co-adaptation of feature detectors, arXiv preprint arXiv:1207.0580, 2012.

[71]. Fisher Yu and VladlenKoltun, Multi-Scale Context Aggregation by Dilated Convolutions, ICLR,2016

[72]. Asifullah Khan, AnabiaSohail, UmmeZahoora, and Aqsa Saeed Qureshi, A Survey of the Recent Architectures of Deep Convolutional Neural Networks, Artificial Intelligence Review, DOI: https://doi.org/10.1007/s10462-020-09825-6

[73]. Qiang Yang, Pan SJ, Yang Q, Fellow QY (2008) A Survey on Transfer Learning. IEEE Trans Knowl Data Eng 1:1–15. doi: 10.1109/TKDE.2009.191

[74]. Qureshi AS, Khan A (2018) Adaptive Transfer Learning in Deep Neural Networks: Wind Power Prediction using Knowledge Transfer from Region to Region and Between Different Task Domains. arXivPrepr arXiv181012611

[75]. Qureshi AS, Khan A, Zameer A, Usman A (2017) Wind power prediction using deep neural network based meta regression and transfer learning. Appl Soft Comput J 58:742–755. doi: 10.1016/j.asoc.2017.05.031

[76]. Zagoruyko S, Komodakis N (2016) Wide Residual Networks. Procedings Br Mach Vis Conf 2016 87.1-87.12. doi: 10.5244/C.30.87

[77]. Han D, Kim J, Kim J (2017) Deep Pyramidal Residual Networks. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 6307–6315

[78]. Xie S, Girshick R, Dollar P, et al (2017) Aggregated Residual Transformations for Deep Neural Networks. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 5987–5995

[79]. Zhang X, Li Z, Loy CC, Lin D (2017) PolyNet: A Pursuit of Structural Diversity in Very Deep Networks. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 3900–3908

[80]. Wang F, Jiang M, Qian C, et al (2017a) Residual Attention Network for Image Classification. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 6450–6458

[81]. Khan A, Sohail A, Ali A (2018a) A New Channel Boosted Convolutional Neural Network using Transfer Learning. arXivPrepr arXiv180408528

[82]. Woo S, Park J, Lee JY, Kweon IS (2018) CBAM: Convolutional block attention module. Lect Notes ComputSci (including SubserLect Notes ArtifIntellLect Notes Bioinformatics) 11211 LNCS:3–19. doi: 10.1007/978-3-030-01234-2_1

[83]. LeCun Y, et al., 1998, Gradient-based learning applied to document recognition. Proc IEEE 86:2278–2324

[84]. LeCun Y, Jackel LD, Bottou L, et al (1995) Learning algorithms for classification: A comparison on handwritten digit recognition. Neural networks Stat MechPerspect 261:276

[85]. Schmidhuber J (2007) New millennium AI and the convergence of history. In: Challenges for computational intelligence. Springer, pp 15–35

[86]. Simard PY, Steinkraus D, Platt JC (2003) Best practices for convolutional neural networks applied to visual document analysis. In: null. p 958

[87]. Glorot X, Bengio Y (2010) Understanding the difficulty of training deep feedforward neural networks. In: Proceedings of the thirteenth international conference on artificial intelligence and statistics. pp 249–256

[88]. Ranzato M, Huang FJ, Boureau YL, LeCun Y (2007) Unsupervised learning of invariant feature hierarchies with applications to object recognition. In: Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition. IEEE, pp 1–8

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[89]. Giusti A, Ciresan DC, Masci J, et al (2013) Fast image scanning with deep max-pooling convolutional neural networks. In: 2013 IEEE International Conference on Image Processing. IEEE, pp 4034–4038

[90]. Oh K-S, Jung K (2004) GPU implementation of neural networks. Pattern Recognit 37:1311–1314

[91]. Strigl D, Kofler K, Podlipnig S (2010) Performance and scalability of GPU-based convolutional neural networks. In: Parallel, Distributed and Network-Based Processing (PDP), 2010 18th Euromicro International Conference on. pp 317–324

[92]. Cireşan DC, Meier U, Masci J, et al (2011) High-Performance Neural Networks for Visual Object Classification. arXivPrepr arXiv11020183

[93]. Nguyen G, Dlugolinsky S, Bobák M, et al (2019) Machine Learning and Deep Learning frameworks and libraries for large-scale data mining: a survey. ArtifIntell Rev 52:77–124. doi: 10.1007/s10462-018-09679-z

[94]. Nickolls J, Buck I, Garland M, Skadron K (2008) Scalable parallel programming with CUDA. In: ACM SIGGRAPH 2008 classes on - SIGGRAPH '08. ACM Press, New York, New York, USA, p 1

[95]. Lindholm E, Nickolls J, Oberman S, Montrym J (2008) NVIDIA Tesla: A Unified Graphics and Computing Architecture. IEEE Micro 28:39–55. doi: 10.1109/MM.2008.31

[96]. Krizhevsky A, Sutskever I, Hinton GE (2012) ImageNet Classification with Deep Convolutional Neural Networks. Adv Neural Inf Process Syst 1–9. doi: 10.1061/(ASCE)GT.1943-5606.0001284

[97]. Simonyan K, Zisserman A (2015) Very Deep Convolutional Networks For Large-Scale Image Recognition. ICLR 75:398–406. doi: 10.2146/ajhp170251

[98]. Amer M, Maul T (2019) A review of modularization techniques in artificial neural networks. ArtifIntell Rev 52:527–561. doi: 10.1007/s10462-019-09706-7

[99]. Szegedy C, Wei Liu, YangqingJia, et al (2015) Going deeper with convolutions. In: 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 1–9

[100]. Srivastava RK, Greff K, Schmidhuber J (2015a) Highway Networks. doi: 10.1002/esp.3417

[101]. He K, Zhang X, Ren S, Sun J (2015a) Deep Residual Learning for Image Recognition. Multimed Tools Appl 77:10437–10453. doi: 10.1007/s11042-017-4440-4

[102]. Huang G, Liu Z, Van Der Maaten L, Weinberger KQ (2017) Densely connected convolutional networks. Proc - 30th IEEE ConfComput Vis Pattern Recognition, CVPR 2017 2017-Janua:2261–2269. doi: 10.1109/CVPR.2017.243

[103]. Lin TY, Dollár P, Girshick R, et al (2017) Feature pyramid networks for object detection. In: Proceedings - 30th IEEE Conference on Computer Vision and Pattern Recognition, CVPR 201

[104]. Cai Z, Vasconcelos N (2019) Cascade R-CNN: High Quality Object Detection and Instance Segmentation. IEEE Trans Pattern Anal Mach Intell. doi: 10.1109/tpami.2019.2956516

[105]. Pang J, Chen K, Shi J, et al (2020) Libra R-CNN: Towards Balanced Learning for Object Detection

[106]. Chen W, Wilson JT, Tyree S, et al (2015) Compressing neural networks with the hashing trick. In: 32nd International Conference on Machine Learning, ICML 2015

[107]. Han S, Mao H, Dally WJ (2016) Deep compression: Compressing deep neural networks with pruning, trained quantization and Huffman coding. In: 4th International Conference on Learning Representations, ICLR 2016 - Conference Track Proceedings

[108]. Wu J, Leng C, Wang Y, et al (2016) Quantized convolutional neural networks for mobile devices. In: Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition

[109]. Frosst N, Hinton G rey (2018) Distilling a neural network into a soft decision tree. In: CEUR Published in Artificial Intelligence Review, DOI: https://doi.org/10.1007/s10462-020-09825-6

[110]. MadhusmitaSahu and Rasmita Dash, A Survey on Deep Learning: Convolution Neural Network (CNN), https://www.researchgate.net/ publication/343969393, 2021

[111]. QianruZhanga, MengZhanga,_, TinghuanChenb, ZhifeiSuna, YuzheMab, Bei Yu, Recent Advances in Convolutional Neural Network Acceleration, Neurocomputing, 2018

[112]. Y. LeCun, Y. Bengio, G. Hinton, Deep learning, Nature 521 (7553) (2015) 436–444.

[113]. Y. Lecun, et al., , Gradient-based learning applied to document recognition, Proceedings of the IEEE 86 (11) (1998) 2278–2324.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[114].M. Moczulski, M. Denil, J. Appleyard, N. de Freitas, ACDC: A structured e_cient linear layer, in: International Conference on Learning Representations (ICLR), 2016.

[115].M. Jaderberg, A. Vedaldi, A. Zisserman, Speeding up convolutional neural networks with low rank expansions, in: British Machine Vision Conference (BMVC), 2014.

[116].V. Nair, G. E. Hinton, Rectified linear units improve restricted boltzmann machines, in: International Conference on Machine Learning (ICML), 2010, pp. 807–814.

[117].A. L. Maas, A. Y. Hannun, A. Y. Ng, Rectifier nonlinearitiesimprove neural network acoustic models, in: InternationalConference on Machine Learning (ICML), 2013.

[118].K. He, X. Zhang, S. Ren, J. Sun, Delving deep into rectifiers:Surpassing human-level performance on imagenet classification,in: IEEE International Conference on Computer Vision(ICCV), 2015, pp. 1026–1034.

[119].L. Xu, N. Wang, T. Chen, M. Li, Empirical evaluation of rectifiedactivations in convolutional network, in: InternationalConference on Machine Learning Workshop, 2015.

[120].D.-A. Clevert, T. Unterthiner, S. Hochreiter, Fast and accuratedeep network learning by exponential linear units (elus), in:International Conference on Learning Representations (ICLR),2016.

[121]. ArohanAjit, Koustav Acharya, AbhishekSamanta A Review of Convolutional Neural Networks, 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE) February 2020

[122]. Chenyou Fan, Indiana University Bloomington, IN Survey of Convolutional Neural Network

[123]. AzeddineElhassouny, FlorentinSmarandacheTrends in deep convolutional neural Networks

[124].architectures: a review, IEEE/ICCSRE2019, 2019, Agadir, Morocco

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

Study of Convolutional Neural Network

Avinash H. Hedaoo
Assistant Professor, Department of Computer Science
Prerna College of Commerce, Nagpur, Maharashtra, India

Abstract: *The success of traditional methods for solving computer vision problems heavily depends on the feature extraction process. But Convolutional Neural Networks (CNN)have provided an alternative for automatically learning the domain specific features. Now every problem in the broader domain of computer vision is re-examined from the perspective of this new methodology. In deep learning, Convolutional Neural Networks (CNN) are found to give the most accurate results in solving real world problems such as several engineering fields, including array processing, wireless communications, medical signal processing, speech processing and biomedical engineering. The availability of a large amount of data and improvement in the hardware technology has accelerated the research in CNNs. This paper intends to provide a detail study over basic concepts of CNN and its applications.*

Keywords: Convolutional Neural Networks, Machine Learning, computer vision, deep leaning, Machine learning

I. INTRODUCTION

The term artificial intelligence (AI) was first coined by John McCarthy in 1956[2].In recent years, AI based applications have rapidly been developed in all fields[3].Machine learning is defined by TM Mitchell:"Machine learning is the study of computer algorithms that allow computer programs to automatically improve through experience."[4].Deep learning algorithms are a subset of Machine Learning algorithms [5][1].

With the recent advancement in digital technologies, the size of data sets has become too large in which traditional data processing and machine learning techniques are not able to cope with effectively [10,11]. However, analyzing complex, high dimensional, and noise-contaminated data sets is a huge challenge [12-14]. To undertake these problems, in recent years, various deep architectures with different learning paradigm are quickly introduced to develop machines that can perform similar to human or even better [15][9].

A convolutional neural network, symbolled as CNN, or ConvNet, most commonly applied to analyse visual imagery [16]. Such networks are characterised by being multi-layered, and so they are large and they are consequently complex. [17]. These networks are also called "shift invariant" type of artificial neural networks and symbolled as SIANN [18][19].

The concept of neural network has already existed since 1950s whenFrank Rosenblatt created the perceptron. Even convolutional neural network itself is not a new conceptat all [20].In 1959, Hubel & Wiesel [28] found that cells in animal visual cortex are responsible for detecting light in receptive fields. Inspired by this discovery, Kunihiko Fukushima proposed the neocognitron in 1980 [29], which could be regarded as the predecessor of CNN. In 1990, LeCun et al . [30] published the seminal paper establishing the modern framework of CNN, and later improved it in [31]. Like other neural networks, LeNet-5 has multiple layers and can be trained with the back propagation algorithm [32][27].The convolutional neural network was firstly introduced in [21] to recognize handwritten ZIP code in1989, and later extended to recognition and classification of various objects such as hand-written digits (MNIST) [22],house numbers [23], traffic signs [24], Caltech-101 [25] and more recently 1000-category ImageNet dataset [26][20].Initially CNN had been widely used for object recognition tasks but now it is being examined in other domains as well like object tracking [48], pose estimation [49], text detection and recognition [50], visual saliency detection [51], action recognition [52], scene labelling [53] and many more [54].[47]

CNNs saw extensive use in the 90s of 20th century, butfell out of fashion with the emergence of SVM and Bayesian models. One important reason is, small datasets in 1990s and early 2000s such has MNISTandCaltech-101[20].However with the availability of big data and advancements in hardware are the main reasons for the recent

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

success of deep CNNs. Recently, it is shown that different levels of features, including both low and high-level, can be transferred to a generic recognition task by exploiting the concept of Transfer Learning (TL)[73][74][75]. Different architectural designs such as Wide ResNet, ResNeXt, Pyramidal Net, Xception, PolyNet, and many others explore the effect of multilevel transformations on CNNs learning capacity by introducing cardinality or increasing the width [76][77][78][79]. Therefore, the focus of research shifted from parameter optimization and connections readjustment towards the improved architectural design of the network. This shift resulted in many new architectural ideas such as channel boosting, spatial and feature-map wise exploitation and attention-based information processing etc.,[80][81][82][72]. In industry, companies such as Google, Microsoft, AT&T, NEC, and Facebook have developed active research groups for exploring new architectures of CNN [6] [7][1].

This review gives an insight into the basic structure of CNN as well as its historical perspective. This survey will help the readers to develop the theoretical insight into the design principles of CNN and thus may further accelerate the architectural innovations in CNN. The rest of the paper is organized in the following order: Section I develops the systematic understanding of CNN, discusses its resemblance with primate's visual cortex, as well as its contribution to MV. Section II provides history of CNN, Section III discusses about various layers of CNN. Whereas, Section IV discusses the recent innovations in CNN architectures. Section V discusses on applications of CNNs. Finally, the last section concludes.

II. HISTORY OF CNN

With the discovery of concepts such as convolution and back propagation applied to neural networks, NN got better. With the power of GPUs and more efficient algorithms, CNNs can be applied to real life applications[8].

In 1959, Hubel & Wiesel [28] found that cells in animal visual cortex are responsible for detecting light in receptive fields[27].In 1959, an apparatus was developed by Russell Kirsch along with his colleagues for transforming images into grids of numbers so that the machine can understand the images[110]. The evolutionary history of deep CNN architectures is pictorially represented in Fig. 1. Improvements in CNN architectures can be categorized into five different area that are discussed below.

2.1 Origin of CNN: Late 1980s-1999

In 1998, LeCuN proposed an improved version of ConvNet, which was famously known as LeNet-5 [83][84]. Due to the good performance of CNN in optical character and fingerprint recognition, its commercial use in ATM and Banks started in 1993 and 1996, respectively.

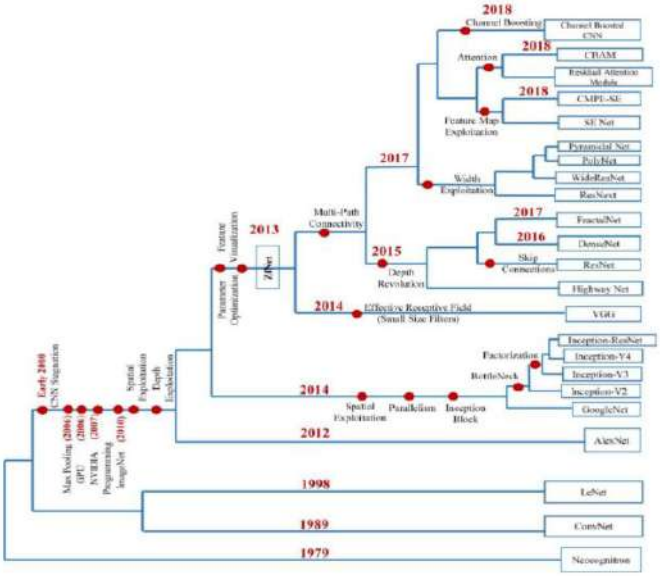


Fig. 1 Evolutionary history of deep CNNs showing architectural innovations from ConvNet till to date architectures.

A. Stagnation of CNN: Early 2000

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

As CNN was not effective in converging to the global minima of the error surface it was considered as a less effective feature extractor compared to handcrafted features [85]. In 2003, [86] improved CNN architecture and showed good results compared to SVM on a hand digit benchmark dataset.

2.2 Revival of CNN: 2006-2011

Hinton reported the concept of greedy layer-wise pre-training in 2006. Experimental studies showed that both supervised and unsupervised pre-training could initialize a network in a better way than random initialization. The observation of Bengio and other researchers started the use of activation functions other than sigmoid such as ReLU, tanh etc., [87]. [88]used max-pooling instead of subsampling, which showed good results by learning invariant features [89]. In late 2006, researchers started using graphics processing units (GPUs) to accelerate the training of deep NN and CNN architectures [90][91][92][93]. In 2007, NVIDIA launched the CUDA programming platform, which allows exploitation of parallel processing capabilities of GPU with a greater degree [94] [95]. ImageNet Large Scale Visual Recognition Challenge (ILSVRC)and Neural Information Processing Systems Conference (NIPS) are the two platforms that play a dominant role in strengthening research and increasing the use of CNN and thus making it popular.

2.3 Rise of CNN: 2012-2014

The main breakthrough in CNN performance was brought by AlexNet, which showed exemplary performance in 2012-ILSVRC [96]. The problems of determining filter dimensions, stride, padding, and other hyper-parameters for each layerresolved by the concept of modularity in CNNs made it easy to tailor them for different tasks effortlessly [97][98]. In this connection, a different idea of branching and block within a layer was introduced by the Google group [99].

2.4 Rapid Increase In Architectural Innovations And Applications of CNN: 2015-Present

In 2015, different ideas such as information gating mechanism across multiple layers, skip connections, and cross-layer channel connectivity was introduced [100][101][102]. Most of the famous object detection and segmentation architectures such as Single Shot Multibox Detector (SSD), Region-based CNN (R-CNN), Faster R-CNN, Mask R-CNN and Fully Convolutional Neural Network (FCN) are built on the lines of ResNet, VGG, Inception, etc. [103][104][105]. Applications of deep showed state-of-the-art results on MS COCO-2015 image captioning challenge.
Similarly, in 2016, it was observed that the stacking of multiple transformations not only depth-wise but also in parallel fashion showed good learning for complex problems [76][77]. Different researchers used a hybrid of the already proposed architectures to improve deep CNN performance [102]. In 2017, the focus was on designing of generic blocks In 2018, a new idea of channel boosting was introduced by [81].
The solutions to the problems of high computational cost and memory requirement are discussed in [106][107][108][109]. From 2012 up till now, many improvements have been reported in CNN architectures[72].

III. CNN LAYERS

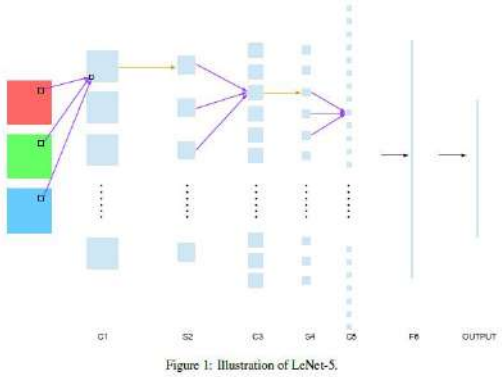


Figure 1: Illustration of LeNet-5.

Fig 2 : Illustration of LeNet-5

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

Convnets are very similar to normal neural networks which can be visualized as a collection of neurons arranged as an acyclic graph. The main difference from a neural network isthat a hidden layer neuron is only connected to a subset of neurons in the previous layer. Because of this sparse connectivity it is capable to learn features implicitly. The deep architecture of the network results in hierarchical feature extraction [47].

The modern convolutional neural networks proposed by LeCun [113] is a 7-layer (excluding the input layer)LeNet-5structure. It has the following structure C1,S2, C3, S4, C5, F6, OUTPUT as shown in Figure 2,where C indicates convolutional layer, S indicates sub sampling layer, and F indicates fully-connected layer.

Among different structures, they share fourkey features including weight sharing, local connection, pooling, and the use of many layers [112]. There are some commonly used layers such as convolutional layers, sub sampling layers (pooling layers), and fully connected layers. Usually, there is a convolutional layer after the input. The convolutional layer is often followed by a subsampling layer. This combination repeats several times to increase the depth of CNN. The fully connected layers are designed as the last few layers in order to map from extracted features to labels. [111]

As fundamental building blocks of CNNs, CNN layers have shown their variety and flexibility both in their designed structures and the connections. The efforts in modifying layer structures and connections have led to the possibility of training a CNN faster and of making it perform better. In following subsections, we will introduce common layers of modern CNNs and their functions.

3.1 Activation function

Activation function serves as a decision function and helps in learning of intricate patterns. The activation function for a convolved feature-map is defined in equation (3).

$$T_i^{\ell} \ge_a ( ) \quad (3) \quad F_i^{\ell}$$

In the above equation,F_i^{ℓ}an output of a convolution, which is assigned to activation functionga(.) that adds non-linearity and returns a transformed output for lth laT_i^{ℓ}r.[72]There are several types of activation functions[72][20][27] [47][111].

3.2 Pooling

Feature motifs, which result as an output of convolution operation, can occur at different locations in the image. Oncefeatures are extracted, its exact location becomes less important as long as its approximate position relative to others ispreserved. Pooling or down-sampling is an interesting local operation. It sums up similar information in theneighborhood of the receptive field and outputs the dominant response within this local region (Lee et al. 2016). [47]Pooling is an important step to further reduce thedimensions of the activation map, keeping only the importantfeatureswhile also reducing the spacial invariance. This inturn reduces the number of learnable features for the model.Thishelps to resolve the problem of overfitting. Poolingallows CNN to incorporate all the different dimensions of animageso that it successfully recognises the given object evenif its shape is skewed or is present at a different angle.[121]

3.3 Convolutional Layer

The convolutional layer is composed of a set of convolutional kernels where each neuron acts as a kernel. However, if the kernel is symmetric, the convolution operation becomes a correlation operation. Convolutional kernel works by dividing the image into small slices, commonly known as receptive fields. The division of an image into small blocks helps in extracting feature motifs. Kernel convolves with the images using a specific set of weights by multiplying its elements with the corresponding elements of the receptive field[72].

Convolution Layer basically convolves or multiplies the pixel matrix generated for the given image or object to produce an activation map for the given image. The main advantage of activation map is that it stores all the distinguishing features of a given image while at the same time reducing the amount of data to be processed. The matrix with which the data is convolved is a feature detector which basically is a set of values with which the machine is compatible. Different versions of image are generated using different values of feature detector. The convoluted model is also trained with back propagation in order to ascertain minimal error in each layer. According to the lowest error set, depth and padding is set.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

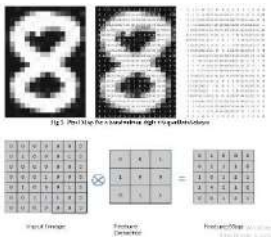


Fig 3. Convolution to produce an Activation Map ©SuperDataScience

Fig. 3 above shows how convolution works. This step involves convoluting the matrix containing the image data and then feature detector which gives us an activation map or a feature map. What happens in convolution is that the values on identical positions in the data and feature map i.e. values having value 1 or more than 1 are kept while rest areremoved. The matrix from the image data is compared 3x3 at a time. The size of feature detector varies with the type of CNN used. For example there are versions of CNN which use 5x5 or even7x7 scale filters for convolution. Convolution follows which aims to show how one function modifies the shape of the other [121].

The spatial extend of sparse connectivity between the neurons of two layers is a hyper paramter called receptive field. The hyper parameters that control the size of the output volume are the depth(number of filters at a layer), stride(for filter movement) and zero padding(to control spatial size of output). The ConvNets are trained with Back propagation and the backward pass as well involves convolution operation but with spatially flipped filters. One of the variants of the traditional CNN is "Network In Network"(NIN) proposed by Lin et al. [114] [115]. To alleviate saturation problem, many non-saturated activations are proposed such as Rectified Linear Unit (ReLU) [116], Leaky ReLU [117], Parametric ReLU (PReLU) [118], Randomized Leaky ReLU (RReLU) [119], and Exponential Linear Unit (ELU) [120][111].

Convolution filter in basic CNNs is a Generalized Linear Model (GLM) for the underlying local image patch. It works well for abstraction when instances of latent concepts are linearly separable. There are some types of convolution which can be sued to enhance CNN's representation abilitylike, Tiled Convolution, Transposed Convolution, Dilated Convolution, Network in Network, Inception Module[27].

3.4 Fully Connected (FC)

The fully connected layer is the last layer of CNN architecture. Neurons in this layer are fully connected to all neurons in the previous layer, as in a regular Neural Network. High level reasoning is done here. The neurons are not spatially arranged(one dimensional) so there cannot be a conv layer after a fully connected layer [47]. In a typical CNN, the feature maps of last convolutional layer are vectorized and fully connected with output units, which are followed by a softmax loss layer [122]. This FC layer takes input from other layers and transforms them into specific no. of classes which are already decided by the network. The output layer of the FC layer is computed for error calculation. Then, a loss function(SVM/Softmax) is defined to compute the gradient of error. These errors are propagated backwardly to update weights and bias in back propagation neural network. In one forward and backward pass, one cycle is completed for training[110].

3.5 Loss Layer

The last fully connected layer serves as the loss layer that computes the loss or error which is a penalty for discrepancy between desired and actual output. For predicting a single class out of K mutually exclusive classes Softmax loss isused. It is the commonly used loss function. Basically it is multinomial logistic regression. It maps the predictions tonon- negative values and also normalized to get probability distribution over classes. Large margin classifier, SupportVector Machine, is trained by calculating Hinge loss. For regressing to real-valued labels Euclidean loss can be used. [47]Four representative losses are Hinge loss, Softmax loss, Contrastive loss, Triplet loss.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

IV. CNN ARCHITECTURES

4.1 LeNet

This was one of the pioneering work in Convolutional Neural Networks by LeCun et al. In 1990 [56] and later improved it in 1998 [57]. Itfinds application in reading zip codes, digits, etc. [47]. LeNet exploited the underlying basis of the image that the neighboring pixels are correlated to each other and feature motifs are distributed across the entire image. Therefore, convolution with learnable parameters is an effective way to extract similar features at multiple locations with few parameters. Learning with sharable parameters changed the conventional view of training where each pixel was considered as a separate input feature from its neighborhood and ignored the correlation among them. LeNet was the first CNN architecture, which not only reduced the number of parameters but was able to learn features from raw pixels automatically [72].The final input that isprovided to the FCNis of dimension 120x1x1. No. of parameters taken into account are approximately 60,000[121].

4.2 AlexNet

This architecture developed by Alex Krizhevsky, Ilya Sutskever and Geoff Hinton [58] is credited as the first work in Convolutional Networks to popularize it in the field of computer vision and was published in 2012. The network was similar to LeNet but instead of alternating conv layers and pooling layers, AlexNet had all the conv layers stacked together [47]. Input provided was about 15million RGB image data of dimensions 3x224x224 image(which was later corrected to 227x227) from about 22,000categories. This Deep CNN consists of 7 layers and 60million parameters. The operations consists of 11x11,5x5,3x3 convolutions, 3x3 max pooling ending with 2 fully connected layers of 4096 layers each. AlexNet was able to win the ILSVRC-2012 competitions achieving top-1and top-5 error rates on test dataset[121].To address challenge of over fitting, Krizhevesky et al. (2012) exploited the idea of Hinton (Dahl et al. 2013; Srivastava et al. 2014)[72].

4.3 GoogleNet

This ConvNet architecture from Szegedy et al.[59] from Google won the ILSVRC 2014 competition. They have proposed a new architecture called Inception (v1) that gives more utilization of the computing resources in the network[47].The GoogLeNet also followed the block pattern as followed by VGG 16 and each block is called Inception Module. GoogLeNet uses total of 9 inception module. This network 22 layers deep but compensated by relatively much lesser no. of parameters of about 5 million compared to runner up VGG's 138 million parameters. [121] In GoogleNet, conventional convolutional layers are replaced in small blocks similar to the idea of substituting each layer with micro NN as proposed in Network in Network (NIN) architecture (Lin et al. 2013). The exploitation of the idea of split, transform, and merge by GoogleNet, helped in addressing a problem related to the learning of diverse types of variations present in the same category of images having different resolutions. GoogleNet regulates the computations by adding a bottleneck layer of 1x1 convolutional filter, before employing large size kernels. Other regulatory factors applied were batch normalization and the use of RmsProp as an optimizer (Dauphin et al. 2015). GoogleNet also introduced the concept of auxiliary learners to speed up the convergence rate. However, the main drawback of the GoogleNet was its heterogeneous topology and a representation bottleneck[72].

4.4 VGG(16) Net

Karen Simonyan and Andrew Zisserman have done a thorough analysis of the depth factor in a ConvNet, keeping all other parameters fixed [47].VGG stands for Visual Geometric Group. This network contains about 138 million parameters. Thereare total 16 convolutional layers in VGG 16, distributed in 3blocks containing 2layers of 3x3 convolutions followed by2x2 max pooling and 2 blocks containing 3 layers of 3x3convolutions followed by 2x2 max pooling. The architecture isfinally finished by 2 fully connected layers of 4096 hidden layers each. [121] The use of the small size filters provides an additional benefit of low computational complexity by reducing the number of parameters. VGG regulates the complexity of a network by placing 1x1 convolutions in between the convolutional layers, which, besides, learn a linear combination of the resultant feature-maps. For the tuning of the network, max-pooling is placed after the convolutional layer, while padding was performed to maintain the spatial resolution (Ranzato et al. 2007)[123].VGG was at 2nd place in the 2014-ILSVRC competition but, got fame due to its simplicity, homogenous

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

topology, and increased depth. The main limitation associated with VGG was the use of 138 million parameters, which make it computationally expensive and difficult to deploy it on low resource systems. [72]

4.5 ResNet

Kaiminget. al. [60] have presented a residual learning framework where the layers learn residual functions with respect to the inputs received instead of learning unreferenced functions[47]. ResNet or Deep Residual Network was the winner for ImageNet challenge for 2015 surpassing the human accuracy error for the first time with an error rate of about 3.6%. The network is very very deep and the one presented at challenge was 152 layers deep. In order to counter Vanishing Gradient Problem, ResNet introduced a feature of skip connection. The concept behind resnet was that even if thenet work was deep, the training of the network was similar to that of shallow network by skipping after every 2 layer. In order to compute, the input and output both were copied to the next layer basically learning the residual of previous computation. No. of parameters computed were about 65 million. Some layers also have bottleneck starting and ending by 1x1convolution. Batch Normalization was used after each convolution.[121]In order to address the problems faced during training of deep networks, ResNet exploited the idea of bypass pathways used in Highway Networks (He et al. 2015a). Residual links (shortcut connections) speed up the convergence of deep networks, thus giving ResNet the ability to avoid gradient diminishing problems. [72]To overcome the problem of high depth in residual networks, authors Zagoruyko et al. [21] proposed wide residual networks (WRNs) used for mitosis detection in breast histology images [22]. Larsson et al. [23] proposed Fractalnet [123].

4.6 ResNeXt

ResNeXt, also known as Aggregated Residual Transform Network, is an improvement over the Inception Network (Xie et al. 2017). Cardinality is an additional dimension, which refers to the size of the set of transformations (Han et al. 2018; Sharma and Muttoo 2018). ResNeXt utilized the deep homogenous topology of VGG and simplified GoogleNet architecture. ResNeXt used multiple transformations within a split, transform and merge block and defined these transformations in terms of cardinality. The complexity of ResNeXt was regulated by applying low embedding's (1x1 filters) before 3x3 convolution, whereas training was optimized by using skip connections (Larsson et al. 2016).[72]

V. CNN APPLICATION

Because of CNN popularity, it has many applications and used in extensive manner. Some of them are discussed below:

5.1 Natural Language Processing (NLP)

Natural Language Processing (NLP) converts language into a presentation that can easily be exploited by any computer. CNNs have also been utilized in NLP based applications such as language modeling, and analysis, etc. Especially, language modelling or sentence modelling has taken a twist after the introduction of CNN as a new representation learning algorithm.[72] CNNs are usually utilized in natural language processing [61]. CNN models are useful for numerous natural language processing issues and achieved glorious results in text categorization, semantic parsing [62], search query retrieval [63], and classification [64], prediction [65], text categorization [66], diversified traditional natural language processing [61][47] , Statistical Language Modelling, Text Classification[27], Sentence Modelling, Twitter Sentiment Analysis and Semantic Role Labeling tasks[8].

5.2 Computer Vision and Related Applications

Computer vision (CV) focuses on developing an artificial system that can process visual data, including images and videos and can effectively understand, and extract useful information from it .Farfade, et al. proposed deep CNN for detecting faces from different poses as well as from occluded faces [67]. In another work, Zhang et al. performed face detection using a new type of multitasking cascaded CNN [68]. Zhang's technique showed good results when compared to state-of-the-art techniques [69].Experimental results have shown that Wang's technique outperforms other activity recognition based techniques [70, 71]. Similarly, another three dimensional CNN based action recognition system is proposed by Ji et al. [72]. [47] [72] Deep Pose is the first application of CNNs to human pose estimation problem [27].

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

5.3 Object Detection and Segmentation

Object detection focuses on identifying different objects in images. Recently, R-CNN has been widely used for object detection[47] . Recently, AE based CNN architectures have shown success in segmentation tasks. [72] One of the most famous object proposal based CNN detector is Region-based CNN (R-CNN) [33]. Spatial pyramid pooling network (SPP net) [34] is a pyramid-based version of R-CNN [33], which introduces an SPP layer to relax the constraint that input images must have a fixed size. Fast RCNN [35] improves SPP net by using an end-to-end training method. Later, Faster R-CNN [35] introduces a region proposal network (RPN) for object proposals generation and achieves further speed-up. More recently, YOLO [36] and SSD [37] allow single pipeline detection that directly predicts class labels.[27]

5.4 Image Classification

CNN has been widely used for image classification. One Recently, Spanhol et al. used CNN for the diagnosis of breast cancer images, and results are compared against a network trained on a dataset containing handcrafted descriptors [47], Wahab et al. 2017, Cireşan et al. 2012]. The different pixel neighborhoods can be evaluated with the help of spatial dependencies of cell and non-cell pixels. In (Su, Liu, Xie, et al. 2015), proposed method is used to segment a high resolution image (1000*1000) done in only 2.3 seconds[38].

Subcategory classification is another rapidly growing subfield of image classification. Along this way, Branson et al .[39] propose a method which detects parts and extracts CNN features from multiple pose-normalized regions. Zhanget al . [40] propose a part-based R-CNN which can learn whole-object and part detectors. Lin et al . [41] incorporate part localization, alignment, and classification into one recognition system which is called Deep LAC. Krause et al . [42] use the ensemble of localized learned feature representations for fine-grained classification.

5.5 Object Tracking

There are several attempts to employ CNNs for visual tracking. Fan et al . [43] use CNN as a base learner. In [43], the authors design a CNN tracker with a shift-variant architecture Li et al. [44] propose a target-specific CNN for object tracking, where the CNN is trained incrementally during tracking with new examples obtained online. Li et al . [44] use a relatively small number of filters in the CNN within a framework equipped with a temporal adaptation mechanism. In [45], a CNN object tracking method is proposed to address limitations of handcrafted features and shallow classifier structures in object tracking problem. In [46] propose a visual tracking algorithm based on a pre-trained CNN[27].

VI. CONCLUSION

CNN has made remarkable progress, especially in image processing and vision-related tasks, and has thus revived the interest of researchers in ANNs. In this context, several research works have been carried out to improve CNN's performance on such tasks. Due to the advantages of CNNs, such as local connection, weight sharing, and down sampling dimensionality reduction, CNN has been widely deployed in both research and industry projects. The advancements in CNNs can be categorized in different ways, including activation, loss function, optimization, regularization, learning algorithms, and innovations in architecture. This paper studies advancement in the CNN architectures, especially based on the design patterns of the processing units and thus has proposed the taxonomy for recent CNN architectures. In addition to the categorization of CNNs into different classes, this paper also covers the history of CNNs, its applications. The learning capacity of CNN is significantly improved over the years by exploiting depth and other structural modifications. It is observed in recent literature that the main boost in CNN performance has been achieved by replacing the conventional layer structure with blocks. Even though convolutions possess many benefits and have been widely used, we reckon that they can be refined further in terms of model size, and security. Moreover, there are lots of problems that convolution is hard to handle, such as low generalization ability, lack of equivariance, and poor crowded-scene results, so that several promising directions are pointed. Although CNNs have achieved great success in experimental evaluations, there are still lots of issues that deserve further investigation. Firstly, they require large-scale dataset and massive computing power for training. Manually collecting labeled dataset requires huge amounts of human efforts. Thus, it is desired to explore unsupervised learning of CNNs. Meanwhile ,to speed up training procedure, it is still worth to develop effective and scalable parallel training algorithms. It is important

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

to investigate how to reduce the complexity and obtain fast-to-execute models without loss of accuracy. Furthermore, one major barrier for applying CNN on a new task is that it requires considerable skill and experience to select suitable hyper parameters. These hyper-parameters have internal dependencies which make them particularly expensive for tuning. Finally, the solid theory of CNNs is still lacking. Meanwhile, it is also worth exploring how to leverage natural visual perception mechanism to further improve the design of CNN. I hope that this paper not only provides a better understanding of CNNs but also facilitates future research activities and application developments in the field of CNNs.

REFERENCES

[1]. S. Majid Rezaee, A Review On Convolutional Neural Networks And Its Applications, https://www.researchgate.net/publication/353922229, July 2021

[2]. John McCarthy. what is artificial intelligence? Computer Science Department Stanford University.www-formal.stanford.edu/jmc/. 2007 Nov 12.

[3]. RaffaeleCioffi, Marta Travaglioni, GiuseppinaPiscitelli, AntonellaPetrillo, andFabio De Felice . Artificial Intelligence and Machine Learning Applications in Smart production: Progress, Trends, and Directions. Sustainability 2020, 12, 492; doi:10.3390/su12020492.

[4]. Tom M. Mitchell. Machine Learning Definition, McGraw-Hill Science, Engineering, Math; (March 1, 1997), Page 1.

[5]. Adrian Carrio, Carlos Sampedro, Alejandro Rodriguez-Ramos, and PascualCampoy. Review Article A Review of Deep Learning Methods and Applications for Unmanned Aerial

[6]. Deng L, Yu D, Delft B— (2013) Deep Learning: Methods and Applications Foundations and Trends R in Signal Processing. Signal Processing 7:3–4. doi: 10.1561/2000000039.

[7]. Asifullah Khan, AnabiaSohailUmmeZahoora, and Aqsa Saeed Qureshi. A Survey of the Recent Architectures of Deep Convolutional Neural Networks. Published in Artificial Intelligence Review, DOI: https://doi.org/10.1007/s10462-020-09825-6.

[8]. D. T. Mane, SGGS IE&T, Nanded, India, U. V. Kulkarni, A Survey on Supervised Convolutional Neural Network and Its Major ApplicationsInternational Journal of Rough Sets and Data Analysis, Volume 4 , Issue 3, 2017

[9]. Xizhao Wang1 • Yanxia Zhao1 • Farhad Pourpanah2, Recent advances in deep learning, International Journal of Machine Learning and Cybernetics (2020) 11:747–750

[10]. Wang X, Joshua HZ (2015) Uncertainty in learning from big data. Fuzzy Sets Syst 258:1–4

[11]. Rezvani S, Wang X, Pourpanah F (2019) Intuitionistic fuzzy twin support vector machines. IEEE Trans Fuzzy Syst 27(11):2140–2151

[12]. Wang Z, Wang X (2018) A deep stochastic weight assignment network and its application to chess playing. J Parallel DistribComput 117:205–211

[13]. Wang Z, Wang X (2018) A deep stochastic weight assignment network and its application to chess playing. J Parallel DistribComput 117:205–211

[14]. Pourpanah F, Lim CP, Wang X, Tan CJ, Seera M, Shi Y (2019) A hybrid model of fuzzy minmax and brain storm optimization for feature selection and data classification. Neurocomputing 333:440–451

[15]. Sengupta S, Basak S, Saikia P, Paul S, Tsalavoutis V, Atiah F, Ravi V, Peters A (2020) A review of deep learning with special emphasis on architectures, applications and recent trends. Knowl-Based Syst https ://doi.org/10.1016/j.knosy s.2020.10559 6

[16]. I. Krizhevsk, Alex Sutskever and G. E. Hinton, "ImageNetClassificationWithDeepConvolutionalNeural Networks," Adv. Neural Inf. Process. Syst., 2012.

[17]. T. Chilimbi, Y. Suzue, J. Apacible, and K. Kalyanaraman "ProjectAdam: Building An Efficient And Scalable DeepLearning Training System," 11th USENIX Symp. Oper. Syst. Des. Implement., pp. 571–582, 2014.

[18]. W. Zhang, K. Itoh, J. Tanida, and Y. Ichioka, "Parallel distributed processing model with local spaceinvariant interconnections and its optical architecture," Appl. Opt., 1990.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[19]. Ali FadhilYaseen, A Survey on the Layers of Convolutional Neural Networks, IJCSMC Journal, Vol.7 Issue.12, December- 2018, pg. 191-196

[20]. Chenyou Fan Indiana University Bloomington, IN, Survey of Convolutional Neural Network

[21]. Y. LeCun, et al.,Backpropagation applied to handwritten zip code recognition. Neural computation, 1(4):541–551, 1989.

[22]. Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner. Gradientbased learning applied to document recognition. Proceedings of the IEEE, 86(11):2278–2324, 1998

[23]. P. Sermanet, S. Chintala, and Y. LeCun. Convolutional neural networks applied to house numbers digit classification. In Pattern Recognition (ICPR), 2012 21st International Conference on, pages 3288–3291. IEEE, 2012.

[24]. P. Sermanet and Y. LeCun. Traffic sign recognition with multi-scale convolutional networks. In Neural Networks (IJCNN), The 2011 International Joint Conference on, pages 2809–2813. IEEE, 2011

[25]. L. Fei-Fei, R. Fergus, and P. Perona. Learning generative visual models from few training examples: An incremental bayesian approach tested on 101 object categories. Computer Vision and Image Understanding, 106(1):59–70, 2007.

[26]. I. Krizhevsky, I. Sutskever, and G. E. Hinton. Imagenet classification with deep convolutional neural networks. In Advances in neural information processing systems, pages 1097–1105, 2012.

[27]. JiuxiangGu et al., Recent Advances in Convolutional Neural Networks, arXiv:1512.07108v6 [cs.CV] 19 Oct 2017

[28]. D. H. Hubel, T. N. Wiesel, Receptive fields and functional architecture of monkey striate cortex, The Journal of physiology (1968) 215–243.

[29]. K. Fukushima, S. Miyake, Neocognitron: A self-organizing neural network model for a mechanism of visual pattern recognition, in: Competition and cooperation in neural nets, 1982, pp. 267–285.

[30]. *B. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard, L. D. Jackel, Handwritten digit recognition with a back propagation network, in: Proceedings of the Advances in Neural Information Processing Systems (NIPS), 1989, pp. 396–404.*

[31]. Y. LeCun, et al., Gradient-based learning applied to document recognition, Proceedings of IEEE 86 (11) (1998) 2278–2324.

[32]. R. Hecht-Nielsen, Theory of the backpropagation neural network, Neural Networks 1 (Supplement-1) (1988) 445–448.

[33]. R. Girshick, J. Donahue, T. Darrell, J. Malik, Rich feature hierarchies for accurate object detection and semantic segmentation, in: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2014, pp. 580–587

[34]. K. He, X. Zhang, S. Ren, J. Sun, Spatial pyramid pooling in deep convolutional networks for visual recognition, IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI) 37 (9) (2015) 1904–1916.

[35]. S. Ren, K. He, R. Girshick, J. Sun, Faster r-cnn: Towards real-time object detection with region proposal networks, IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI) 39 (6) (2017) 1137–1149.

[36]. J. Redmon, S. Divvala, R. Girshick, A. Farhadi, You only look once: Unified, real-time object detection, in: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 779–788.

[37]. W. Liu, D. Anguelov, D. Erhan, C. Szegedy, S. Reed, Ssd: Single shot multibox detector, in: Proceedings of the European Conference on Computer Vision (ECCV), 2016, pp. 21–37.

[38]. O. Russakovsky, J. Deng, H. Su, J. Krause, S. Satheesh, S. Ma, Z. Huang, A. Karpathy, A. Khosla, M. Bernstein, et al., Imagenet large scale visual recognition challenge, International Journal of Conflict and Violence (IJCV) 115 (3) (2015) 211–252.

[39]. S. Branson, G. Van Horn, P. Perona, S. Belongie, Improved bird species recognition using pose normalized deep convolutional nets, in: Proceedings of the British Machine Vision Conference (BMVC), 2014.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[40]. N. Zhang, J. Donahue, R. Girshick, T. Darrell, Part-based r-cnns for fine-grained category detection, in: Proceedings of the European Conference on Computer Vision (ECCV), 2014, pp. 834–849.

[41]. Lin, X. Shen, C. Lu, J. Jia, Deep lac: Deep localization, alignment and classification for fine-grained recognition, in: Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2015, pp. 1666–1674.

[42]. J. Krause, T. Gebru, J. Deng, L.-J. Li, L. Fei-Fei, Learning features and parts for fine-grained recognition, in: Proceedings of the International Conference on Pattern Recognition (ICPR), 2014, pp. 26–33.

[43]. J. Fan, W. Xu, Y. Wu, Y. Gong, Human tracking using convolutional neural networks, IEEE Trans. Neural Networks(TNN) 21 (10) (2010) 1610–1623.

[44]. H. Li, Y. Li, F. Porikli, Deeptrack: Learning discriminative feature representations by convolutional neural networks for visual tracking, in: Proceedings of the British Machine Vision Conference (BMVC), 2014.

[45]. Y. Chen, X. Yang, B. Zhong, S. Pan, D. Chen, H. Zhang, Cnntracker: Online discriminative object tracking via deep convolutional neural network, Appl. Soft Comput. 38 (2016) 1088–1098.

[46]. S. Hong, T. You, S. Kwak, B. Han, Online tracking by learning discriminative saliency map with convolutional neural network, in: Proceedings of the International Conference on Machine Learning (ICML), 2015, pp. 597–606.

[47]. Neena Aloysius and Geetha M, A Review on Deep Convolutional Neural Networks, International Conference on Communication and Signal Processing, April 6-8, 2017, India

[48]. J. Fan, W. Xu, Y. Wu, and Y. Gong, Human tracking using convolutionalneural networks, Neural Networks, IEEE Transactions, 2010.

[49]. I. Toshev and C. Szegedy, Deep -pose: Human pose estimation viadeepneural networks, in CVPR, 2014.

[50]. M. Jaderberg, A. Vedaldi, and A. Zisserman, Deep features for textspotting, in ECCV, 2014.

[51]. R. Zhao, W. Ouyang, H. Li, and X. Wang, Saliency detection by multicontextdeep learning, in CVPR, 2015.

[52]. J. Donahue, Y. Jia, O. Vinyals, J. Hoffman, N. Zhang, E. Tzeng, and T.Darrell, Decaf: A deep convolutional activation feature for generic, 2014

[53]. *Farabet, C. Couprie, L. Najman, and Y. LeCun, Learning hierarchicalfeatures for scene labeling, PAMI, 2013.*

[54]. Nithin, D Kanishka and Sivakumar, P Bagavathi, Generic Feature Learningin Computer Vision, Elsevier, Vol.58, Pages202-209, 2015.

[55]. Matthew D. Zeiler, Rob Fergus, Visualizing and Understanding Convolutional Networks, 13th European Conference, Zurich, Switzerland,2014, Proceedings, Part I, Volume 8689, pages:818-833.

[56]. B. B. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hub- bard, and L. D. Jackel, Handwritten digit recognition with a back- propagation network, in NIPS, 1990.

[57]. Y. LeCun, L. Bottou, Y. Bengio, and P. Haffner, Gradient-based learning applied to document recognition, Proceedings of the IEEE,1998

[58]. Alex Krizhevsky, Sutskever I, and Hinton G.E. Imagenet classificationwith deep convolutional neural networks. In NIPS, 2012.

[59]. C. Szegedy, W. Liu, Y. Jia, P. Sermanet, S. Reed, Going deeper withconvolutions, CoRR, 2014.

[60]. K. He, X. Zhang, S. Ren, and J. Sun. Deep residual learning for imagerecognition, arXiv preprint arXiv:1512.03385, 2015.

[61]. B. B. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hubbard, and L. D. Jackel, Handwritten digit recognition with a backpropagation network, in NIPS. Citeseer, 1990.

[62]. Y. LeCun, et al., Gradient-based learningapplied to document recognition, Proceedings of the IEEE, 1998.

[63]. Alex Krizhevsky, Sutskever I, and Hinton G.E, Imagenet classificationwith deep convolutional neural networks. In NIPS, 2012.

[64]. K. Jarrett, K. Kavukcuoglu, M. A. Ranzato, and Y. LeCun. What is the best multi-stage architecture for object recognition? In International Conference on Computer Vision, pages 21462153. IEEE, 2009.

[65]. I. Krizhevsky. Convolutional deep belief networks on cifar-10. Unpublished manuscript, 2010.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[66]. L. Le Cun, J. S. Denker, D. Henderson, R. E. Howard, W. Hub- bard, and L. D. Jackel, Handwritten digit recognition with a backpropagationnetwork, in NIPS. Citeseer, 1990

[67]. Zeiler M., Taylor G., and Fergus R. Adaptive deconvolutional networks for mid and high level feature learning, In ICCV, 2011.

[68]. S. Hochreiter, Y. Bengio, P. Frasconi, and J. Schmidhuber. Gradient flow in recurrent nets: the difficulty of learning long-term dependencies,2001.

[69]. A. Krizhevsky. Convolutional deep belief networks on cifar-10. Unpublished manuscript, 2010. G.E. Hinton, N. Srivastava, A. Krizhevsky, I. Sutskever, and R. R.

[70]. Salakhutdinov, Improving neural networks by preventing co-adaptation of feature detectors, arXiv preprint arXiv:1207.0580, 2012.

[71]. Fisher Yu and VladlenKoltun, Multi-Scale Context Aggregation by Dilated Convolutions, ICLR,2016

[72]. Asifullah Khan, AnabiaSohail, UmmeZahoora, and Aqsa Saeed Qureshi, A Survey of the Recent Architectures of Deep Convolutional Neural Networks, Artificial Intelligence Review, DOI: https://doi.org/10.1007/s10462-020-09825-6

[73]. Qiang Yang, Pan SJ, Yang Q, Fellow QY (2008) A Survey on Transfer Learning. IEEE Trans Knowl Data Eng 1:1–15. doi: 10.1109/TKDE.2009.191

[74]. Qureshi AS, Khan A (2018) Adaptive Transfer Learning in Deep Neural Networks: Wind Power Prediction using Knowledge Transfer from Region to Region and Between Different Task Domains. arXivPrepr arXiv181012611

[75]. Qureshi AS, Khan A, Zameer A, Usman A (2017) Wind power prediction using deep neural network based meta regression and transfer learning. Appl Soft Comput J 58:742–755. doi: 10.1016/j.asoc.2017.05.031

[76]. Zagoruyko S, Komodakis N (2016) Wide Residual Networks. Procedings Br Mach Vis Conf 2016 87.1-87.12. doi: 10.5244/C.30.87

[77]. Han D, Kim J, Kim J (2017) Deep Pyramidal Residual Networks. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 6307–6315

[78]. Xie S, Girshick R, Dollar P, et al (2017) Aggregated Residual Transformations for Deep Neural Networks. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 5987–5995

[79]. Zhang X, Li Z, Loy CC, Lin D (2017) PolyNet: A Pursuit of Structural Diversity in Very Deep Networks. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 3900–3908

[80]. Wang F, Jiang M, Qian C, et al (2017a) Residual Attention Network for Image Classification. In: 2017 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 6450–6458

[81]. Khan A, Sohail A, Ali A (2018a) A New Channel Boosted Convolutional Neural Network using Transfer Learning. arXivPrepr arXiv180408528

[82]. Woo S, Park J, Lee JY, Kweon IS (2018) CBAM: Convolutional block attention module. Lect Notes ComputSci (including SubserLect Notes ArtifIntellLect Notes Bioinformatics) 11211 LNCS:3–19. doi: 10.1007/978-3-030-01234-2_1

[83]. LeCun Y, et al., 1998, Gradient-based learning applied to document recognition. Proc IEEE 86:2278–2324

[84]. LeCun Y, Jackel LD, Bottou L, et al (1995) Learning algorithms for classification: A comparison on handwritten digit recognition. Neural networks Stat MechPerspect 261:276

[85]. Schmidhuber J (2007) New millennium AI and the convergence of history. In: Challenges for computational intelligence. Springer, pp 15–35

[86]. Simard PY, Steinkraus D, Platt JC (2003) Best practices for convolutional neural networks applied to visual document analysis. In: null. p 958

[87]. Glorot X, Bengio Y (2010) Understanding the difficulty of training deep feedforward neural networks. In: Proceedings of the thirteenth international conference on artificial intelligence and statistics. pp 249–256

[88]. Ranzato M, Huang FJ, Boureau YL, LeCun Y (2007) Unsupervised learning of invariant feature hierarchies with applications to object recognition. In: Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition. IEEE, pp 1–8

[89]. Giusti A, Ciresan DC, Masci J, et al (2013) Fast image scanning with deep max-pooling convolutional neural networks. In: 2013 IEEE International Conference on Image Processing. IEEE, pp 4034–4038
[90]. Oh K-S, Jung K (2004) GPU implementation of neural networks. Pattern Recognit 37:1311–1314
[91]. Strigl D, Kofler K, Podlipnig S (2010) Performance and scalability of GPU-based convolutional neural networks. In: Parallel, Distributed and Network-Based Processing (PDP), 2010 18th Euromicro International Conference on. pp 317–324
[92]. Cireşan DC, Meier U, Masci J, et al (2011) High-Performance Neural Networks for Visual Object Classification. arXivPrepr arXiv11020183
[93]. Nguyen G, Dlugolinsky S, Bobák M, et al (2019) Machine Learning and Deep Learning frameworks and libraries for large-scale data mining: a survey. ArtifIntell Rev 52:77–124. doi: 10.1007/s10462-018-09679-z
[94]. Nickolls J, Buck I, Garland M, Skadron K (2008) Scalable parallel programming with CUDA. In: ACM SIGGRAPH 2008 classes on - SIGGRAPH '08. ACM Press, New York, New York, USA, p 1
[95]. Lindholm E, Nickolls J, Oberman S, Montrym J (2008) NVIDIA Tesla: A Unified Graphics and Computing Architecture. IEEE Micro 28:39–55. doi: 10.1109/MM.2008.31
[96]. Krizhevsky A, Sutskever I, Hinton GE (2012) ImageNet Classification with Deep Convolutional Neural Networks. Adv Neural Inf Process Syst 1–9. doi: 10.1061/(ASCE)GT.1943-5606.0001284
[97]. Simonyan K, Zisserman A (2015) Very Deep Convolutional Networks For Large-Scale Image Recognition. ICLR 75:398–406. doi: 10.2146/ajhp170251
[98]. Amer M, Maul T (2019) A review of modularization techniques in artificial neural networks. ArtifIntell Rev 52:527–561. doi: 10.1007/s10462-019-09706-7
[99]. Szegedy C, Wei Liu, YangqingJia, et al (2015) Going deeper with convolutions. In: 2015 IEEE Conference on Computer Vision and Pattern Recognition (CVPR). IEEE, pp 1–9
[100]. Srivastava RK, Greff K, Schmidhuber J (2015a) Highway Networks. doi: 10.1002/esp.3417
[101]. He K, Zhang X, Ren S, Sun J (2015a) Deep Residual Learning for Image Recognition. Multimed Tools Appl 77:10437–10453. doi: 10.1007/s11042-017-4440-4
[102]. Huang G, Liu Z, Van Der Maaten L, Weinberger KQ (2017) Densely connected convolutional networks. Proc - 30th IEEE ConfComput Vis Pattern Recognition, CVPR 2017 2017-Janua:2261–2269. doi: 10.1109/CVPR.2017.243
[103]. Lin TY, Dollár P, Girshick R, et al (2017) Feature pyramid networks for object detection. In: Proceedings - 30th IEEE Conference on Computer Vision and Pattern Recognition, CVPR 201
[104]. Cai Z, Vasconcelos N (2019) Cascade R-CNN: High Quality Object Detection and Instance Segmentation. IEEE Trans Pattern Anal Mach Intell. doi: 10.1109/tpami.2019.2956516
[105]. Pang J, Chen K, Shi J, et al (2020) Libra R-CNN: Towards Balanced Learning for Object Detection
[106]. Chen W, Wilson JT, Tyree S, et al (2015) Compressing neural networks with the hashing trick. In: 32nd International Conference on Machine Learning, ICML 2015
[107]. Han S, Mao H, Dally WJ (2016) Deep compression: Compressing deep neural networks with pruning, trained quantization and Huffman coding. In: 4th International Conference on Learning Representations, ICLR 2016 - Conference Track Proceedings
[108]. Wu J, Leng C, Wang Y, et al (2016) Quantized convolutional neural networks for mobile devices. In: Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition
[109]. Frosst N, Hinton G rey (2018) Distilling a neural network into a soft decision tree. In: CEUR Published in Artificial Intelligence Review, DOI: https://doi.org/10.1007/s10462-020-09825-6
[110]. MadhusmitaSahu and Rasmita Dash, A Survey on Deep Learning: Convolution Neural Network (CNN), https://www.researchgate.net/ publication/343969393, 2021
[111]. QianruZhanga, MengZhanga,_, TinghuanChenb, ZhifeiSuna, YuzheMab, Bei Yu, Recent Advances in Convolutional Neural Network Acceleration, Neurocomputing, 2018
[112]. Y. LeCun, Y. Bengio, G. Hinton, Deep learning, Nature 521 (7553) (2015) 436–444.
[113]. Y. Lecun, et al., , Gradient-based learning applied to document recognition, Proceedings of the IEEE 86 (11) (1998) 2278–2324.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 1, October 2022
Impact Factor: 6.252

[114].M. Moczulski, M. Denil, J. Appleyard, N. de Freitas, ACDC: A structured e_cient linear layer, in: International Conference on Learning Representations (ICLR), 2016.

[115].M. Jaderberg, A. Vedaldi, A. Zisserman, Speeding up convolutional neural networks with low rank expansions, in: British Machine Vision Conference (BMVC), 2014.

[116].V. Nair, G. E. Hinton, Rectified linear units improve restricted boltzmann machines, in: International Conference on Machine Learning (ICML), 2010, pp. 807–814.

[117].A. L. Maas, A. Y. Hannun, A. Y. Ng, Rectifier nonlinearitiesimprove neural network acoustic models, in: InternationalConference on Machine Learning (ICML), 2013.

[118].K. He, X. Zhang, S. Ren, J. Sun, Delving deep into rectifiers:Surpassing human-level performance on imagenet classification,in: IEEE International Conference on Computer Vision(ICCV), 2015, pp. 1026–1034.

[119].L. Xu, N. Wang, T. Chen, M. Li, Empirical evaluation of rectifiedactivations in convolutional network, in: InternationalConference on Machine Learning Workshop, 2015.

[120].D.-A. Clevert, T. Unterthiner, S. Hochreiter, Fast and accuratedeep network learning by exponential linear units (elus), in:International Conference on Learning Representations (ICLR),2016.

[121]. ArohanAjit, Koustav Acharya, AbhishekSamanta A Review of Convolutional Neural Networks, 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE) February 2020

[122]. Chenyou Fan, Indiana University Bloomington, IN Survey of Convolutional Neural Network

[123]. AzeddineElhassouny, FlorentinSmarandacheTrends in deep convolutional neural Networks

[124].architectures: a review, IEEE/ICCSRE2019, 2019, Agadir, Morocco

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Deep Learning and its Application: A Review

Avinash H. Hedaoo

Dept. of Computer Science, Prerna College of Commerce, Nagpur -44009, (M.S.) India

ABSTRACT

Click here and insert your abstract text. Nowadays, deep learning is a current and a stimulating field of machine learning. Deep learning is the most effective, supervised, time and cost efficient machine learning approach. Deep learning is not a restricted learning approach, but it abides various procedures and topographies which can be applied to an immense speculum of complicated problems. The technique learns the illustrative and differential features in a very stratified way. Deep learning methods have made a significant breakthrough with appreciable performance in a wide variety of applications with useful security tools. It is considered to be the best choice for discovering complex architecture in high-dimensional data by employing back propagation algorithm. Deep learning has exploded in the public consciousness, primarily as predictive and analytical products suffuse our world, in the form of numerous human-centered smart-world systems, including targeted advertisements, natural language assistants and interpreters, and prototype self-driving vehicle systems. Yet to most, the underlying mechanisms that enable such human-centered smart products remain obscure. In contrast, researchers across disciplines have been incorporating deep learning into their research to solve problems that could not have been approached before. In this paper, the author seeks to provide a thorough investigation of deep learning in its applications and mechanisms. The state of the art review further provides a general overview on the novel concept and the ever-increasing advantages and popularity of deep learning. Finally, the paper ends with the conclusion.

Keywords: Machine learning algorithm, deep learning, neural networks, survey, Algorithms, supervised and unsupervised learning

1. Introduction

The term ”Deep Learning” (DL) was first introduced to Machine Learning (ML) in 1986, and later used for Artificial Neural Networks (ANN) in 2000 (Schmidhuber, 2015). Deep learning methods are composed of multiple layers to learn features of data with multiple levels of abstraction (LeCun et al., 2015). DL approaches allow computers to learn complicated concepts by building them out of simpler ones (Goodfellow et al., 2016). For Artificial Neural Networks (ANN), Deep Learning (DL) aka hierarchical learning (Deng and Yu, 2014) is about assigning credits in many computational stages accurately, to transform the aggregate activation of the network (Schmidhuber, 2014). To learn complicated functions, deep architectures are used with multiple levels of abstractions i.e. non-linear operations; e.g. ANNs with many hidden layers (Bengio, 2009). To sum it accurately, Deep Learning is a sub-field of Machine Learning, which uses many levels of non-linear information processing and abstraction, for supervised or unsupervised feature learning and representation, classification and pattern recognition (Deng and Yu, 2014). Deep Learning i.e. Representation Learning is class or sub-field of Machine Learning. Recent deep learning methods are mostly said to be developed since 2006 (Deng, 2011) (Matiur Rahman Minar, Jibon Naher Jul 2018).

Along with Big Data and Analytics, Cloud/Edge Computing-based Big Computing (W. Shi, J. Cao, Q. Zhang, Y. Li, and L. Xu, 2014), (W. Yu et al.,2017), and the Internet of Things (IoT)/Cyber-Physical Systems (CPS) , the topic of Deep Learning has come to dominate industry and research spheres for the development of a variety of smart- world systems. Deep learning has shown significant potential in approximating and reducing large, complex datasets into highly accurate predictive and transformational output, greatly facilitating human-centered smart systems (X.W. Chen and X. Lin,2014), (N. D. Nguyen, T. Nguyen, and S. Nahavandi, 2017). In contrast to complex hard-coded programs developed for a sole inflexible task, deep learning architectures can be applied to all types of data, be they visual, audio, numerical, text, or some combination. In addition, advanced deep learning platforms are becoming ever more sophisticated, often open source and available for widespread use (William Grant Hatcher and Wei Yu, 2018). Active researchers in this area include those at University of Toronto, New York University, University of Montreal, Microsoft Research, Google, IBM Research, Baidu, Facebook, Stanford University, University of Michigan, MIT, University of Washington, and numerous other places. These researchers have demonstrated successes of deep learning in diverse applications of computer vision, phonetic recognition, voice search, conversational speech recognition, speech and image feature coding, semantic utterance classification, hand-writing recognition, audio processing, visual object recognition, information retrieval, and even in the analysis of molecules that may lead to discovering new drugs as reported recently in (Arel et al., 2014, Li Deng, 2014). In recent years, various deep architectures with different learning paradigm are quickly introduced to develop machines that can perform similar to human or even better in different domains of application such as medical diagnosis, self-driving cars, natural language and image processing, and predictive forecasting (Sengupta S, et al., 2020, Xizhao Wang, 2020) With the unceasing growth of IoT and smart-world systems driven by the advance of CPS, in which all devices are network connected and able to communicate sensed data and monitor physical objects, larger and larger datasets are becoming available for the application of deep learning, poised to materially impact our daily lives. As a solution to the processing, dimensionality reduction, compression, and

extraction of such Big Data, deep learning provides the most immediately relevant and appropriate tools, enabling the rapid analysis of complex data that spans a variety of modalities (William Grant Hatcher and Wei Yu, 2018).

Contributions of this paper are outlined as follows:

- This review almost provides a deep survey of the most important aspects of deep learning. This review helps researchers and students to have a good understanding.
- This paper explains DL in deep which the most popular deep learning algorithm by describing the concepts, theory, and state-of-the-art architectures.
- Reviews current challenges (limitations) of Deep Learning including lack of training data, Vanishing gradient problem, Exploding Gradient Problem, and Under specification.

The remainder of this paper is as follows. In Section II, provides a brief overview of deep learning. Section III, provides categorization of deep learning. Section IV, outlines basic deep learning architectures. In Section V, Deep learning methods are discussed in detail, Section VI provide detail discussion on Deep learning platforms, Section VII presents a broad review of the applications of deep learning. Finally, Section VIII, provides concluding remarks.

2. Evolution of Deep Learning

Artificial Neural Networks (ANN) have come a long way, as well as other deep models. First Generation of Artificial Neural networks(ANN) was composed of perceptrons in neural layers, which were limited in computations. The second- generation calculated the error rate and backpropagated the error. Restricted Boltzmann machine overcame the limitation of backpropagation, which made the learning easier. Then other networks are evolved eventually. Figure.1 illustrates a timeline showing the evolution of deep models (Amitha Mathew et al., 2021). The DBN-training procedure is not the only one that makes effective training of DNNs possible. Alternatively denoising autoencoder, "contractive" autoencoders , sparse encoding symmetric machine (SESM), can be used for effective training of DNNs. Historically, the use of the generative model of DBN to facilitate the training of DNNs plays an important role in igniting the interest of deep learning for speech feature coding and for speech recognition (Li Deng, 2014). This improvement has been complemented by the proliferation of cheaper processing units such as the general-purpose graphic processing unit (GPGPU) and large volume of data set (big data) to train from. In addition to the backpropagation algorithm and GPU, the adoption and advancement of ML and particularly Deep Learning can be attributed to the explosion of data or bigdata in the last 10 years (Ajay Shrestha et al., 2019). Other techniques and neural networks came as well e.g. Feedforward Neural Networks (FNN), Convolutional Neural Netowrks (CNN), Recurrent Neural Networks (RNN) etc. along with Deep Belief Networks, Autoencoders and such (Hinton, The next generation of neural networks). From that point, ANNs got improved and designed in various ways and for various purposes. Schmidhuber (2014), Bengio (2009), Deng and Yu (2014), Goodfellow et al. (2016), Wang et al. (2017a) etc. provided detailed overview on the evolution and history of Deep Neural Networks (DNN) as well as Deep Learning (DL). Deep architectures are multilayer non-linear repetition of simple architectures in most of the cases, which helps to obtain highly complex functions out of the inputs (LeCun et al., 2015, Matiur Rahman Minar et al., 2018). The concept of deeplearning was put forward in 2006 at first. Googel's AlphaGo program defeated Lee Sedol in Go competition, which showed that deep learning had a strong learning ability. Google's DeepDream is an excellent software which can not only classify images but generating strange and artificial paintings based on its own knowledge. Facebook announced a new artificial intelligence system named Deep Text. Deep Text is a deeplearning-based text understanding engine which can classify massive amounts of data, provide corresponding services after identifying users' chatting messages and clean up span message. Baidu's unmanned ground vehicle has accomplished road test under complicated road conditions. IFLYTEK started the research of speech recognition based on Deep Neural Network (DNN) 2010. They launched the first online Chinese speech recognition system and an advanced technology to recognize different languages. And now, they have published a high performance computing (HPC) platform in cooperation with Intel. (Xuedan Du et al., 2016). ML will continue to impact and disrupt all areas of our lives from education, finance, governance, healthcare, manufacturing, marketing and others (Ajay Shrestha et al., 2019). Now a days deep learning is used in a lot many applications such as Google's voice and image recognition, Netflix and Amazon's recommendation engines, Apple's Siri, automatic email and text replies, chatbots etc. (Amitha Mathew et al., 2021).

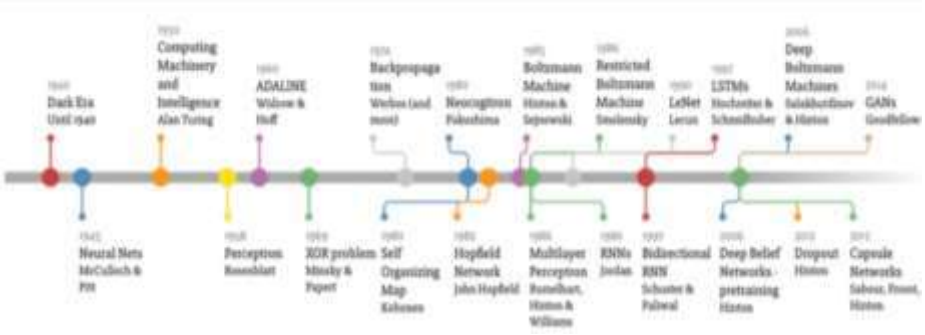


Fig. 1 - Evolution of Deep models [An intelligent framework for modelling and simulation of artificial neural networks (ANNs) based on augmented reality - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Timeline-of-deep-learning-adopted-from-20_fig1_344738477 [accessed 1 Sep, 2022]]

3. Categorization of Deep Learning

DL techniques are classified into three major categories: unsupervised, partially supervised (semi-supervised) and supervised. Furthermore, deep reinforcement learning (DRL), also known as RL, is another type of learning technique, which is mostly considered to fall into the category of partially supervised (and occasionally unsupervised) learning techniques.

3.1 Supervised Learning

In Supervised learning technique labeled data is used. In the case of supervised DL approaches, the environment has a set of inputs and corresponding outputs$(xt,yt)\sim\rho$. For example, if for input xt, the intelligent agent predicts $\hat{yt}=(xt)$, the agent will receive a loss value $l(yt,\hat{yt})$. The agent will then iteratively modify the network parameters for better approximation of the desired outputs. After successful training, the agent will be able to get the correct answers to questions from the environment. There are different supervised learning approaches for deep leaning including Deep Neural Networks (DNN), Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN) including Long Short Term Memory (LSTM), and Gated Recurrent Units (GRU) (Md Zahangir Alom1 et al., 2018). The main advantage of this technique is the ability to collect data or generate a data output from the prior knowledge. However, the disadvantage of this technique is that decision boundary might be overstrained when training set doesn't own samples that should be in a class. Overall, this technique is simpler than other techniques in the way of learning with high performance (Laith Alzubaidi et al., 2021). The two primary learning tasks in supervised learning are classification and regression.

3.1.1 Classification

In classification, the output of the learning task will be of a finite set of classes. This can take the form of binary classification of only two classes (0 or 1), multi-class classification resulting in one class out of a set of three or more total classes (red, green, blue, etc.), as multi-label classification, where objects can belong to multiple binary classes (red or not red, and car or not car), and even as all pairs classification, in which every class in a finite set is directly compared to every other class in a binary way (Szegedy C et al., 2015). In all pairs classification, comparing red, green and blue, the resulting output would be test: red vs. green, red vs. blue, and green vs. blue. Examples for deep learning applications of classification include binary output in malware detection (Malicious and Benign, Shorfuzzaman M et al., 2020), as well as non-binary classification of handwritten number, as in the MNIST dataset (Le QV, 2013).

3.1.2 Regression

In contrast to classification, the output of regression learning is one or more continuous-valued numbers. Regression analysis is a convenient mechanism to provide scored labels equivalent to multi-label classification, where each item of a set has a probability of belonging (i.e., 0.997 red, 0.320 green, 0.008 blue). Regression has been applied in various areas, including monocular image object recognition for outdoor localization (T. Naseer and W. Burgard, 2017), among others (William Grant Hatcher and Wei Yu, 2018).

3.2 Semi-Supervised Learning

In this technique, the learning process is based on semi-labeled datasets. Occasionally, generative adversarial networks (GANs) and DRL are employed in the same way as this technique. In addition, RNNs, which include GRUs and LSTMs, are also employed for partially supervised learning. One of the advantages of this technique is to minimize the amount of labeled data needed. On other the hand, One of the disadvantages of this technique is irrelevant input feature present training data could furnish incorrect decisions. Text document classifier is one of the most popular example of an application of semi-supervised learning. Due to difficulty of obtaining a large amount of labeled text documents, semi-supervised learning is ideal for text document classification task (Laith Alzubaidi et al., 2021).

3.3 Unsupervised Learning

Unsupervised learning systems are ones that can learn without the presence of data labels. In this case, the agent learns the internal representation or important features to discover unknown relationships or structure within the input data. Often clustering, dimensionality reduction, and generative techniques are considered as unsupervised learning approaches. There are several members of the deep learning family that are good at clustering and non-linear dimensionality reduction, including Auto Encoders (AE), Restricted Boltzmann Machines (RBM), and the recently developed GAN. In addition, RNNs, such as LSTM and RL, are also used for unsupervised learning in many application domains (Md Zahangir Alom1 et al., 2018). The main disadvantages of unsupervised learning are unable to provide accurate information concerning data sorting and computationally complex. One of the most popular unsupervised learning approaches is clustering (Saeed MM et al., 2020, Laith Alzubaidi et al., 2021). The three primary learning tasks in unsupervised learning are Dimensionality Reduction, Clustering and Density Estimation.

3.3.1 Dimensionality Reduction

Dimensionality reduction can be carried out in various ways, including different forms of component and discriminant analysis. As an example, auto-encoders can transform input data into a reduced or encoded output for the purposes of data compression or storage space reduction. Examples of dimensionality reduction include the reduction of sequential data, such as video frames, to reduce noisy or redundant data while maintaining important

features of the original data (B. Su et al. 2018), or the use of deep belief networks to reduce dimensionality of hyperspectral (400-2500 nm) images of landscapes to determine plant life content (D. M. S. Arsa et al., 2016).

3.3.2 Clustering

Clustering algorithms are used to statistically group data. Generally speaking, this occurs through the alternating selection of cluster centroids, and cluster membership. For example, k-means and fuzzy c-means clustering utilize the least mean square error of the distances between clusters and centroids. In the latter, fuzzing allows data membership in multiple cluster centroids, making the edges of the clusters ``fuzzy." Other clustering algorithms utilize the Gaussian Mixture Model (GMM), or other statistical and probabilistic mechanisms, instead of Euclidean Distance, as a means to make cluster selection (Y. P. Raykov, et al., 2016, X. Yang, 2017). In addition, deep neural network architectures can provide deep learning implementations for cluster analysis . Examples include the use of Self-Orienting Feature Maps (SOFMS) to satisfy real-time image registration , and the TSK_DBN fuzzy learning network that combines the Takagi-Sugeno-Kang (TSK) fuzzy system with a Deep Belief Network (DBN), among others.

3.3.3 Density Estimation

Density estimation, in general, is the statistical extraction or approximation of features of a data distribution, such as the extraction of densities of subgroups of data to evaluation correlations, or the approximation of the data distribution as a whole. Examples of density estimation include the estimation of power spectral density for noise reduction in binaural assisted listening devices (D. Marquardt and S. Doclo,2017), and intersection vehicle traffic density estimation utilizing CNNs on heterogeneous distributed video (C. Yeshwanth, et al., 2017, William Grant Hatcher and Wei Yu, 2018).

3.4 Reinforcement Learning

Reinforcement Learning operates on interacting with the environment, while supervised learning operates on provided sample data. This technique was developed in 2013 with Google Deep Mind (Laith Alzubaidi et al., 2021). Reinforcement learning uses a system of reward and punishment to train the algorithm. In this, the algorithm or an agent learns from its environment. The agent gets rewards for correct performance and penalty for incorrect performance. For example, consider the case of a self-driving car, the agent gets a reward for driving safely to destination and penalty for going off-road. Similarly, in the case of a program for playing chess, the reward state may be winning the game and the penalty for being checkmated. The agent tries to maximize the reward and minimize the penalty. In reinforcement learning, the algorithm is not told how to perform the learning; however, it works through the problem on its own (Amitha Mathew et al., 2021).

Deep Reinforcement Learning is a learning technique for use in unknown environments. Depending upon the problem scope or space, you can decide which type of RL needs to be applied for solving a task. If the problem has a lot of parameters to be optimized, DRL is the best way to go. If the problem has fewer parameters for optimization, a derivation free RL approach is good. An example of this is annealing, cross entropy methods, and SPSA (Md Zahangir Alom1 et al., 2018). The two primary means of reinforcement can be divided between policy search and value function approximation.

3.4.1 Policy Search

Policy search can be carried out by gradient-based (via backpropagation) or gradient-free (evolutionary) methods, to directly search for an optimal policy. These typically output parameters for a probability distribution, either for continuous or discreet actions, resulting in a stochastic policy (K. Arulkumaran et al., 2017). Though prior implementations of Google's AphaGo program, which were the first to beat a professional human player without handicap (D. Silver et al. 2016), were a hybrid of policy search and value function approaches, the most recent implementation, AlphaGo Zero, is entirely policy search-based, learned without any human input, and significantly outperforms the prior implementations.

3.4.2 Value Function

Value function methods operate by estimating the expected return of being in a given state, attempting to select an optimal policy, which chooses the action that maximizes the expected value given all actions for a given state. The policy can be improved by iterative evaluation and update of the value function estimate. The state-action value function, otherwise known as the quality function, is the source of Q-learning (K. Arulkumaran et al., 2017 , A. Bonarini, et al., 2009). An alternative to the quality function, the advantage function represents relative state-action values, as opposed to absolute state-action values (K. Arulkumaran et al., 2017). As a seminal work on the application of Q-learning and Deep Q-Networks (DQN), (V. Mnih et al.2015) implemented a DQN to play 49 different Atari 2600 videogames, observing four frames as environment data, extracting the game score as reward, with controller and button combinations encoded as actions. Their DQN implementation outperformed human users in the majority of games, as well as outperforming the best linear learners handily (William Grant Hatcher and Wei Yu, 2018).

4. Basic Architectures of Deep Neural Network (DNN)

Different names for deep learning architectures embrace deep belief networks, recurrent neural networks and deep neural networks. DNN can be constructed by adding multiple layers which are hidden layers in between the input layers and the output layers of Artificial Neural Network with various topologies. The deep neural network can model convoluted and non-linear relationships and generates models in which the object is treated as a layered configuration of primitives. These are such feed forward networks which have no looping and the flow of data is from the input layer to the output layer.

There are wide varieties of architectures and algorithms that are helpful in implementing the concept of deep learning. Table 1 depicts the year wise distribution in the architecture of deep learning.

Table 1: Years with the usage of architectures of deep learning

Year	Architecture of deep learning
1990–1995	Recurrent neural network
1995–2000	Long short term memory, convolutional neural network
2000–2005	Long short term memory, convolutional neural network
2005–2010	Deep belief network
2010–2017	Deep stacked network, gated recurrent unit

Here, we will discuss six basic types of the deep learning architectures as follows :-

4.1 Autoencoders

An AE is a deep neural network approach used for unsupervised feature learning with efficient data encoding and decoding. The main objective of auto encoder to learn and representation (encoding) of data, typically for data dimensionality reduction, compression, fusion and many more. This auto encoder technique consists of two parts: the encoder and the decoder. In the encoding phase, the input samples are mapped usually in the lower dimensional features space with a constructive feature representation. This approach can be repeated until the desired feature dimensional space is reached. Whereas in the decoding phase, we regenerate actual features from lower dimensional features with reverse processing (Md Zahangir Alom1 et al., 2018). In an autoencoder, the first layer is built as an encoding layer and transpose of that as a decoder (Amitha Mathew et al., 2021). The learning algorithm is based on the implementation of the backpropagation. Autoencoders extend the idea of principal component analysis (PCA) (Ajay Shrestha et al., 2019).

Autoencoders (AE) are neural networks (Laith Alzubaidi et al., 2021) where outputs are the inputs. AE takes the original input, encodes for compressed representation and then decodes to reconstruct the input (Wang). In a deep AE, lower hidden layers are used for encoding and higher ones for decoding, and error back-propagation is used for training (Deng and Yu, 2014).Goodfellow et al. (2016)(Matiur Rahman Minar et al., 2018)

Following are the types of Auto-encoders:

4.1.1 De-noising Auto-encoder

It is an advanced version of basic auto-encoders. To addresses the identity functions, these encoders corrupt the input and afterwards, reconstruct them. It is also called the stochastic version of the auto-encoders (Shaveta Dargan et al., 2019). In early Auto-Encoders (AE), encoding layer had smaller dimensions than the input layer. In Stacked Denoising Auto-Encoders (SDAE), encoding layer is wider than the input layer (Deng and Yu, 2014) (Matiur Rahman Minar, Jibon Naher Jul 2018).

4.1.2 Sparse Auto-encoder

These auto-encoders have the learning methods that automatically extract the features from the unlabeled data. Here the word sparse indicates that hidden units are allowed to fire only for the certain type of inputs and not too frequently (Shaveta Dargan et al., 2019).

4.1.3 Variational Auto-Encoder (VAE)

It consists of an encoder, decoder and a loss function. They are used for the designing of the complex models of the data that too with large datasets. It is also known as high resolution network (Shaveta Dargan et al., 2019). Variational Auto-Encoders (VAE) can be counted as decoders (Wang). VAEs are built upon standard neural networks and can be trained with stochastic gradient descent (Doersch, 2016)(Matiur Rahman Minar, Jibon Naher Jul 2018).

4.1.4 Contractive Auto-encoder (CAE)

These are robust networks as de-noising auto-encoders but the difference is that the contractive auto-encoders generate robustness in the networks through encoder function whereas de-noising auto-encoders work with the reconstruction process (Shaveta Dargan et al., 2019).

4.1.5 Transforming Autoencoders

Deep Auto-Encoders (DAE) can be transformation-variant, i.e., the extracted features from multilayers of non-linear processing could be changed due to learner. Transforming Auto-Encoders (TAE) work with both input vector and target output vector to apply transformation-invariant property and lead the codes towards a desired way (Deng and Yu, 2014) (Matiur Rahman Minar, Jibon Naher Jul 2018).

4.2 Convolutional Neural Networks

This network structure was first proposed by Fukushima in 1988 . It was not widely used however due to limits of computation hardware for training the network. In the 1990s, LeCun et al. applied a gradient-based learning algorithm to CNNs and obtained successful results for the handwritten digit classification problem (Md Zahangir Alom1 et al., 2018). The first CNN was developed by(LeCun et al., Shaveta Dargan et al., 2019) ConvNets are designed to process data that come in the form of multiple arrays, for example a colour image composed of three 2D arrays containing pixel intensities in the three colour channels. There are four key ideas behind ConvNets that take advantage of the properties of natural signals: local connections, shared weights, pooling and the use of many layers (Yann LeCun et al., 2015).

The architecture of a typical ConvNet is structured as a series of stages. The first few stages are composed of two types of layers: convolutional layers and pooling layers. Units in a convolutional layer are organized in feature maps, within which each unit is connected to local patches in the feature maps of the previous layer through a set of weights called a filter bank. The result of this local weighted sum is then passed through a non-linearity such as a ReLU. All units in a feature map share the same filter bank. Different feature maps in a layer use different filter banks. Mathematically, the filtering operation performed by a feature map is a discrete convolution, hence the name.

Although the role of the convolutional layer is to detect local conjunctions of features from the previous layer, the role of the pooling layer is to merge semantically similar features into one. Because the relative positions of the features forming a motif can vary somewhat, reliably detecting the motif can be done by coarse-graining the position of each feature. A typical pooling unit computes the maximum of a local patch of units in one feature map (or in a few feature maps). Neighbouring pooling units take input from patches that are shifted by more than one row or column, thereby reducing the dimension of the representation and creating an invariance to small shifts and distortions. Two or three stages of convolution, non-linearity and pooling are stacked, followed by more convolutional and fully-connected layers. Backpropagating gradients through a ConvNet is as simple as through a regular deep network, allowing all the weights in all the filter banks to be trained.

Deep neural networks exploit the property that many natural signals are compositional hierarchies, in which higher-level features are obtained by composing lower-level ones. In images, local combinations of edges form motifs, motifs assemble into parts, and parts form objects. Similar hierarchies exist in speech and text from sounds to phones, phonemes, syllables, words and sentences. The pooling allows representations to vary very little when elements in the previous layer vary in position and appearance.

The convolutional and pooling layers in ConvNets are directly inspired by the classic notions of simple cells and complex cells in visual neuroscience, and the overall architecture is reminiscent of the LGN–V1–V2–V4–IT hierarchy in the visual cortex ventral pathway.

4.2.1 Image Understanding With Deep Convolutional Networks

Since the early 2000s, ConvNets have been applied with great success to the detection, segmentation and recognition of objects and regions in images. These were all tasks in which labelled data was relatively abundant, such as traffic sign recognition, the segmentation of biological images particularly for connectomics, and the detection of faces, text, pedestrians and human bodies in natural images. A major recent practical success of ConvNets is face recognition.

Importantly, images can be labelled at the pixel level, which will have applications in technology, including autonomous mobile robots and self-driving cars. Other applications gaining importance involve natural language understanding and speech recognition.

ConvNets are now the dominant approach for almost all recognition and detection tasks and approach human performance on some tasks. A recent stunning demonstration combines ConvNets and recurrent net modules for the generation of image captions.

ConvNets are easily amenable to efficient hardware implementations in chips or field-programmable gate arrays. A number of companies such as NVIDIA, Mobileye, Intel, Qualcomm and Samsung are developing ConvNet chips to enable real-time vision applications in smartphones, cameras, robots and self-driving cars (Yann LeCun et al., 2015).

The different CNN architectures include Deep Max-Pooling Convolutional Neural Networks, Very Deep Convolutional Neural Networks, Network In Network, Region-based Convolutional Neural, Fast R-CNN, Faster R-CNN, Mask R-CNN, Multi-Expert R-CNN, Deep Residual Networks, Resnet in Resnet, ResNeXt and Capsule Networks (Matiur Rahman Minar, Jibon Naher Jul 2018).

4.3 Restricted Boltzmann Machine (RBM)

Restricted Boltzmann Machines (RBM) are special type of Markov random field containing one layer of stochastic hidden units i.e. latent variables and one layer of observable variables (Deng and Yu 2014, Goodfellow et al. 2016).Hinton and Salakhutdinov (2011) proposed a Deep Generative Model using Restricted Boltzmann Machines (RBM) for document processing (Matiur Rahman Minar, Jibon Naher Jul 2018). (Hinton and Sejnowski) proposed Boltzmann Machine (BM) in 1986. Boltzmann Machine is a random neural network belonging to the type of feedback neural network. Boltzmann Machine consists of some visible units (visible variables, i.e. data samples) and some hidden units (hidden variables), each visible unit is connected to all the hidden units, the visible variables and hidden variables are binary variables, the state is 0 or 1, 0 represents the neuron is in suppressed state, and 1 represents the neuron is in active state. (Sejnowski et al.) further proposed restricted Boltzmann machine (RBM). Input the training data to the visible layer, then the hidden layer detects the features of input data, the neurons are disconnected in the same layer but fully connected between two layers. The training of Restricted Boltzmann machine is faster than Autoencoder. In (Le Q V, 2011) proposed a more efficient optimization algorithm based on the

stochastic gradient descent method. The traditional training method of RBM requires a large number of sampling steps, which makes the training efficiency of RBM still not high. The contrastive divergence proposed by Hinton solved this problem (Ruihui Mu et al., 2019).

4.4 Deep Stacking Network (DSN)

Deep Stacking Networks (DSN) is also acknowledged as deep convex networks. DSN is different from other traditional deep learning structures. It is called deep because of the fact that it contains a large number of deep individual networks where each network has its own hidden layers. The DSN believes that training is not a particular and isolated problem, but it holds the combination of individual training problems. The DSN is made up of a combination of modules which are part of the network and present in the architecture. There are three modules that work for the DSN. Here every module in the model is having an input zone, a single hidden zone and an output zone. Subroutines are placed one over the top of another with the input to the every module is taken as the outputs of the preceding layer and the authentic input vector. In DSN, every module is trained in isolation so as to make it productive and competent with the ability to work in coordination. The process of supervised method of training is practiced as the back-propagation for each module and not for the entire network. DSNs works superior than typical DBNs making it suitable and accepted network architecture (Shaveta Dargan et al., 2019).

4.5 Long Short Term Memory (LSTM)/Gated Recurrent Unit (GRU) Network

Hochreiter and Schmidhuber (1997) proposed Long Short-Term Memory (LSTM) which overcomes the error back-flow problems of Recurrent Neural Networks (RNN). LSTM is based on recurrent network along with gradient-based learning algorithm (Hochreiter and Schmidhuber, 1997) LSTM introduced self-loops to produce paths so that gradient can flow (Goodfellow et al., 2016). (Greff et al. 2017) provided large-scale analysis of Vanilla LSTM and eight LSTM variants for three uses i.e. speech recognition, handwriting recognition, and polyphonic music modeling. They claimed that eight variants of LSTM failed to perform significant improvement, while only Vanilla LSTM performs well (Greff et al., 2015, Shi et al. 2016b) proposed Deep Long Short-Term Memory (DLSTM), which is a stack of LSTM units for feature mapping to learn representations (Shi et al., 2016b) (Haohan Wang et al., 2017).

LSTM network is a variant of RNN. LSTM can work well for the time-sequential data. LSTM can avoid the disappearance of gradient at some extent by controlling the gate through the long memory and short memory. LSTM is different from RNN, because LSTM can determine which information are useful through the cell, the cell includes forget gate except for input gate and output gate. Input a message to LSTM, then determine the information to retain or forget according to whether or not match to the certification of algorithm. In the network structure of the LSTM, the input of the previous layer acts on the output through more paths, and the introduction of the gate makes the network have a focusing effect. LSTM generally included the input gate, forget gate, and output gate. The input gate is to supplement the latest input from the current input after the state of the "forgotten" part. The output gate will be based on the latest state C_t, the previous moment output and the current input x_t determine the output h_t at this moment. The forget gate is to make the recurrent neural network "forget" information that was not used before. LSTM can more naturally remember the input long before a long time. The storage unit Cell is a special unit that acts like an accumulator or a "gated leaky neuron": this unit has a direct connection from the previous state to the next state, so it can replicate its current state and accumulate all external signals, and due to the presence of the forget gate, the LSTM can learn to decide when to clear the contents of the memory unit.

Types of LSTM are Batch-Normalized LSTM (Cooijmans et al. (2016)), Pixel RNN (van den Oord et al. (2016b)), Bidirectional LSTM (W¨ollmer et al. (2010)), Variational Bi-LSTM (Shabanian et al. (2017)) (Matiur Rahman Minar, Jibon Naher Jul 2018).

4.6 Recurrent Neural Network (RNN)

RNNs can produced an output by comprising the new input with the latent vector. RNNs have three layers: the input layer, the hidden layer, the output layer. In theory, RNNs can work well for the sequential data, and complexity of the network is simple, because the current data is only dependent on the previous data. Fig. 2 shows the schematic diagram of RNN. The neurons are connected in the hidden layer, and RNNs can retain the former information. Where o and x represent the output information and input information respectively, h denotes the hidden unit, W, U, V represent weights. t denotes time, the input at time t and the previous state at time t are both determine the output of hidden unit at time t (Ruihui Mu et al., 2019).

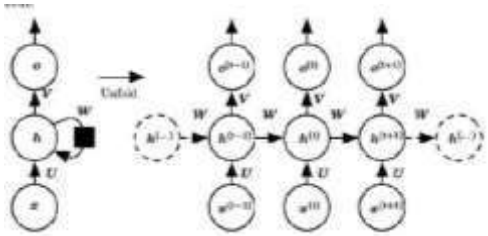


Fig : 2 : RNN expands over time

However, RNN's sensitivity to the exploding gradient and vanishing problems represent one of the main issues with this approach . More specifically, during the training process, the reduplications of several large or small derivatives may cause the gradients to exponentially explode or decay. With the entrance of new inputs, the network stops thinking about the initial ones; therefore, this sensitivity decays over time. Furthermore, this issue can be handled using LSTM]. This approach offers recurrent connections to memory blocks in the network. Every memory block contains a number of memory

cells, which have the ability to store the temporal states of the network. In addition, it contains gated units for controlling the flow of information. In very deep networks, residual connections also have the ability to considerably reduce the impact of the vanishing gradient issue (Laith Alzubaidi et al., 2021).

RNNs have been found to be very good at predicting the next character in the text or the next word in a sequence, but they can also be used for more complex tasks. [MM]

According to the different domains, RNNs have different variants, LSTM(long short-term memory network) is an example. Bidirectional RNNs, Echo State Networks and so on (Ruihui Mu et al., 2019). Various models of RNN are Recurrent Neural Networks with External Memory (RNN-EM), Gated Feedback Recurrent Neural Networks (GF-RNN), Conditional Random Fields as Recurrent Neural Networks(CRF-RNN), Quasi Recurrent Neural Networks (QRNN) (Matiur Rahman Minar, Jibon Naher Jul 2018).

5. Deep Learning Methods

Some of the powerful techniques that can be applied to deep learning algorithms to reduce the training time and to optimize the model are discussed in the following section. The merits and demerits of each method are comprised in the Table 1.

5.1 Backpropagation

Backpropagation first propagates the error term at output layer back to the layer at which parameters need to be updated, then uses standard gradient descent to update parameters with respect to the propagated error. Intuitively, the derivation of backpropagation is about organizing the terms when the gradient is expressed with the chain rule (Haohan Wng et al., 2017).

5.2 Stochastic Gradient Descent

Stochastic gradient descent (SGD) and its variants, are the dominant optimization methods in deep learning (Fengxiang He et al., 2021). SGD, updates are applied after running through a minibatch of n number of samples. Since we are updating the weights more frequently in SGD than in GD, we can converge towards global minimum much faster (Ajay Shrestha et al., 2019). However, because it is frequently updated, it takes extremely noisy steps in the direction of the answer, which in turn causes the convergence behavior to become highly unstable (Yann LeCun et al., 2015).

5.3 Learning Rate Decay

Learning rates have a huge impact on training DNN. It can speed up the training time, help navigate flat surfaces better and overcome pitfalls of non-convex functions (Ajay Shrestha et al., 2019). Adjusting the learning rate increases the performance and reduces the training time of stochastic gradient descent algorithms. The widely used technique is to reduce the learning rate gradually, in which we can make large changes at the beginning and then reduce the learning rate gradually in the training process. This allows fine-tuning the weights in the later stages (Amitha Mathew et al., 2021). There are three common approaches used for reducing the learning rate during training: constant, factored, and exponential decay (Md Zahangir Alom1 et al., 2018). Several innovative methods have been proposed like Delta-bar Algorithm, AdaGrad, RMSProp and Adam (Ajay Shrestha et al., 2019).

5.4 Dropout

(Srivastava et al., 2014) proposed Dropout to prevent neural networks from overfitting. Dropout is a neural network model-averaging regularization method by adding noise to its hidden units. It drops units from the neural network along with connections randomly during training (Matiur Rahman Minar, Jibon Naher Jul 2018). In doing this, the feature selection power is distributed equally across the whole group of neurons, as well as forcing the model to learn different independent features. (Laith Alzubaidi et al., 2021) Dropout can be used with any kind of neural networks, even in graphical models like RBM (Srivastava et al., 2014). A very recent proposed improvement of dropout is Fraternal Dropout (Anonymous, 2018a) for Recurrent Neural Networks (RNN) (Matiur Rahman Minar, Jibon Naher Jul 2018).

5.5 Max-Pooling

In max-pooling a filter is predefined, and this filter is then applied across the nonoverlapping sub-regions of the input taking the max of the values contained in the window as the output. Dimensionality, as well as the computational cost to learn several parameters, can be reduced using maxpooling (Amitha Mathew et al., 2021).

5.6 Batch normalization

As the network is getting trained with variations to weights and parameters, the distribution of actual data inputs at each layer of DNN changes too, often making them all too large or too small and thus making them difficult to train on networks, especially with activation functions that implement saturating nonlinearities, e.g., sigmoid and tanh functions. Iofee and Szegedy proposed the idea of batch normalization in 2015. It has made a huge difference in improving the training time and accuracy of DNN. It updates the inputs to have a unit variance and zero mean at each mini-batch (Ajay Shrestha et al., 2019). It is employed to reduce the "internal covariance shift" of the activation layers. The advantages of utilizing batch normalization are as follows:

- It prevents the problem of vanishing gradient from arising.
- It can effectively control the poor weight initialization.
- It significantly reduces the time required for network convergence (for large-scale datasets, this will be extremely useful).
- It struggles to decrease training dependency across hyper-parameters.

Chances of over-fitting are reduced, since it has a minor influence on regularization. (Laith Alzubaidi et al., 2021)

6. Deep learning platforms

Besides algorithms and data, the third component that enabled deep learning is the availability of fast GPU hardware and software to easily access it. This is often regarded as the most important element. Evaluating a CNN consists mainly of convolutions and large matrix multiplications , both suited for GPUs with their large number of computational cores and high memory bandwidth. The market is dominated by NVIDIA hardware together with CUDA and cuDNN libraries:

– Multi-GPU systems for fast network training.

– Embedded systems for deploying neural networks.

Specialized neural network processors like Google's Tensor Processing Unit [24] or Intel Nervana [35] provide further speed-up.[DD] There are a good number of open-source libraries and frameworks available for deep learning. Most of them are built for python programming language. Such as Theano (Bergstra et al., 2011), Tensorflow (Abadi et al., 2016), PyTorch, PyBrain (Schaul et al., 2010), Caffe (Jia et al., 2014), Blocks and Fuel (van Merri¨enboer et al., 2015), CuDNN (Chetlur et al., 2014), Honk (Tang and Lin, 2017), ChainerCV (Niitani et al., 2017), PyLearn2, Chainer, torch, neon etc. Bahrampour et al. (2015) did a comparative study of several deep learning frameworks (Matiur Rahman Minar, Jibon Naher Jul 2018).

7. Applications of Deep Learning

In this section, we review the primary applications of deep learning. A significant body of work toward the application of deep learning has grown steadily in the last few years. Particularly, the primary advances have been in the application of deep learning toward multimedia analysis, including image, audio, and natural language processing, which has afforded significant leaps in the state of the art for autonomous systems. Indeed, machine learning is fundamentally concerned with data fitting, the primary uses of which are optimization, discrimination, and prediction. In addition, advances in big data and cloud computing have created the potential for machine learning to flourish, enabling the requisite data collection and dissemination, as well as the computational capacity to execute deep models (W. Yu, G. Xu, Z. Chen, and P. Moulema, 2013). The existence of the data, and the nature of its potential have directly necessitated more accurate, generalized, and efficient learning mechanisms (William Grant Hatcher and Wei Yu, 2018).

7.1 Internet of Things

In considering the applications of deep learning for IoT, significant work has been carried out toward broadly applying typical categories like image/video/audio processing, text analysis, etc. across centralized and distributed cloud computing frameworks, utilizing IoT devices and some novel mechanisms(S. C. Kim, 2017). For instance, (S. C. Kim, 2017) proposed a deep learning system for use in identifying and tracking motion of individuals via Channel State Information (CSI) of IoT devices. Mohammadi et al. (M. Mohammadi, A. Al-Fuqaha, M. Guizani, and J. S. Oh, 2017) developed a semi-supervised deep reinforcement learning system to support smart city applications based on both structured and unstructured data. Utilizing Variational Autoencoders (VAEs), (William Grant Hatcher and Wei Yu, 2018) studied indoor user localization using Bluetooth Low Energy (BLE), collecting the received signal strength indicator (RSSI) from a grid of iBeacon devices. In addition, (C. Wu, H. P. Cheng, S. Li, H. Li, and Y. Chen, 2016) developed an efficient road scene segmentation deep learning model for embedded devices, termed ApesNet. Via time profiling and analysis, (William Grant Hatcher and Wei Yu, 2018) developed an asymmetric encoder-decoder network, and limited the size of large feature maps in convolutional layers. (S. Valipour, M. Siam, E. Stroulia, and M. Jagersand, 2016) developed a deep convolutional network for parking stall vacancy detection. (S. Park, M. Sohn, H. Jin, and H. Lee, 2016) designed a Situation Reasoning framework that extracts multiple low-level contexts in DNN modules, and combines them in a higher level Situation Reasoning module based on the Feature Comparison Model of cognitive psychology.

7.2 Cyber-Physical Systems

Cyber-Physical Systems (CPS) include the vertical layering of IoT devices, networking, service, applications, and command and control (C&C) platforms. Examples of CPS systems include smart transportation system with self- driving vehicles, smart cities, smart electrical grids, etc. (P. Zhao et al., 2018). More specifically, as applied to power generation, monitoring and control, (Mocanu et al., 2016) utilized Factored Four-Way Conditional Restricted Boltzmann Machines (FFW-CRBMs) and Disjunctive Factored Four-Way Conditional Restricted Boltzmann Machines (DFFW-CRBMs) to carry out energy disaggregation, and flexibility classification and prediction, on smart appliance data. Likewise, (Huang et al., 2017) investigated electrical load forecasting in the smart grid via deep learning. In addition, Zhao et al. leverage convolutional neural networks to develop a new deep heartbeat classification system, which can accurately analyzing the raw electrocardiogram (ECG) signal in healthcare smart-world system. Further, (Li et al., 2018) proposed a deep convolutional computation model, which is used for conducting hierarchical feature learning on IoT big data. Another relevant work is to adapt the ST-ResNet structure to predict the hourly distribution of crime in parceled areas in the city of Los Angeles (B. Wang, et. al., 2017) .

7.3 Network Management and Control

Deep learning offers a viable technique that can effectively learn the characteristics of the network and the behavior of users, leading to better network management and control decisions and outcomes. In this regard, very little research has been conducted. For example, (Zhu et al.) implemented stacked auto-encoders (SAEs) to realize Q-learning for transmission scheduling in cognitive IoT relays. Likewise, (Lopez-Martin et al., 2017) demonstrated flow

statistics-based network traffic classification via deep neural networks. (Aminanto et al., 2018) developed a three-layer Wi-Fi impersonation attack detection system.

7.4 Secure Deep Learning

(Li et al., 2017) proposed multiple schemes for machine learning on multi-key homomorphic encrypted data in the cloud. A recent work by (Yuan et al., 2017) specifically investigated the space of the attacks that target only the inference mechanism through adversarial input. In the interim, (Goodfellow et al., 2014) proposed the generative adversarial network, pitting generator and discriminator networks against one another in a minimax game. In addition, (Pei et al., 2017) developed DeepXplore, the first whitebox testing framework for evaluating deep learning systems. (Booz et al., 2018) investigated how to fine-tune parameters of deep learning to improve the accuracy of detecting Android malware (William Grant Hatcher and Wei Yu, 2018).

7.5 Speech and audio

Deep learning and DNN started making impact in speech recognition in 2010, after close collaborations between academic and industrial researchers (see reviews in (Hinton, G. et al., 2012, Deng, L et al., 2013). A combination of three factors quickly spread the success of deep learning in speech recognition to the entire speech industry and academia: (1) minimally required decoder changes under the new DNN based speech recognizer deployment conditions enabled by the use of senones as the DNN output; (2) significantly lowered errors compared with the then-state-of-the-art GMM HMM system; and (3) training simplicity empowered by big data for training. By the ICASSP-2013 timeframe, at least 15 major speech recognition groups worldwide confirmed the experimental success of DNNs with very large tasks and with the use of raw speech spectral features away from MFCCs. Moreover, the most recent work of (Sainath, T. et al., 2013) shows that CNNs are also useful for large vocabulary continuous speech recognition and further demonstrates that multiple convolutional layers provide even more improvement when the convolutional layers use a large number of convolution kernels or feature maps. In addition to the RBM, DBN, CNN, and DSN, the deep-structured CRF, which stacks many layers of CRFs, have been successfully used in the task of language identification (Yu, D. et al., 2010), phone recognition (Yu, D., 2010), sequential labeling in natural language processing [96], and confidence calibration in speech recognition (Yu, D.; Deng, L.; Dahl, G., 2010, Yu, D.; Li, J.-Y.; Deng, L, 2010). Learning algorithms for RNNs have been dramatically improved since then, and better results have been obtained recently using RNNs (Graves, A. et al., 2006, Maas, A et al., 2012), especially when the structure of long short-term memory (LSTM) is embedded into the RNN with several layers and trained bi-directionally (Graves, A.;Mahamed, A.; Hinton, G. , 2013) RNNs have also been recently applied to audio/music processing applications (Bengio, Y et al., 2013), where the use of rectified linear hidden units instead of logistic or tanh non-linearities is explored in RNN.

In addition to speech recognition, the impact of deep learning has recently spread to speech synthesis, (In Ling et al., 2013, Ling, Z.; Deng, L.; Yu, D., 2013), the RBM and DBN as generative models are used to replace the traditional Gaussian models, achieving significant quality improvement, in both subjective and objective measures, of the synthesized voice. In the approach developed in (Kang, S. et al., 2013), the DBN as a generative model is used to represent joint distribution of linguistic and acoustic features. Both the decision trees and Gaussian models are replaced by the DBN. On the other hand, the study reported in (Zen, H. et al., 2013) makes use of the discriminative model of the DNN to represent the conditional distribution of the acoustic features given the linguistic features. No joint distributions are modeled. Finally, in (Fernandez, R. et al., 2013), the discriminative model of DNN is used as a feature extractor that summarizes high-level structure from the raw acoustic features. Such DNN features are then used as the input for the second stage of the system for the prediction of prosodic contour targets from contextual features in the fill speech synthesis system (Li Deng et al., 2014).

7.6 Biometrics

In 2009, an automatic speech recognition application was carried out to decrease the Phone Error Rate (PER) by using two different architectures of deep belief networks . In 2012, CNN method was applied within the framework of a Hybrid Neural Network - Hidden Markov Model (NN – HMM). As a result, a PER of 20.07 % was achieved. The PER obtained is better in comparison with a 3 – layer neural network baseline method previously applied. Smartphones and their camera resolution have been tested on iris recognition. Using mobile phones developed by different companies the iris recognition accuracy can reach up to 87% of effectiveness .

In terms of security, especially access control; deep learning is used in conjunction with biometric characteristics. DL was employed to speed up the developing and optimization of FaceSentinel face recognition devices. According to this manufacturer, their devices could expand their identification process from one–to–one to one–to– many in nine months. This engine advancement could have taken 10 man years without DL introduction. It accelerated the production and launch of the equipment. These devices are used in Heathrow airport in London and have the potential to be used for time and attendance and in the banking sector (R. Vargas et al., 2017).

7.7 Language modelling

The use of DNNs for LMs appeared more recently in (Wang Z et al., 2015). An NNLM is one that exploits the neural network's ability to learn distributed representations in order to reduce the impact of the curse of dimensionality. The temporally factored RBM was used for language modeling. As another example neural-network-based LMs, makes use of RNNs to build large scale language models, called RNNLMs. Fast and simple training algorithm also developed for NNLMs (Ruihui Mu et al., 2019).

7.8 Information Retrieval

Information retrieval (IR) is a process whereby a user enters a query into the automated computer system that contains a collection of many documents with the goal of obtaining a set of most relevant documents. A deep generative model of DBN is exploited for this purpose. The more advanced and recent approach to large-scale document retrieval (Web search) based on a specialized deep architecture, called deep-structured semantic model or deep semantic similarity model (DSSM), and its convolutional version (CDSSM),. The deep stacking network (DSN) has also been explored recently for IR with insightful results (Li Deng et al., 2013).

8. Conclusion

In this paper, the researcher provided a thorough overview of the neural networks and deep neural networks. Deep learning is indeed a fast growing application of machine learning. The rapid use of the algorithms of deep learning in different fields really shows its success and versatility. While the full-scale adoption of deep learning technologies in industry is ongoing, measured steps should be taken to ensure appropriate application of deep learning, as the subversion of deep learning models may result in significant loss of monetary value, trust, or even life in extreme cases. The author introduced many common and widely adopted deep learning frameworks, and considered them from the perspectives of design, extensibility and comparative efficacy. Additionally, thoroughly investigated the state-of-the-art in deep learning research. Given the widespread adoption of deep learning, and the inevitability of increasingly sophisticated cyber threats, the development of mechanisms to harden systems against adversarial data input is imperative. Some points are analysed in order to conclude review are, DL requires sizeable datasets (labeled data preferred) to predict unseen data and to train the models. Many of the current deep-learning models utilize supervised learning. Utilizing cloud computing offers the flexibility to train DL architectures. With the recent development in computational tools we will see more DL applications on mobile devices. Regarding the issue of lack of training data, transfer learning will be considered . I hope this work provides a valuable reference for researchers and computer science practitioners alike in considering the techniques, tools, and applications of deep learning, and provokes interest into areas that desperately need further consideration.

References

Matiur Rahman Minar, Jibon Naher Jul 2018, Recent Advances in Deep Learning , arXiv:1807.08169v1 [cs.LG]

William Grant Hatcher and Wei Yu, A Survey of Deep Learning: Platforms, Applications and Emerging Research Trends , VOLUME 6, 2018, IEEE Access.

X.W. Chen and X. Lin, ``Big data deep learning: Challenges and perspectives," IEEE Access, vol. 2, pp. 514_525, 2014.

N. D. Nguyen, T. Nguyen, and S. Nahavandi, ``System design perspective for human-level agents using deep reinforcement learning: A survey," IEEE Access, vol. 5, pp. 27091_27102, 2017.

T. Naseer and W. Burgard, ``Deep regression for monocular camera-based 6-DoF global localization in outdoor environments," in Proc. IEEE/RSJ Int. Conf. Intell. Robots Syst. (IROS), Sep. 2017, pp. 1525_1530.

C. Yeshwanth, P. S. A. Sooraj, V. Sudhakaran, and V. Raveendran, ``Estimation of intersection traf_c density on decentralized architectures with deep networks," in Proc. Int. Smart Cities Conf. (ISC2), Sep. 2017, pp. 1_6.

D. Marquardt and S. Doclo, ``Noise power spectral density estimation for binaural noise reduction exploiting direction of arrival estimates," in Proc. IEEE Workshop Appl. Signal Process. Audio Acoust. (WASPAA), Oct. 2017, pp. 234_238. 19, 21 19 93

K. Arulkumaran, M. P. Deisenroth, M. Brundage, and A. A. Bharath, ``Deep reinforcement learning: A brief survey," IEEE Signal Process. Mag., vol. 34, no. 6, pp. 26_38, Nov. 2017.

A. Bonarini, A. Lazaric, F. Montrone, and M. Restelli, ``Reinforcement distribution in fuzzy Q-learning," Fuzzy Sets Syst., vol. 160, no. 10, pp. 1420_1443, 2009.

V. Mnih et al., ``Human-level control through deep reinforcement learning," Nature, vol. 518, pp. 529_533, Feb. 2015.

D. Silver et al., ``Mastering the game of Go with deep neural networks and tree search," Nature, vol. 529, pp. 484_489, Jan. 2016.

W. Yu, G. Xu, Z. Chen, and P. Moulema, ``A cloud computing based architecture for cyber security situation awareness," in Proc. IEEE Conf. Commun. Netw. Secur. (CNS), Oct. 2013, pp. 488_492.

S. C. Kim, ``Device-free activity recognition using CSI big data analysis: A survey," in Proc. 9th Int. Conf. Ubiquitous Future Netw. (ICUFN), Jul. 2017, pp. 539_541.

M. Mohammadi, A. Al-Fuqaha, M. Guizani, and J. S. Oh, ``Semisupervised deep reinforcement learning in support of iot and smart city services," IEEE Internet Things J., vol. 5, no. 2, pp. 624_635, Apr. 2017.

C. Wu, H. P. Cheng, S. Li, H. Li, and Y. Chen, ``ApesNet: A pixel-wise ef_cient segmentation network for embedded devices," IET Cyber-Phys. Syst., Theory Appl., vol. 1, no. 1, pp. 78_85, 2016.

S. Valipour, M. Siam, E. Stroulia, and M. Jagersand, ``Parking-stall vacancy indicator system, based on deep convolutional neural networks," in Proc. IEEE 3rd World Forum Internet Things (WF-IoT), Dec. 2016, pp. 655_660.

S. Park, M. Sohn, H. Jin, and H. Lee, ``Situation reasoning framework for the internet of things environments using deep learning results," in Proc. IEEE Int. Conf. Knowl. Eng. Appl. (ICKEA), Sep. 2016, pp. 133_138.

P. Li et al., ``Multi-key privacy-preserving deep learning in cloud computing," Future Generat. Comput. Syst., vol. 74, pp. 76_85, Sep. 2017.

I. J. Goodfellow et al., ``Generative adversarial networks," ArXiv e-prints, Jun. 2014. [Online]. Available: http://adsabs.harvard.edu/abs/2014arXiv1406.2661G

J. Booz, J. McGiff, W. G. Hatcher, W. Yu, J. Nguyen, and C. Lu, ``Tuning deep learning performance for Android malware detection," in Proc. 19th IEEE/ACIS Int. Conf. Softw. Eng., Artif. Intell., Netw. Parallel/Distrib. Comput. (SNPD), Jun. 2018.

P. Zhao, W. Yu, D. Quan, and X. Yang, ``Deep learning-based detection scheme with raw ECG signal for wearable telehealth systems," Dept. Comput. Inf. Sci., Towson Univ., Towson, MD, USA, Tech. Rep. 2018-CS-021, Mar. 2018.

D. C. Mocanu, E. Mocanu, P. H. Nguyen, M. Gibescu, and A. Liotta, ``Big IoT data mining for real-time energy disaggregation in buildings," in Proc. IEEE Int. Conf. Syst., Man, (SMC), Oct. 2016, pp. 003765_003769.

B. Wang, P. Yin, A. L. Bertozzi, P. J. Brantingham, S. J. Osher, and J. Xin. (Nov. 2017). ``Deep learning for real-time crime forecasting and its ternarization." [Online]. Available: https://arxiv.org/abs/1711.08833

P. Li, Z. Chen, L. T. Yang, Q. Zhang, and M. J. Deen, ``Deep convolutional computation model for feature learning on big data in Internet of Things," IEEE Trans. Ind. Informat., vol. 14, no. 2, pp. 790_798, Feb. 2018.

M. Lopez-Martin, B. Carro, A. Sanchez-Esguevillas, and J. Lloret, ``Network traf_c classi_er with convolutional and recurrent neural networks for Internet of Things," IEEE Access, vol. 5, pp. 18042_18050, 2017.

M. E. Aminanto, R. Choi, H. C. Tanuwidjaja, P. D. Yoo, and K. Kim, ``Deep abstraction and weighted feature selection forWi-Fi impersonation detection," IEEE Trans. Inf. Forensics Security, vol. 13, no. 3, pp. 621_636, Mar. 2018.

X. Yuan, P. He, Q. Zhu, R. R. Bhat, and X. Li. (Dec. 2017). ``Adversarial examples: Attacks and defenses for deep learning." [Online]. Available: https://arxiv.org/abs/1712.07107

K. Pei, Y. Cao, J. Yang, and S. Jana. (May 2017). ``DeepXplore: Automated whitebox testing of deep learning systems." [Online]. Available: https://arxiv.org/abs/1705.06640

Li Deng ,A tutorial survey of architectures, algorithms, and applications for deep learning, Cambridge University Press, 2014 VOL 3 Arel, I.; Rose, C.; Karnowski, T.: Deep machine learning – a new frontier in artificial intelligence, in IEEE Computational Intelligence Mag., 5 (2010), 13–18.

Xizhao Wang et al., Recent advances in deep learning, International Journal of Machine Learning and Cybernetics, 2020, 11:747–750 Sengupta S, Basak S, Saikia P, Paul S, Tsalavoutis V, Atiah F, Ravi V, Peters A (2020) A review of deep learning with special emphasis on architectures, applications and recent trends. Knowl- Based Syst https ://doi.org/10.1016/j.knosy s.2020.10559 6

Hinton, G. et al.: Deep neural networks for acoustic modeling in speech recognition. IEEE Signal Process.Mag., 29 (6) (2012), 82–97.

Deng, L.; Hinton, G.; Kingsbury, B.: New types of deep neural network learning for speech recognition and related applications: an overview, in Proc. ICASSP, 2013.

Sainath, T.;Mohamed, A.; Kingsbury, B.; Ramabhadran, B.: Convolutional neural networks for LVCSR, in Proc. ICASSP, 2013.

Yu, D.; Wang, S.; Karam, Z.; Deng, L.: Language recognition using deep-structured conditional random fields, in Proc. ICASSP, 2010, 5030–5033.

Yu, D.; Deng, L.: Deep-structured hidden conditional randomfields for phonetic recognition, in Proc. Interspeech, September. 2010.

Yu, D.; Deng, L.; Dahl, G.: Roles of pre-training and fine-tuning in context-dependent DBN-HMMs for real-world speech recognition, in Proc. NIPSWorkshop, 2010.

Yu, D.; Li, J.-Y.; Deng, L.: Calibration of confidence measures in speech recognition. IEEE Trans. Audio Speech Lang., 19 (2010), 2461–2473.

Maas, A.; Le, Q.; O'Neil, R.; Vinyals, O.; Nguyen, P.; Ng, Y.: Recurrent neural networks for noise reduction in robust ASR, in Proc. Interspeech, 2012.

Graves, A.; Fernandez, S.; Gomez, F.; Schmidhuber, J.: Connectionist temporal classification: labeling unsegmented sequence data with recurrent neural networks, in Proc. ICML, 2006

Graves, A.;Mahamed, A.; Hinton, G.: Speech recognition with deep recurrent neural networks, in Proc. ICASSP, 2013.

Bengio, Y.; Boulanger, N.; Pascanu, R.: Advances in optimizing recurrent networks, in Proc. ICASSP, 2013.

Ling, Z.; Richmond,K.; Yamagishi, J.:Articulatory control ofHMMbased parametric speech synthesis using feature-space-switched multiple regression. IEEE Trans. Audio Speech Lang. Process., 21 (2013), 207–219.

Ling, Z.; Deng, L.; Yu, D.: Modeling spectral envelopes using restricted Boltzmann machines and deep belief networks for statistical parametric speech synthesis. IEEE Trans. Audio Speech Lang. Process., 21 (10) (2013), 2129–2139.

Kang, S.;Qian, X.;Meng, H.:Multi-distribution deep belief network for speech synthesis, in Proc. ICASSP, 2013, 8012–8016.

Zen, H.; Senior, A.; Schuster, M.: Statistical parametric speech synthesis using deep neural networks, in Proc. ICASSP, 2013, 7962– 7966.

Fernandez, R.; Rendel, A.; Ramabhadran, B.; Hoory, R.: F0 contour prediction with a deep belief network-Gaussian process hybrid Model, in Proc. ICASSP, 2013, 6885–6889.

R. Vargas, A. Mosavi, L. Ruiz, DEEP LEARNING: A REVIEW, Advances in Intelligent Systems and Computing, (2017).

Ruihui Mu, Xiaoqin Zeng A Review of Deep Learning Research, KSII Transactions On Internet And Information Systems Vol. 13, no. 4, Apr. 2019

Wang Z., Liu D., Yang J., Han W., Huang T, "Deep Networks for Image Super-Resolution with Sparse Prior," in Proc. of the International Conference on Computer Vision, Santiago, Chile, pp.370-278, 2015. Article (CrossRef Link).

Ajay Shrestha And Ausif Mahmood, Review of Deep Learning Algorithms and Architectures, Vol 7 2019 IEEE Access

Xuedan Du, Yinghao Cai, Sho Wang, and Leijie Zhang, Overview of Deep Learning, 31st outh Academic Annual Conference of Chinese Association of Automation Whan, China, 2016

Md Zahangir Alom1, Tarek M. Taha, Chris Yakopcic, Stefan Westberg, Paheding Sidike, Mst Shamima Nasrin, Brian C Van Essen, Abdul A S. Awwal, and Vijayan K. Asari, The History Began from AlexNet: A Comprehensive Survey on Deep Learning Approaches, Computer Vision and Pattern Recognition, 2018

Laith Alzubaidi, Jinglan Zhang, Amjad J. Humaidi, Ayad Al-Dujaili, Ye Duan, Omran Al-Shamma, J. Santamaria, Mohammed A. Fadhel, Muthana Al-Amidie and Laith Farhan, Review of deep learning: concepts, CNN architectures, challenges, applications, future directions, Journal of Big Data, 2021

Saeed MM, Al Aghbari Z, Alsharidah M. Big data clustering techniques based on spark: a literature review. PeerJ Comput Sci. 2020;6:321.

Shorfuzzaman M, Hossain MS. Metacovid: a siamese neural network framework with contrastive loss for n-shot diagnosis of COVID-19 patients. Pattern Recogn. 2020;113:107700.

Szegedy C, Liu W, Jia Y, Sermanet P, Reed S, Anguelov D, Erhan D, Vanhoucke V, Rabinovich A. Going deeper with convolutions. In: Proceedings of the IEEE conference on computer vision and pattern recognition; 2015. p. 1–9.

D. M. S. Arsa, G. Jati, A. J. Mantau, and I. Wasito, ``Dimensionality reduction using deep belief network in big data case study: Hyperspectral image classi_cation," in Proc. Int.Workshop Big Data Inf. Secur. (IWBIS), Oct. 2016, pp. 71_76.

B. Su, X. Ding, H. Wang, and Y. Wu, ``Discriminative dimensionality reduction for multi-dimensional sequences," IEEE Trans. Pattern Anal. Mach. Intell., vol. 40, no. 1, pp. 77_91, Jan. 2018.

Y. P. Raykov, A. Boukouvalas, F. Baig, and M. A. Little, ``What to do when K-Means clustering fails: A simple yet principled alternative algorithm," PLoS ONE, vol. 11, no. 9, p. e0162259, 2016.

Shaveta Dargan, Munish Kumar, Maruthi Rohit Ayyagari, Gulshan Kumar, A Survey of Deep Learning and Its Applications: A New Paradigm to Machine Learning , CIMNE, Barcelona, Spain 2019

Yann LeCun, Yoshua Bengio, Geoffrey Hinton, Vol 521, Nature, 2015

Haohan Wang, Bhiksha Raj, On the Origin of Deep Learning, https://doi.org/10.48550/arXiv.1702.07800, 2017

Fengxiang He, Dacheng Tao, Recent advances in deep learning theory, arXiv:2012.10931v2 [cs.LG] 2021

Li Deng and Dong Yu, Deep Learning Methods and Applications, Foundations and Trends R_ in Signal Processing, Vol. 7, 2013

Machine Learning and It's Application: A Survey

Dr. Avinash H. Hedaoo
Dept of Computer Science
Prerna College of Commerce, Nagpur, (MS) – India

Abstract- *The possibility of this research paper is to create attentiveness among upcoming scholars about recent advances in technology, specifically machine learning which finds applications in big data analytics and artificial intelligence. Machine learning is the core issue of artificial intelligence research, this paper introduces the definition of machine learning and its basic structure, and describes a variety of machine learning methods, and also discuss application of machine learning. This paper also brings foreword the objectives of machine learning, and points out the development trend of machine learning.*

Keywords- machine learning, methods, application, Artificial Intelligence, Big Data

I. INTRODUCTION

Learning is the main hallmark of human intelligence and the basic means to obtain knowledge. Machine learning is the fundamental way to make the computer intelligent. R.Shank has said: "If a computer can not learn, it will not be called intelligent." Since learning is an integrative mental activity with memory, thinking, perception, feeling, and other mental activities closely related [1].

Nowadays ML is an established discipline in many ways. The methodology of application of ML considers selection of relevant data and its pre-processing, selection of adequate algorithms and solution quality assessment. Development of this vast domain includes search for optimal usage of accumulated potential of big and heterogeneous data, search for rapid learning methods and analysis of application features depending on the field of application [2].

In recent years many successful machine learning applications have been developed, ranging from data mining programs that learn to detect fraudulent credit card transactions, to information filtering systems that learn user's reading preferences, to autonomous vehicles that learn to drive on public highways [3].

As "Machine Learning" is very useful in analysis of data, in this paper, I have discussed in detail various types of machine learning algorithms that can be applied to enhance the intelligence and the capabilities of an application. Thus, the key contribution of this study is explaining the principles and potentiality of different machine learning techniques, and their applicability in various real world application areas.

The rest of the paper is organized as follows. The next section presents the types of data and machine learning algorithms in a broader sense. I briefly discuss and explain different machine learning algorithms in the subsequent section followed by which various real-world application areas based on machine learning algorithms are discussed and summarized and the final section concludes this paper.

II. TYPES DATA

Following, are the types of data:

A. Structured

Data that fits neatly within fixed fields and columns in relational databases and spreadsheets. Examples: names, dates, credit card numbers, and more.

B. Unstructured

The data which does not conforms to a data model and has no easily identifiable structure such that it can not be used by a computer program easily. Example: Web pages, Images (JPEG, PNG, etc.), Videos, Memos, Reports, can be considered as unstructured data.

C. Semi-structured

Semi-structured data is a form of structured data that does not obey the tabular structure of data models associated with relational databases or other forms of data tables, but nonetheless contains tags or other markers to separate semantic elements and enforce hierarchies of records and fields within the data. HTML, XML, JSON documents, NoSQL databases, etc., are some examples of semi-structured data.

D. Metadata

It is not the normal form of data, but "data about data". metadata describes the relevant data information, giving

it more significance for data users. A basic example of a document's metadata might be the author, file size, date generated by the document, keywords to define the document, etc[4][5].

III. TYPES OF MACHINE LEARNING TECHNIQUES

Machine Learning algorithms are mainly divided into four categories: Supervised learning, Unsupervised learning, Semi-supervised learning, and Reinforcement learning. Following are types of learning technique:

A. Supervised

Supervised learning (SL) is the machine learning task of learning a function that maps an input to an output based on example input-output pairs. It infers a function from labelled training data consisting of a set of training examples. In supervised learning, each example is a pair consisting of an input object (typically a vector) and a desired output value (also called the supervisory signal). A supervised learning algorithm analyzes the training data and produces an inferred function, which can be used for mapping new examples. An optimal scenario will allow for the algorithm to correctly determine the class labels for unseen instances [6].

B. Unsupervised

Unsupervised learning is a type of algorithm that learns patterns from untagged data. The hope is that through mimicry, which is an important mode of learning in people, the machine is forced to build a compact internal representation of its world and then generate imaginative content from it. In contrast to supervised learning, unsupervised methods exhibit self-organization that captures patterns as probability densities or a combination of neural feature preferences.

Two broad methods in unsupervised learning are neural networks and probabilistic methods [7].

C. Semi-supervised

Semi-supervised learning is an approach to machine learning that combines a small amount of labeled data with a large amount of unlabeled data during training. Semi-supervised learning falls between unsupervised learning and supervised learning. It is a special instance of weak supervision.

The cost associated with the labeling process may render large, fully labeled training sets infeasible, whereas acquisition of unlabeled data is relatively inexpensive. In such situations, semi-supervised learning can be of great practical value. Semi-supervised learning is also of theoretical interest in machine learning and as a model for human learning[8].

D. Reinforcement

Reinforcement learning (RL) is an area of machine learning concerned with how intelligent agents ought to take actions in an environment in order to maximize the notion of cumulative reward.

In Reinforcement learning focus is on finding a balance between exploration (of uncharted territory) and exploitation (of current knowledge). Partially supervised RL algorithms can combine the advantages of supervised and RL algorithms.

The environment is typically stated in the form of a Markov decision process (MDP), because many reinforcement learning algorithms for this context use dynamic programming techniques. The main difference between the classical dynamic programming methods and reinforcement learning algorithms is that the latter do not assume knowledge of an exact mathematical model of the MDP and they target large MDPs where exact methods become infeasible[9].

IV. MACHINE LEARNING TASKS AND ALGORITHMS

In this section, discussion is given over various machine learning algorithms, feature engineering for dimensionality reduction, as well as deep learning methods.

A. Classification Analysis

Classification is regarded as a supervised learning method in machine learning, referring to a problem of predictive modeling as well, where a class label is predicted for a given example[4]. For example, spam detection such as "spam" and "not spam" in email service providers . In the following, we summarize the common classification problems.

Binary classification: It refers to the classification tasks having two class labels such as "true and false" or "yes and no" [4].

Multiclass classification: Traditionally, this refers to those classification tasks having more than two class labels [4]. For example, in the NSL-KDD [10] dataset, the attack categories are classified into four class labels, such as DoS (Denial of Service Attack), U2R (User to Root Attack), R2L (Root to Local Attack), and Probing Attack.

Multi-label classification: In this an example is associated with several classes or labels. Thus, it is a generalization of multiclass classification, where the classes involved in the problem are hierarchically structured, and each example may simultaneously belong to more than one class in each hierarchical level, e.g., multi-level text classification. For instance, Google news can be presented under the categories of a "city name", "technology", or "latest news", etc. [11].

Many classification algorithms have been proposed in the machine learning and data science literature.[4][12]. In the following, we summarize the most common and popular methods that are used widely in various application areas.

1) Naive Bayes (NB)

Naïve Bayes is a subset of Bayesian decision theory. It's called naive because the formulation makes some naïve assumptions. Python's text-processing abilities which split up a document into a vector are used. This can be used to classify text. Classifies may put into human-readable form. It is a popular classification method in addition to conditional independence, overfitting, and Bayesian methods. Naive Bayes is among the simplest probabilistic classifiers. The Naive Bayes algorithm is used in multiple real-life scenarios such as Text classification, Spam filtration, etc., Advantages of this algorithm are relatively simple algorithm to understand and build, faster to predict classes using this algorithm and can be easily trained using a small dataset. On the other hand, disadvantages are Naïve Bayes is known as the "Zero Conditional Probability Problem." This problem wipes out all the information in other probabilities too. Another disadvantage is the very strong assumption of independence class features that it makes [13].

2) Linear Discriminant Analysis (LDA)

Linear discriminant analysis (LDA), Normal Discriminant Analysis (NDA), or discriminant function analysis is a generalization of Fisher's linear discriminant, a method used in statistics and other fields, to find a linear combination of features that characterizes or separates two or more classes of objects or events. The resulting combination may be used as a linear classifier, or, more commonly, for dimensionality reduction before later classification.

LDA is closely related to analysis of variance (ANOVA) and regression analysis.Discriminant analysis has continuous independent variables and a categorical dependent variable (i.e. the class label).LDA is also closely related to principal Component Analysis (PCA) and factor analysis. LDA works when the measurements made on independent variables for each observation are continuous quantities. Discriminant function analysis is classification - the act of distributing things into groups, classes or categories of the same type [14].

3) Logistic regression (LR):

Logistic Regression is a statistical approach and a Machine Learning algorithm that is used for classification problems and is based on the concept of probability. It is used when the dependent variable (target) is categorical.It is widely used when the classification problem at hand is binary; true or false, yes or no, etc. For example, it can be used to predict whether an email is spam (1) or not (0).Logistics regression uses the sigmoid function to return the probability of a label[15].

$$g(z) = \frac{1}{1 + exp(-z)}$$

4) K-nearest neighbors (KNN):

KNN is a non-parametric method used for classification. It is also one of the best-known classification algorithms. The principle is that known data are arranged in a space defined by the selected features. When a new data is supplied to the algorithm, the algorithm will compare the classes of the k closest data to determine the class of the new data. In Medjahed et al. (2013) a study of a KNN algorithms is performed to classify breast cancer. Analysis consists in the observation of the impact of parameters such as distance and classification rules on classification results. The major advantage of the KNN classification is its simplicity, it is also an efficient method. However, despite its efficiency, computation times can be long with large databases, the determination of the number of neighbors to use (k) requires trial and error and the algorithm is weak with outliers which can strongly impact its efficiency[16].

5) Support vector machine (SVM):

SVM's are a learning method used for binary classification. The basic idea is to find a hyperplane which separates the d-dimensional data perfectly into its two classes. SVM's are intuitive, theoretically well- founded, and have shown to be practically successful. SVM's have also been extended to solve regression tasks (where the system is trained to output a numerical value, rather than "yes/no" classification)[17].

6) Decision tree (DT):

Decision Tree Learning is supervised learning approach used in statistics, data mining and machine learning. In this formalism, a classification or regression decision tree is used as a predictive model to draw conclusions about a set of observations. Tree models where the target variable can take a discrete set of values are called classification trees; in these tree structures, leaves represent class labels and branches represent conjunctions of features that lead to those class labels. Decision trees where the target variable can take continuous values (typically real numbers) are called regression trees. Decision trees are among the most popular machine learning algorithms given their intelligibility and simplicity [18].

7)Random forest (RF)

Random forests or random decision forests is an ensemble learning method for classification, regression and other tasks that operates by constructing a multitude of decision trees at training time. Random forests generally outperform decision trees, but their accuracy is lower than gradient boosted trees. Random forests are frequently used as "black box" models in businesses, as they generate reasonable predictions across a wide range of data while requiring little configuration [19].

8) Adaptive Boosting (AdaBoost):

AdaBoost, short for Adaptive Boosting, isa statistical classification meta- algorithm . It can be used in conjunction with many other types of learning algorithms to improve performance. The output of the other learning algorithms ('weak learners') is combined into a weighted sum that represents the final output of the boosted classifier. Usually, AdaBoost is presented for binary classification, although it can be generalized to multiple classes or bounded intervals on the real line.AdaBoost is adaptive in the sense that subsequent weak learners are tweaked in favor of those instances misclassified by previous classifiers. In some problems it can be less susceptible to the overfitting problem than other learning algorithms. AdaBoost is often referred to as the best out-of-the-box classifier[20].

9)Extreme gradient boosting (XGBoost):

Extreme Gradient Boosting(XGBoost) is a form of gradient boosting that takes more detailed approximations into account when determining the best model [21]. It computes second-order gradients of the loss function to minimize loss and advanced regularization (L1 and L2) [21], which reduces over-fitting, and improves model generalization and performance. XGBoost is fast to interpret and can handle large-sized datasets well.

10) Stochastic gradient descent (SGD):

Stochastic gradient descent is an iterative method for optimizing an objective function with suitable smoothness properties. It can be regarded as a stochastic approximation of gradient descent optimization, since it replaces the actual gradient (calculated from the entire data set) by an estimate thereof (calculated from a randomly selected subset of the data). Especially in high-dimensional optimization problems this reduces the very high computational burden, achieving faster iterations in trade for a lower convergence rate[22].

11) Rule-based classification:

The term rule-based classification can be used to refer to any classification scheme that makes use of IF-THEN rules for class prediction. The decision tree is one of the most common rule-based classification Algorithms. It has several advantages, such as being easier to interpret; the ability to handle high-dimensional data; simplicity and speed; good accuracy; and the capability to produce rules for human clear and understandable classification. Since the rules are easily interpretable, these rule based classifiers are often used to produce descriptive models that can describe a system including the entitiesand their relationships [23][24].

B. Regression Analysis

In statistical modeling, regression analysis is a set of statistical processes for estimating the relationships between a dependent variable (often called the 'outcome' or 'response' variable, or a 'label' in machine learning parlance) and one or more independent variables (often called 'predictors', 'covariates', 'explanatory variables' or 'features'). Regression analysis is primarily used for two conceptually distinct purposes.

First, regression analysis is widely used for prediction and forecasting, where its use has substantial overlap with the field of machine learning.

Second, in some situations regression analysis can be used to infer causal relationships between the independent and dependent variables. Some of the familiar types of regression algorithms are explained briefly in the following[25].

1) Simple and multiple linear regression:

This is one of the most popular ML modeling techniques as well as a well-known regression technique. In this technique, the dependent variable is continuous, the independent variable(s) can be continuous or discrete, and the form of the regression line is linear. Linear regression creates a relationship between the dependent variable (Y) and one or more independent variables (X) (also known as regression line) using the best fit straight line [4].

2) Polynomial regression:

Polynomial regression is a form of regression analysis in which the relationship between the independent variable x and the dependent variable y is modelled as an nth degree polynomial in x[26].

3) LASSO and ridge regression:

Lasso (least absolute shrinkage and selection operator; also Lasso or LASSO) is a regression analysis method that performs both variable selection and regularization in order to enhance the prediction accuracy and interpretability of the resulting statistical model. Lasso's ability to perform subset selection relies on the form of the constraint and has a variety of interpretations including in terms of geometry, Bayesian statistics and convex analysis[27]. Ridge regression is a method of estimating the coefficients of multiple-regression models in scenarios where the independent variables are highly correlated. It has been used in many fields including econometrics, chemistry, and engineering. Ridge regression was developed as a possible solution to the imprecision of least square estimators when linear regression models have some multicollinear (highly correlated) independent variables—by creating a ridge regression estimator (RR). This provides a more precise ridge parameters estimate, as its variance and mean square estimator are often smaller than the least square estimators previously derived[28].

C. Cluster Analysis

Cluster analysis or clustering is the task of grouping a set of objects in such a way that objects in the same group (called a cluster) are more similar (in some sense) to each other than to those in other groups (clusters). It is used in many fields, including pattern recognition, image analysis, information retrieval, bioinformatics, data compression, computer graphics and machine learning. Cluster analysis as such is not an automatic task, but an iterative process of knowledge discovery or interactive multi-objective optimization that involves trial and failure. It is often necessary to modify data preprocessing and model parameters until the result achieves the desired properties [29].

In the following, we summarize the popular methods that are used widely in various application areas.

1) K-means clustering:

K-means [30] is one of the simplest unsupervised learning algorithms that solve the well known clustering problem. The procedure follows a simple and easy way to classify a given data set through a certain number of clusters. The main idea is to define k centers, one for each cluster. These centers should be placed in a cunning way because of different location causes different result. So, the better choice is to place them is much as possible far away from each other. K-medoids clustering [31] is a variant of K-means that is more robust to noises and outliers.

2) Mean-shift clustering:

Mean-shift clustering [32] is a nonparametric clustering technique that does not require prior knowledge of the number of clusters or constraints on cluster shape. Mean-shift clustering aims to discover “blobs” in a smooth distribution or density of samples [21]. It is a centroid-based algorithm that works by updating centroid candidates to be the mean of the points in a given region. To form the final set of centroids, these candidates are filtered in a post-processing stage to remove near-duplicates. Cluster analysis in computer vision and image processing are examples of application domains. Mean Shift has the disadvantage of being computationally expensive.

3) DBSCAN:

DBSCAN or Density-Based Spatial Clustering of Applications with Noise is a powerful algorithm that can easily solve non-convex problems where k-means fails. The idea is simple. The procedure starts by analyzing a small area (formally, a point surrounded by a minimum number of other samples). If the density is enough, it is considered part of a cluster. At this point, the neighbors are taken into account. If they also have a high density, they are merged with the first area; otherwise, they determine a topological separation. When all the areas have been scanned, the clusters have also been determined because they are islands surrounded by empty space.

4) GMM clustering:

The GMM(Gaussian Mixture Model) assumes that the underlying distribution in the dataset can be described as the mixture of a finite number of Gaussian (normal) distributions. The GMM fits Gaussian distribution to generate groups of observations from the data. The main limitation of GMM is that it can be successfully applied only when the underlying distribution is a combination of Gaussian distributions. There are other mixture models that assume other types of statistical distributions, but they will all have limitations when dealing with datasets including groups with diverse shapes. Fortunately, in many scientific applications, the distribution is actually a mixture of Gaussians, thus the GMM algorithm can be successfully applied [33].

5) Agglomerative hierarchical clustering:

The most common method of hierarchical clustering used to group objects in clusters based on their similarity is agglomerative clustering. This technique uses a bottom-up approach, where each object is first treated as a singleton cluster by the algorithm. Following that, pairs of clusters are merged one by one until all clusters have been merged into a single large cluster containing all objects. The result is a dendrogram, which is a tree-based representation of the elements. Single linkage [34], Complete linkage [35], BOTS [36] etc. are some examples of such techniques. The main advantage of agglomerative hierarchical clustering over k-means is that the tree-structure hierarchy generated by agglomerative clustering is more informative than the unstructured collection of flat clusters returned by k-means, which can help to make better decisions in the relevant application areas.

D. Dimensionality Reduction and Feature Learning

Most machine learning and data mining techniques may not work effectively if the dimensionality of the data is high. Feature selection or feature reduction is usually carried out to reduce the dimensionality of the feature vectors. A short feature set can also improve computational efficiency involved in classification and avoids the problem of overfitting.

Feature reduction aims to map the original high-dimensional data onto a lower-dimensional space, in which all of the original features are used. [37] The primary distinction between the selection and extraction of features is that the "feature selection" keeps a subset of the original features , while "feature extraction" creates brand new ones . In the following, these techniques are discussed briefly :

1) Feature Selection:

Feature selection, as a dimensionality reduction technique, aims to choosing a small subset of the relevant features from the original features by removing irrelevant, redundant or noisy features. Feature selection usually can lead to better learning performance, i.e., higher learning accuracy, lower computational cost, and better model interpretability.

Feature selection technique can be roughly classified into three families: supervised methods, semi-supervised methods, and unsupervised methods. The availability of label information allows supervised feature selection algorithms to effectively select discriminative and relevant features to distinguish samples from different classes. When a small portion of data is labeled, we can utilize semi-supervised feature selection which can take advantage of both labeled data and unlabeled data. Due to the absence of labels that are used for guiding the search for discriminative features, unsupervised feature selection is considered as a much harder problem .

Based on the different strategies of searching, feature selection can also be classified into three methods, i.e., filter methods, wrapper methods and embedded methods. Filter methods select the most discriminative features through the character of data. Generally, filter methods perform feature selection before classification and clustering tasks and usually fall into a two-step strategy. First, all features are ranked according to certain criteria. Then, the features with the highest rankings are selected. Wrapper methods use the intended learning algorithm itself to evaluate the features. Embedded models perform feature selection in the process of model construction[38].

2) Feature extraction:

Feature extraction is the process to retrieve the most important data from the raw data. The major goal of feature extraction is to extract a set of features, which maximizes the recognition rate with the least amount of elements and to generate similar feature set for variety of instance of the same symbol. The widely used feature extraction methods are Template matching, Deformable templates, Unitary Image transforms, etc[39].

3) Association Rule Learning :

Association rules are if/then statements that help to uncover relationships between unrelated data in a database, relational database or other information repository. Association rules are used to find the relationships between the objects which are frequently used together. Applications of association rules are basket data analysis, classification, cross-

marketing, clustering, catalogue design, and loss-leader analysis etc. For example, if the customer buys bread then he may also buy butter. If the customer buys laptop then he may also buy memory card. There are two basic criteria that association rules uses, support and confidence. It identifies the relationships and rules generated by analyzing data for frequently used if/then patterns. Association rules are usually needed to satisfy a user-specified minimum support and a user -specified minimum confidence at the same time[40]. The most popular association rule learning algorithms areAIS and SETM, Apriori, [41].

V. APPLICATIONS OF MACHINE LEARNING

In the following, we summarize and discuss popular application areas of machine learning technology.

A. Predictive analytics and intelligent decision-making:

A major application field of machine learning is intelligent decision-making by data-driven predictive analytics [42][43]. The basis of predictive analytics is capturing and exploiting relationships between explanatory variables and predicted variables from previous events to predict the unknown outcome [4]. For instance, identifying suspects or criminals after a crime has been committed, or detecting credit card fraud as it happens. Another application, where machine learning algorithms can assist retailers in better understanding consumer preferences and behavior, better manage inventory, avoiding out-of-stock situations, and optimizing logistics and warehousing in e-commerce. Since accurate predictions provide insight into the unknown, they can improve the decisions of industries, businesses, and almost any organization.

B. Cybersecurity:

Cybersecurity is one of the most essential areas of Industry 4.0. [41], which is typically the practice of protecting networks, systems, hardware, and data from digital attacks [41].In (Bernabeu, Thorp, & Centeno, 2012), the authors used a machine learning technique to detect the stressed condition of the power system. They used decision tree based approach to define a discrimination function to classify the system state to either as stressed or safe. Morita et al. (2013) have proposed an automatic detection system based on machine learning techniques in case of STUXNET. ML can be used in intrusion detection in SCADA systems. Zhang and Zhu (2018) have proposed a machine-learning-based collaborative IDS (CIDS) architecture. It basically trains a classifier to detect intrusions in VANET. The popular machine learning techniques among the researchers for the detection of second generation malware are Naive Bayes[44].

C. Internet of things (IoT) and Smart Cities:

Internet of Things (IoT) is becoming a new pervasive and ubiquitous network paradigm offering distributed and transparent services. Through IoT, lots of smart devices are connected, such as sensors, mobile phones and other smart devices. These smart devices can communicate with each other and exchange information. According to the IDC statistical report, there are over 50 billion IoT devices in the world; they will produce over 60ZB data by 2020.Major applications of machine learning for IoT and the relevant techniques, including traffic profiling, IoT device identification, security, edge computing infrastructure, network management based on SDN, and typical IoT applications[45].

With the progress of urbanization and the popularity of automobiles, transportation problems are becoming more and more challenging: traffic flow is congested, accidents are frequent, and the traffic environment is deteriorating. Thus, an intelligent transportation system through predicting future traffic is important, which is an indispensable part of a smart city. Accurate traffic prediction based on machine and deep learning modeling can help to minimize the issues [41]. In [46] paper solutions to traffic problems are discussed using ML based models such as regression models, example based models and kernel-based models. They also discussed Neural Network based models such as Feed-Forward NN (FFNN) model, Recurrent NN (RNN) model, and Convolutional NN (CNN) model to cope up with transportation problems.

D. Healthcare:

In medical applications, machine learning algorithms will manufacture higher decisions regarding treatment plans for patients by suggestions of implementing useful health-care system[47]. In [48] applications of ML in Prognosis, Diagnosis, Medical Image Analysis, Treatment, Clinical Workflows have been discussed.

E. E-commerce:

Machine learning used in Automatic recommender systems specialized to recommend products in commerce applications[49]. ML is useful for fraud detection in transactions between buyers and sellers. E-commerce websites uses ML to recommend items based on previous items purchased or searched. Financial services like banks and other business used ML to increase profit, investment and to prevent

fraud. ML algorithms can easily detect frauds and can flag them to the security team [50].

F. NLP :

Natural language processing (NLP) involves the reading and understanding of spoken or written language through the medium of a computer [51][52]. Thus, NLP helps computers, for instance, to read a text, hear speech, interpret it, analyze sentiment, and decide which aspects are significant, where machine learning techniques can be used. Virtual personal assistant, chatbot, speech recognition, document description, language or machine translation, etc. are some examples of NLP-related tasks.

G. Image, speech and pattern recognition:

Image recognition has become an indispensable technology in people's life, from the input of handwritten text to the application of military, it can be said to be ubiquitous. This technique can be implemented by machine learning methods[53]. Speech recognition is a technology that uses machines to recognize and understand speech signals and convert them into corresponding text and commands. The development of deep learning and the continuous progress of artificial intelligence have contributed to the rapid development of speech recognition [54]. Pattern recognition is defined as the automated recognition of patterns and regularities in data, e.g., image analysis. Several machine learning techniques such as classification, feature selection, clustering, or sequence labelling methods are used in the area[41].

H. Agriculture:

Agriculture plays a vital role in the economic growth of any country. With the increase of population, frequent changes in climatic conditions and limited resources, it becomes a challenging task to fulfil the food requirement of the present population. Precision agriculture also known as smart farming have emerged as an innovative tool to address current challenges in agricultural sustainability. The mechanism that drives this cutting edge technology is machine learning. ML with computer vision are reviewed for the classification of a different set of crop images in order to monitor the crop quality and yield assessment. This approach can be integrated for enhanced livestock production by predicting fertility patterns, diagnosing eating disorders, cattle behaviour based on ML models using data collected by collar sensors[55].

In addition to these application areas, machine learning based models can also apply to several other domains such as User behavior analytics and context-aware smartphone applications, bioinformatics, cheminformatics, computer networks, DNA sequence classification, economics and banking, robotics, advanced engineering, and many more[41].

VI. CONCLUSION

In this paper, the researcher has conducted a comprehensive overview of machine learning algorithms and its applications. In this paper, brief discussion is given about making solutions to various real-world issues using various types of machine learning methods. Data and the performance of the learning algorithms play crucial role in success of machine learning model. For intelligent decision-making sophisticated learning algorithms need to be selected, we have to train the algorithms through the collected real-world data and knowledge related to the target application. Brief discussion given over areas where machine learning techniques is being used successfully. Overall, I believe that my study on machine learning-based solutions opens up a promising direction and can be used as a reference guide for potential research and applications for both academia and industry professionals as well as for decision-makers, from a technical point of view.

REFERENCES

[1] Pramila P. Shinde, Dr.Seema Shah,A Brief Review of Machine Learning and itsApplication, Fourth International Conference on Computing Communication Control and Automation, 2018.
[2] Ravil I Muhamedyev , Machine learning methods: An overview, Computer Modelling & New Technologies 2015 19(6) 14-29.
[3] Yagang Zhang, Application of Machine Learning, *ntechweb.org*, February 2010.
[4] Han J, Pei J, Kamber M. Data mining: concepts and techniques.Amsterdam: Elsevier; 2011.
[5] McCallum A. Information extraction: distilling structured datafrom unstructured text. Queue. 2005;3(9):48–57.
[6] Supervised learning, June 2022, https://en.wikipedia.org/w/index.php?title=Supervised_learning&oldid=1093417731.
[7] Unsupervised learning, August 2022, https://en.wikipedia.org/w/index.php?title=Unsupervised_learning&oldid=1095476437.
[8] Semi-supervised learning, July 2022, https://en.wikipedia.org/w/index.php?title=Semi-supervised_learning&oldid=1097439843.

[9] Reinforcement learning, July 2022, https: //en.wikipedia.org/ w/index.php? title=Reinforcement_learning & oldid=1098616481 .
[10] Tavallaee M, Bagheri E, Lu W, Ghorbani AA. A detailed analysisof the kdd cup 99 data set. In.IEEE symposium on computationalintelligence forsecurity and defense applications. IEEE.2009;2009:1–6.
[11] Pedregosa F, Varoquaux G, Gramfort A, Michel V, Thirion B, Grisel O, Blondel M, Prettenhofer P, Weiss R, Dubourg V, et al. Scikit-learn: machine learning in python. J Mach Learn Res. 2011;12:2825–30.
[12] Witten IH, Frank E. Data Mining: Practicalmachine learningtools and techniques. Morgan Kaufmann; 2005
[13] PouriaKaviani , Mrs.SunitaDhotre, Short Survey on Naive Bayes Algorithm, International Journal of Advance Engineering and Research Development, Volume 4, Issue 11, November -2017.
[14] Linear discriminant analysis, Wikipedia, 29 June 2022 20, https://en.wikipedia.org/ w/index. php ?title=Linear_ discriminant _analysis &oldid=1095695170
[15] Nisha Arya, April 4, 2022, https:// www .kdnuggets.com/2022/04/logistic-regression-classification.html
[16] Damien Chanal, ... Marie-Cécile Péra, in Encyclopedia of Energy Storage, 2022.
[17] Dustin Boswell, Introduction to Support Vector Machines, August 6, 2002, pzs.dstu.dp.ua.
[18] Decision tree learning, Wikipedia, 14 July 2022, https://en.wikipedia.org/w/index.php?title=Decision_tree _learning&oldid=1098190172.
[19] Random forest, Wikipedia, 20 June 2022, https://en.wikipedia.org/w/index.php?title=Random_forest&oldid=1094130824.
[20] AdaBoost, Wikipedia, 24 June 2022 22, https://en.wikipedia.org/w/ index.php?title=AdaBoost&oldid=1094851623.
[21] Pedregosa F, Varoquaux G, Gramfort A, Michel V, Thirion B,Grisel O, Blondel M, Prettenhofer P,Weiss R, Dubourg V, et al.Scikit-learn: machinelearning in python. J Mach Learn Res.2011;12:2825–30.
[22] Stochastic gradient descent, July 2022, https://en.wikipedia.org/w/index.php?title=Stochastic_gradient_descent&oldid=1098148439.
[23] Wu C-C, Yen-Liang C, Yi-Hung L, Xiang-Yu Y. Decision treeinduction with a constrained number of leaf nodes. ApplIntell. 2016;45(3):673–85.
[24] Wu X, Kumar V, Quinlan JR, Ghosh J, \Yang Q, MotodaH,McLachlan GJ, Ng A, Liu B, Philip SY, et al. Top 10 algorithmsin data mining. Knowl Inform Syst. 2008;14(1):1–37.
[25] Regression analysis, Wikipedia, June 2022,https://en.wikipedia.org/w/index.php? Title =Regression_analysis&oldid=1093166956.
[26] Polynomial regression, Wikipedia, June 2022, https://en.wikipedia.org/ w / index.php? title = Polynomial _regression &oldid = 1092796478.
[27] Lasso (statistics), Wikipedia, July 2022, https://en.wikipedia.org/w/index.php?title=Lasso_(statistics)&oldid=1096838799.
[28] Ridge regression, Wikipedia, July 2022, https://en.wikipedia.org/w/index.php?title=Ridge_regression&oldid=1098357532
[29] Cluster analysis, Wikipedia , July 2022, https://en.wikipedia.org/w/index.php?title=Cluster_analysis&oldid=1099295050.
[30] BattaMahesh , Machine Learning Algorithms -A Review January 2019, DOI: 10.21275/ART20203995.
[31] Rokach L. A survey of clustering algorithms. In: Data miningand knowledge discovery handbook, pages 269–298. Springer, 2010.
[32] Fukunaga K,Hostetler L. The estimation of the gradient of adensity function, with applications in patternrecognition. IEEETrans Inform Theory.1975;21(1):32–40.
[33] Rafael Garcia-Dias, Machine Learning ,Clustering analysis pg 227, https://doi.org/10.1016/B978-0-12-815739-8.00013-4 ,2020 Elsevier Inc.
[34] Sneath Peter HA. The application of computers to taxonomy. JGen Microbiol. 1957;17(1).
[35] Sorensen T. Method of establishing groups of equal amplitude inplant sociology based onsimilarity of species. Biol Skr. 1948; 5.
[36] Sarker IH, Colman A, Kabir MA, Han J.Individualized timeseriessegmentation for miningmobile phone user behavior.Comput J OxfUniv UK. 2018;61(3):349–68.
[37] Yagang Zhang,Application of Machine Learning, 2010, ntechweb.org.
[38] JianyuMiaoa, LingfengNiub, A Survey on Feature Selection, www.sciencedirect.com.
[39] Gaurav Kumar, Pradeep Kumar Bhatia, A Detailed Review of Feature Extraction in Image Processing Systems, 2014 Fourth International Conference on Advanced Computing & Communication Technologies.
[40] Trupti A. Kumbhare et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (1) , 2014, 927-930.
[41] Iqbal H. Sarker, Machine Learning: Algorithms, Real-World Applications and ResearchDirections, SN Computer Science (2021) 2:160.
[42] Cao L. Data science: a comprehensive overview. ACM ComputSurv (CSUR). 2017;50(3):43.
[43] Mahdavinejad MS, Rezvan M, Barekatain M,Adibi P, BarnaghiP, Sheth AP. Machine learningfor internet of

things data analysis:a survey. Digit CommunNetw. 2018;4(3):161–75.

[44] AnandHanda ,Ashu Sharma , Sandeep K. Shukla, Machine learning in cybersecurity: A review, WIREs Data Mining KnowlDiscov. 2019;e1306.

[45] Laizhong Cui et l, A survey on application of machine learning for Internet of Things, International Journal of Machine Learning and Cybernetics, https://doi.org/10.1007/s13042-018-0834-5.

[46] AzzedineBoukerche, Jiahao Wang, Machine Learning-based traffic prediction models for IntelligentTransportation Systems, 3 September 2020, https://doi.org/10.1016/ j.comnet.2020. 107530.

[47] Mrs.J. Sukanya, "Applications of Big Data Analytics and Machine Learning Techniques in Health Care Sectors", International Journal of Engineering and Computer Science, vol.6, pp.21963-21967, 2017.

[48] Adnan Qayyum ,JunaidQadir , Muhammad Bilal , and Ala Al-Fuqaha, Secure and Robust Machine Learning for Healthcare: A Survey, IEEE Reviews in Biomedical Engineering (Volume: 14), Page(s): 156 – 180, July 2020.

[49] j. Ben Schafer, Joseph A. Konstan, John Riedl, E-Commerce Recommendation Applications, Data Mining and Knowledge Discovery.

[50] Surender Reddy Salkuti ,A survey of big data and machine learning, International Journal of Electrical and Computer Engineering (IJECE), Vol. 10, No. 1, February 2020, pp. 575~580.

[51] Otter DW, Medina JR ,Kalita JK. A survey of the usages ofdeep learning for natural languageprocessing. IEEE Trans NeuralNetw Learn Syst. 2020.

[52] Sarker IH, Hoque MM, MdK Uddin, Tawfeeq A. Mobile datascience and intelligent apps: concepts, ai-based modeling andresearch directions. Mob NetwAppl, pages 1–19, 2020.

[53] Yunfei Lai ,A Comparison of Traditional Machine Learning and Deep Learning in Image Recognition, 2019, IOP Conf. Series J. Phys.: Conf. Ser. 1314 012148.

[54] Feng Li , Yiyang Wei A Study of Speech Recognition with Deep Learning, International Journal Of Multidisciplinary Research And Analysis, Volume 05 Issue 05 May 2022.

[55] Abhinav Sharma, ArpitJain ,Prateek Gupta, and VinayChowdary, Machine Learning Applications for Precision Agriculture: A Comprehensive Review,Page 4843 – 4873, December 2020, IEEE Access Volume: 9.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

Applications of Deep Learning Techniques in Agriculture : A Review

Avinash H. Hedaoo
Assistant Professor, Department of Computer Science
Prerna College of Commerce, Nagpur, Maharashtra, India

Abstract: *Agriculture is one of the major industries in the world. With promising results and enormous capability, deep learning technology has attracted more and more attention to both theoretical research and applications for a variety of image processing and computer vision tasks. In this paper, the author investigate research contributions that apply deep learning techniques and ML to the agriculture domain. Different types of deep neural network architectures and ML techniques in agriculture are surveyed and the current state-of-the-art methods are summarized. The main objective of this paper is to find the various applications of Deep learning in agriculture such as for irrigation, weeding, Pattern recognition, crop disease identification etc. The paper reviews the specific employed deep learning models, the source of the data, the performance of each study, the employed hardware and the possibility of real-time application to study eventual integration with autonomous robotic platforms. The survey shows that deep learning-based research has superior performance in terms of accuracy, which is beyond the standard machine learning techniques nowadays.*

Keywords: Deep learning, agricultural robots, crop management, artificial intelligence, precision livestock farming

I. INTRODUCTION

With the increase in the global population, there has also been a huge increase in the demand of food and agricultural products. To meet this increasing demand, an equivalent increase in the agricultural production is required, without comprising the quality of food products and also without affecting the natural environment. An important research area in this domain is Image acquisition and analysis. Using images of agricultural fields and parts of plants, important aspects of the field and plants can be explored. With the automatic image analysis of the field, the quality of soil can be examined and effective measures can be taken to make the soil fertilize and suitable for crops production[2]. Similarly, the diseases in plants can be detected and essential steps can be taken well in time to improve the quality of crops and reduce the health risks to humans from the diseased crops. Agricultural crops are prone to pests, which have threats of health problems to people [1] .

Emerging ICT technologies relevant to the understanding of agricultural ecosystems include remote sensing , the Internet of Things, cloud computing, and the analysis of big data. Remote sensing provides large-scale snapshots of the agricultural environment by means of satellites, planes and unmanned aerial vehicles (UAVs, i.e. drones).When applied to agriculture it has several advantages, being a well-known, non-destructive method of gathering information on earth features. Remote sensing data can be collected on very large geographic areas, including inaccessible areas. The IoT uses state-of - the-art sensor technology to measure various parameters in the field, while cloud computing is used to collect, store, pre-process and model huge amounts of data from different, heterogeneous sources. Eventually, big data processing is used in conjunction with cloud computing to analyze the data stored in the cloud on a large scale in real time. A large sub-set of the data collected by remote sensing, and the IoT contains images. Images can provide a complete picture of agricultural fields and a number of problems could be solved through image analysis. Therefore, image analysis is an important area of research in the agricultural domain and intelligent inspection techniques are used to identify / classify pictures, recognize abnormalities, etc., in different agricultural applications [13].

Machine learning combined with high-performance computing guarantees the ability to process large amounts of image data effectively. Early solutions to computer vision tasks depended on traditional machine learning methods, i.e., feature-based manual method. Common features include Deformable Part-Based Model (DPM),Histogram of Oriented

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

Gradient (HOG)] and Scales-Invariant Feature Transformation (SIFT) ,Speeded Up Robust Features (SURF) and Haar-like features . They were usually combined with classifiers such as Support Vector Machine (SVM) to classify each image pixel. Although the traditional methods are easy to understand and many improvements have been done to them, most of the mare verified in low and medium density images and they usually need to be changed according to the specific situations . Moreover, most traditional methods either ignore the problems in dense scenes, namely, there is no discussion on dense scenes, or use simple heuristic methods based on shape and size, these methods are very in effective in natural environments with severe occlusion and large scale changes. Therefore, traditional machine learning methods are not appropriate for dense images. It has been demonstrated that in many applications, features extracted by deep learning are more effective than these hand-crafted feature. Moreover, deep learning solves various challenges in dense images. Deep Learning (DL) belongs to machine learning, based on representation learning of data, which realizes artificial intelligence by means of artificial neural networks with many hidden layers and massive training data. DL has been successful in computer vision , natural language processing, bioinformatics , automatic control , machine translation , automatic driving and other practical problems . The reason for the success of DL lies in its unique characteristics of network structure: deep neural network can acquire high-level features by learning local features from the bottom and then synthesizing these features at the top. DL uses multi-level abstraction to learn complex feature representations from raw data and generate components automatically. Different features at different levels can correspond to different tasks. Deep learning is a technology that uses deep network structure to learn features. Deep learning emphasizes the depth of the model structure, highlights the importance of feature learning and proposes various techniques to learn more and higher-level features better and faster. Strong learning ability enables them to implement various kinds of problems especially well and flexibly adapt to numerous highly complex problems. Monitoring and studying a large number of interesting objects in videos or images is an important task for the macro-world and micro-field, for instance, the research on crowding traffic and microscopic microorganisms. Usually, advances in one area are driven more by some combination of expertise, resources, and application requirements in other areas . Similarly, applications of DL in analyzing dense scenes spread to the agricultural sector after advances in medical diagnostics and population analysis. More and more scenes in agriculture produce a lot of high-density images, and they are becoming more and more attention. At present, agricultural tasks have been transformed into tasks of agro vision (computer vision in agriculture). There have been some reviews on the applications of DL in agriculture and some reviews pertinent to the use of DL in computer vision. They either gave a comprehensive overview of DL methods applied throughout the agricultural field or the latest research of DL technology in a certain agricultural field and also reviewed the application of DL methods in general computer vision tasks. However, none of them involved how DL works in dense agricultural scenes. The use of DL in fruit detection and yield estimation is summarized, including the problem of occluded fruit in imaging and the solutions. However, they were only concerned with the detectionand yield estimates while ignoring other agricultural tasks containing a large number of objects. Thus, the motivation for preparing this review stems from the need to summarize the applications of DL in agriculture with the increase of dense scenes and images[14].This paper investigates the applications and techniques of DL in agriculture. This paper aims to provide a reference to the DL methods for agricultural researchers. This paper can be helpful for researchers to retrieve the literatures related to the research problems quickly and accurately. This study is divided into five sections. Section 1 introduces the concept of deep learning in agriculture, Section 2 explains the methodology used in the present study of this article, Section 3 presents review of existing literature, Section 4 discusses Applications of Deep Learning in Agriculture in detail and Section 5 presents the conclusions of the work.

II. METHODOLOGY

In this study, the first step was citation databases analyse, it involved two steps:

- Collection of related works and,
- Detailed review and analysis of the works.

A survey is performed on various research papers on Applications of deep learning in agriculture. For this review paper, multiple sources have been used. Scopus has been used for searching various papers on the topic with the Boolean “Deep Learning and Agriculture. From Mendeley, the abstracts of the papers were studied and those which were found useful for this review, their full papers were downloaded from Scopus, Google Scholar, and Research Gate. The

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

research paper from 2010-2021 selected for study. In the first step, a keyword-based search using all combinations of two groups of keywords of which the first group addresses deep learning and the second group refers to application of deep learning in farming.

III. LITERATURE REVIEW

In [16] proposed a Agri-IoT framework, a semantic framework for IoT based smart farming applications, which supports reasoning over various heterogeneous sensor data streams in real-time. Agri IoT can integrate multiple cross-domain data streams, providing a complete semantic processing pipeline, offering a common framework for smart farming applications. Agri-IoT supports large-scale data analytics and event detection, ensuring seamless interoperability among sensors, services, processes, operations, farmers and other relevant actors, including online information sources and linked open datasets and streams available on the Web.[17] did comprehensive review of research dedicated to applications of deep 9 learning for precision agriculture is presented along with real time applications, 10 tools and available datasets. The findings exhibit the high potential of applying deep 11 learning techniques for precision agriculture. In this paper the role of Smart farming for sustainable agriculture is discussed,a novel approach to fruit production prediction using deep neural networks to build a fast and reliable prediction system for agricultural production is presented. In this article, authors have considered different types of fruit production data (apples, bananas, citrus, pears, grapes, and total fruits), analysed this data, and predicted the future production of these fruits using deep neural networks. The data are taken from the National Bureau of Statistics of Pakistan and the production output of major fruits. Authors have implemented 3 different methods to predict the data for future fruit production. The first method is Levenberg-Marquardt optimization (LM), which was 65.6% accurate; the second method is called scale conjugate gradient back propagation (SCG), which had an accuracy of 70.2%, and the third method, is Bayesian regularization back propagation (BR), which was 76.3% accurate. Incorporates the performance analysis of clustering algorithms when applied to FAO Soya bean dataset. The algorithms are compared on the basis of various parameters, such as time taken for completion, number of iterations, and number of clusters formed and the complexity of the algorithms. Finally, based on the analysis, the paper determines the best befitting algorithm for the FAO Soya bean dataset. Comprehensive review of research dedicated to applications of machine learning in agricultural production systems is performed. The works analyzed were categorized in (a) crop management ; (b) livestock management; (c) water management; and (d) soil management. The survey shows that deep learning-based research has superior performance in terms of accuracy, which is beyond the standard machine learning techniques nowadays.

In [18] examine the ability of deep learning methods for remote sensing image classification for agriculture applications. FCN8s model achieved 75.1% accuracy on detecting weeds compared to 66.72% of U-net using 60 training images. However, the U-net model performed better on detecting crops which is 60.48% compared to 47.86% of FCN-8s.[19] presented a comprehensive analysis of important metrics in practical applications: accuracy, memory footprint, parameters, operations count, inference time and power consumption. Key findings are: (1) power consumption is independent of batch size and architecture; (2) accuracy and inference time are in a hyperbolic relationship; (3) energy constraint is an upper bound on the maximum achievable accuracy and model complexity; (4) the number of operations is a reliable estimate of the inference time. [20] proposed a deep learning-based approach that automates the process of classifying banana leaves diseases. Deep learning based classification framework for remotely sensed time series is developed. For the challenging task of classifying summer crops using Lands at Enhanced Vegetation Index (EVI) time series, two types of deep learning models were designed: one is based on Long Short-Term Memory (LSTM), and the other is based on one-dimensional convolutional (Conv1D) layers. The highest accuracy (85.54%) and F1 score (0.73) were achieved by the Conv1D-based model. The banana harvest data is used from agrarian reform beneficiary (ARB) cooperative in Davao del Norte, Philippines. In this study RNN-LSTM outperforms the ARIMA model with 32.31 percent reduction in error rates.

A simulated deep convolutional neural network for yield estimation is presented. Knowing the exact number of fruits, flowers, and trees helps farmers to make better decisions on cultivation practices, plant disease prevention, and the size of harvest labor force. To count the number of fruits on a coffee branch by using information from digital images of a single side of the branch and its growing fruits is proposed. The use of a state-of-the-art object detection framework,

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

Faster R-CNN, in the context of fruit detection in orchards, including mangoes, almonds and apples is presented. A Convolutional Neural Network (CNN) architecture to classify the type of plants from the image sequences collected from smart agro-stations is proposed. A model is to deliver direct advisory services to even the smallest farmer at the level of his/her smallest plot of crop, using the most accessible technologies using deep learning is proposed. It is a recommender model built using a classifier and an optimization of the classifier. This work proposed MDNN where the weight matrices are calculated with L2 regularization and PSO utilized to tune the hyper parameters of MDNN and its network structure to improve the prediction accuracy[15].

A study explains the harvesting in date fruit orchard using robotics and Deep Learning mechanism. There are two pre-learning CNN mechanisms; namely, AlexNet and VGG-16. The suggested method accomplish extremely good classification based on the difficult dataset with matching ration. A study has planned a correct and strong algorithm for a new mechanism to critically find the growth of cucumber using robotic harvesting automated process in agriculture. This algorithm is a different sort of implementations and mining methodologies of existing data to gain of cucumber field with extraordinary components[22].

In following subsection the author classified 5 agricultural domains namely Plant disease identification, identification of weeds, plant recognition, fruits counting and crop type classification. For this purpose an intensive review of deep neural network efforts in the agriculture domain is performed.

3.1 Yield Prediction

In [33] yield prediction is the most essential aspect of proper agriculture. Some studies have been discussed regarding yield prediction. The authors proposed a model which is an RNN DL algorithm called DRQN over the Q-Learning RL algorithm to determine the crop yield. The main goal of this work was to reduce the error and increase the forecast accuracy, resulting in better food production. In another study of yield prediction, the authors of in a paper used a DL methodology of yield prediction to develop a model for wheat and barley crops based on NDVI and RGB data acquired from UAVs. The main aim of the model was to improve performance and provide accurate yield estimation using RGB images. In a paper , the authors use the field images to develop a DCNN framework for automatically recognizing and classifying several biotic and abiotic paddy crop stressors the pre-trained VGG16 CNN model gained an average accuracy of 92.89%. In another study, the authors proposed a DL framework to predict the yield basis on environmental data and optimization techniques that use CNNs and RNNs. To predict yields for both corn and soybean this model achieved an RMSE of 9% and 8% of their average yields, respectively. A DNN model, CNN, and LSTM are proposed for soybean crop yield prediction by the authors of a study . In this study, the RMSE is 0.81 and the % error is 2.70. The authors of in an article proposed a model that fuses two BPNNs with an IndRNN which is called BBI-model. This model can make accurate predictions in different seasons. In another study of yield prediction, the authors of a paper proposed a DNN based model is used to predict yield. In a paper , the authors developed a combined model which includes CNN and LSTM to predict yield. This model performed well, with an RMSE of 8.24%. Also, in the next work, the authors developed a model Using CNN and LSTM networks. They trained CNN-LSTM, convolutional LSTM, and 3D-CNN architectures with the captured images. With the 3D-CNN model, they have achieved 218.9 kg/ha MAE and 5.51% MAPE. The authors in this paper developed a DNN-based model for crop selection and yield prediction. This model aims to get better output and prediction. Other studies in yield prediction are [38], [39], [40]in [34][20] in [15] and [46]in [45].

3.2 Disease Detection

Crop diseases constitute a major threat in agricultural production systems that deteriorate yield quality and quantity at production, storage, and transportation level. At farm level, reports on yield losses, due to plant diseases, are very common [48]. Furthermore, crop diseases pose significant risks to food security at a global scale. Timely identification of plant diseases is a key aspect for efficient management. In the past few years, computer vision, especially by employing deep learning, has made remarkable progress[47].

DL methods can reduce the problems to a manageable level. The authors are presented with pre-trained models like VGG19 for classifying diseases such as early blight, late blight, and healthy in potato leaves. They have achieved 97.8% accuracy. In a paper the authors identify tomato leaves diseases using CNN; AlexNet and VGG16; GoogLeNet

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

and ResNet; ResNet and the SGD optimization and achieved 99.84% , 97.49%, 97.49%, 97.28% and 99% accuracy respectively. Detect wheat crop diseases using CNN because it has automatically extract features by processing the raw images directly. Their proposed method obtained 84.54% accuracy. The authors developed models to detect nitrogen stressed, and yellow rust infected and healthy winter wheat canopies based on hierarchical self-organizing classifier and hyper spectral reflectance imaging data. They used models like ANN models and spectral reflectance features ; self-organising map (SOM) neural network and data fusion of hyper-spectral reflection and multi-spectral fluorescence imaging. These studies aimed at the accurate detection of categories for a more effective usage of fungicides and fertilizers according to the plant's needs; precise targeting of pesticides in the field; accurate detection, before it can visibly detected, of yellow rust infected winter wheat cultivar "Madrigal"; and accurate discrimination between the plant stress, which is caused by disease and nutrient deficiency stress under field conditions respectively. In another study presented a CNN-based method for the disease detection diagnosis based on simple leaves images with sufficient accuracy to classify between healthy and diseased leaves in various plants[34].In [34] the work discussed are : CNN and MCNN model adopted for detecting diseased leaves in the Mango plant with accuracies 96.67% and 97.13% respectively. In a study the authors detect apple leaves diseases like apple black rot, apple cedar apple rust, healthy apple, and apple scab with their proposed model CNN and they achieved 98.54% accuracy. CNN model is developed based on a Lenet architecture for soybean plant disease recognition and classification. This model performed well and achieved a 99.32% accuracy. In the next paper, a DCNN was designed to operate symptom-wise recognition of cucumber diseases by authors. This model had a significant recognition result, with an accuracy of 93.4%. The authors of [155], proposed a slightly modified CNN model named LeNet. This model was mainly used to detect and identify diseases in tomato leaves using the simplest approach. This model has achieved an average accuracy of 94-95%. The authors in an article , developed a DL system with VGG16 architecture to detect rice plant diseases. Due to the small dataset, the accuracy of the detection was not high enough. This model only achieved a 60% test accuracy. In a paper the authors proposed GoogLeNet and Cifar10 models based on DL are proposed for leaf disease recognition. This model aims to enhance maize leaf disease recognition accuracy and reduce the number of network parameters. The GoogLeNet and Cifar10 models achieved an average accuracy of 98.9%, and 98.8% respectively. A DCNN based method proposed to identify rice diseases. Images of diseased and healthy rice leaves and stems were collected from the rice experimental field to make the dataset. This proposed model has achieved 95.48% of accuracy. a weakly supervised DL framework was proposed by the authors for the recognition and identification of wheat diseases. Two different architectures that are VGG-FCN-VD16 and VGG-FCN-S was implemented to train the dataset. The system achieved the recognition accuracy of 97.95% and 95.12% respectively. Paddy is one of the most important crops all over the world. Lots of farmers are not aware of paddy leaf disease. Here, in [33] studies have been introduced on the application of DL to detect and classify paddy leaf diseases.

3.3 Weed Detection

In [33] four studies have been introduced on the application of DL to the detection of agricultural weeds. In a paper, the authors use the inception model (V2) to the detecting of weeds in crops. Their approach model can detect weed with 98% of accuracy. In a study , the authors detect weed on broad-leaf using CNN algorithms with 96.88% accuracy. Ina paper, the authors proposed a new model using R-FCN with ResNet-101. They also compare their proposed model with Faster R-CNN and R-FCN. Their model gets an overall better result than Faster R-CNN and R-FCN with 81% of accuracy detecting farmland weed. The authors in paper employ the DCNN method to estimate the growth stage of several weed species in terms of the number of leaves with 70%overall accuracy and 96% accuracy while accepting a two-leaf variance. More studies on detection of agricultural weeds are in [34], [58], [59] and [60].

3.4 Species Recognition

In species recognition the main goal is the automatic identification and classification of plant species in order to avoid the use of human experts, as well as to reduce the classification time. A method for the identification and classification of three legume species, namely, white beans, red beans, and soybean, via leaf vein patterns has been presented. Vein morphology carries accurate information about the properties ofthe leaf. It is an ideal tool for plant identification in comparison with color and shape[34].

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

3.5 Soil Management

In Soil Management ML is used in prediction-identification of agricultural soil properties, such as the estimation of soil drying, condition, temperature, and moisture content. The first study for soil management is the work of [41]. More specifically, this study presented a method for the evaluation of soil drying for agricultural planning. The method accurately evaluates the soil drying, with evapotranspiration and precipitation data. The goal of this method was the provision of remote agricultural management decisions. The second study [42] was developed for the prediction of soil condition. In particular, the study presented the comparison of four regression models for the prediction of soil organic carbon (OC), moisture content(MC), and total nitrogen (TN). In a third study [43], the authors developed a new method based on a self adaptive evolutionary-extreme learning machine (SaE-ELM) model and daily weather data. The aim was the accurate estimation of soil temperature for agricultural management. The last study [44] presented a novel method for the estimation of soil moisture, based on ANN models using data from force sensors on ano-till chisel opener[34].

IV. APPLICATIONS OF DEEP LEARNING IN AGRICULTURE

This section describes the survey papers related with applications of deep learning in agriculture.

4.1 Plant Domain

With the development of agricultural modernization, the area of large-scale cultivation becomes increasing. DL has a wide range of applications in the planting of agriculture. There are several works on DL applying to crop disease classification or detection. The work by Ha et al. [42] proposed a highly accurate system to detect radish disease (Fusarium wilt). The radish was classified into diseased and healthy through the deep convolutional neural network (DCNN). Thework by Ma et al. [43] developed a DCNN to recognize cucumber four types of cucumber diseases. Compared to conventional methods (e.g., RF, SVM, and AlexNet), DCNN can detect better cucumber diseases with 93.41% of accuracy. Similar to the research [50] in [49], Lu et al. [51] in [49],[3] and [3] in [1] came up with CNNs to identify types of rice diseases with more than 95% of accuracy, which demonstrated the superiority of CNN based models in identifying rice diseases. The work by Liu et al. [52] in [49] presented a novel AlexNet-based model to detect four types of common apple leaf diseases. The approach demonstrated97.6% and improved the robustness of the CNN model in experiment. Considering the food security issues, Mohanty et al. [53]in [49] proposed to identify 26 types of diseases and14 crop species using the CNN model. The model demonstrated an excellent performance, which proved itself was feasible and robust for detection diseases. In their work[6], the authors have contributed towards the automatic recognition of plant diseases using image analysis. They have used GoogleNetBN and compared the results with VGG16 having 16layers and Inception V3 with 48 layers with accuracy 95.48%. In another work[4], S.Gayathri et al. proposed CNN LeNet model for recognition of four tea leaf diseases – blister blight, red scab, red leaf spot and leaf blight. In their work of 2020[5], the authors have used ResNet50 model to detect 5 strawberry diseases from “Taoyuan No. 1” and “Xiang-Shui” strawberry cultivars in Miaoli County, Taiwan [1].The work by Fuentes et al. [48] in [49] used DL three meta-architectures, faster region-based convolutional neural network (Faster R-CNN), region-based fully convolutional network (R-FCN), and single shot multibox detector (SDD). The work showed that the developed models can effectively detect nine types of diseases and pests in complex surrounding. Other works in recognition of plant diseases are [7] [1],[20] in [15], [47] and [3] in [1].

Crop classification and identification are the critical initial stages of the agricultural monitoring system. Zhong et al. [50] presented a classification framework for identifying crop growth patterns and crop types using DL applied to time-series remotely sensed data based on Conv1-D. Their work showed that the framework was effective in representing the time series of multi-temporal classification tasks. Another study by Milioto et al. [51] presented a system to detect and classify sugar beets and weeds without standing performance. The work by Ghazi et al. [52] combined transfer learning and popular CNN architectures, including VGGNet, AlexNet, and GoogLeNet to recognize plant types. Their model placed the third inPlanCLEF2016. The work by Zhu et al. [53] used an improved inception V2 architecture to identify plant species. Through experiment with real scenes, it was proved that the proposed method had accuracy superior to Faster RCNN in identifying leaf species in a complex environment. In the study, to boost fruit production and quality, the work by Dias et al. [54] developed a robust system to recognize apple flowers using CNN. The problem addressed

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

in many research papers was the recognition of medicinal plants and their uses. In 2019, Krishnaveni et al. [19] were able to classify 12 medicinal plants. In their work of 2019, Dileep et al.[20] proposed AyurLeaf CNN for classification of 40 medicinal plant species. AyurLeaf CNN was based on the CNN architecture AlexNet . A five-fold cross validation was used and the result was compared with AlexNet and DLeaf. Their accuracy was 96.76% which was greater than other models. Dudi et al. [21] used two modules for recognition of medicinal plants – a four layer CNN based feature extraction and machine learning based classification using ANN, SVM, Naïve Bayes and k-Nearest neighbor. More works on Crop classification and identification can be found in n [8], [9], Gokul et al. [10] [11],Adetiba et al. and Bargoti S. et al.[1].

Prediction of crop yield that can predict production in advance before harvest belongs to another area of study in planting. It provides forecast data based on region, crop, and multiple forecast surveys at different growth stages. To observe the growth of apple at every stage, Tian et al. [54] put forward aYOLOV3-dense model to detect apple growth and estimate yield using data augment technique to avoid over fitting. The orchard in their study involved undulating lighting, complex backgrounds, overlapping of fruits. Their approach was concluded as valid for real-time application in apple orchards. The work by Rahnemoonfar and Sheppard [55] used an improved Inception-ResNet model with accuracy for estimating fruit yield in terms of the number of fruits. The model was efficient even with complex condition on fruits.[49] A study on Agricultural Fruit Prediction Using Deep Neural Networks is performed [15].Deep learning is also used to track and predict various environmental impacts on crop yield such as weather changes. Convolutional Neural Networks (CNN) is the most widely used deep learning algorithm in these kind of studies, and the other widely used deep learning algorithms are Long-Short Term Memory (LSTM) and Deep Neural Networks (DNN). Mariannie Rebortera et al. performed a research on Forecasting Banana Harvest Yields using Deep Learning Deep learning techniques[1].

4.2 Animal Domain

As the concern on animals grows, DL technologies have been adopted in the animal domain for monitoring and improving animal breeding environment and the quality of meat products. The study on DL-based face recognition and behavior analysis of pigs and cows is very active in applied research. To develop an automatic recognition method of nursing interactions for animal farms by using DL techniques, it is showed that the fully convolutional network combining spatial and temporal information was able to detect nursing behaviors, which was tremendous progress in identifying nursing behaviors in pig farm. A Mask R-CNN architecture to settle cattle contour extraction and instance segmentation in a sophisticated feedlot surrounding is presented. DL techniques based on nose pattern characteristic to identify cattle to address the loss or exchange of animals and inaccurate insurance claim is used. Inspired by the work of face recognition, the work proposed a CNN-based model to recognize pigs. In order to predict sheep commercial value, an automatic system is built to recognize sheep types in a sheep environment and reached 95.8%accuracy. counting CNN to deal with the pig amounts and got 1.67MAE per image is proposed .Deep learning methods viz. CNN, RNN, LSTM can be used to provide accurate prediction and estimation of farming parameters to optimize the economic efficiency of livestock production systems, such as cattle and eggs production. A study on smart farming is key to developing sustainable agriculture is proposed[15].

4.3 Land Cover

Deep learning is also used in Land cover classification (LCC) is considered as a vital and challenging task in agriculture, and the key point is to recognize what class a typical piece of land is in. Deep learning methods such as CNN, GAN and RNN are able to be used for land cover classification of remote sensing image data. Deep learning applications in land use classification based on Sentinel-2 time series is explained. Agriculture Companies are leveraging computer vision and deep-learning algorithms to process data captured by drones and/or software-based technology to monitor crop and soil health [15]. Kussul et al. [56] presented a multi-level DL technique that classified crop types and land cover from Landsat-8 and Sentinel-1A RS satellite imagery with nineteen multi temporal scenes. Thework by Gaetano et al. [57] proposed a two-branch end-to-end model called MultiReso LCC. The model extracted characteristics of land covers and classified land covers by combing their attributes at the PAN resolution. The work by Scott et al. [58] train eda DCNNs model and used transfer learning and data augmentation to classify land covers for

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

remote sensing imagery. The work by Xing et al. [59] used improved architectures, VGG16, ResNet-50, and AlexNet to validate land cover, and the results showed that the proposed method was effective with accuracy 83.80%. The work by Mahdianpari et al. [60]presented a survey of DL tools for classification of wetland classes and checked seven power of deep networks using multispectral remote sensing imagery[49].

4.4 Other Domains

The development of smart agriculture inevitably requires automated machines. To operate it safely without supervision, it should have the function of detecting and avoiding obstacles. The work by Christiansen et al. [61] detected unusual surrounding areas or unknown target types with distant and occlusion targets using Deep Anomaly, which combined DL algorithms. Compared to Faster R-CNN and most CNN models, Deep Anomaly had better performance and accuracy and requires less computation and fewer parameters for image processing, which was suitable for real-time systems. In contrast to[61],the work by Steen et al. [62] can detect an obstacle with high accuracy in the field of row crops and grass mowing. However, it cannot recognize people and other distant objects. The work by Khan et al. [63]used popular DL networks to estimate vegetation index from RGB images. They used a modified AlexNet deep CNN and Caffe as the base framework for implementation. The work by Kaneda et al. [64] presented a novel prediction system for plant water stress to reproduce tomato cultivation. The work by Song et al.[65] combined DBN and MCA to predict soil moisture in the Zhangye oasis, Northwest China. The workby Wang et al. [66] presented used CNN, ResNet, and modified architecture ResNeXt to examine lousy blueberries. The work by Mandeep et al. [67] employed H2O model to estimate evapotranspiration in Northern India and got a better performance than four learning methods, including DL, generalized linear model (GLM), random forest (RF),and gradient boosting machine (GBM) [49].A research on Deep Learning For Remote Sensing Image Classification For Agriculture Applications is proposed [15].

In another study in 2020, Shiva et al.[12] proposed an automatic image-based plant pheno typing approach for stress classification in plant shoot images. They examined the impact of stress, here, nitrogen deficiency for three weeks. They classified the samples into three classes, healthy, semi-stressed and severely stressed. For healthy plants,100% nitrogen was available, for semi-stressed they provided only 50% of the nitrogen requirement and for severely stressed, only 10% of the nitrogen requirement was given. Results have shown that the performance of CNN with background was 75%and without background was 83% [1].

Another problem addressed in some of the research works that have been reviewed was smart farming. Aiming to achieve this objective, Horng et al. in their work [8] trained neural network models to determine the maturity of tomato plant through object detection and then harvest the mature crops using robotic arm. They have used a combination of MobileNet and SSD model. MobileNet was used for feature extraction from the input image and SSD was used for categorizing the image features. In another work of 2020, Sudiantoet al. [17] achieved the objective of sorting and grading of chilly after harvesting whether its quality is good or not. They used You Look Only Once (YOLOv3) which is a deep learning algorithm based on CNN. The main advantage of YOLOv3 is that it has multi-scale prediction and better backbone classifier which helped it to achieve an accuracy of 99.4%. In the detection of good quality chilies. In their work of 2018[18], Jaromir et al. worked on recognizing the quality of seeds in respect to their viability of sowing. They employed CNN-F architecture with transfer learning. Their experiment showed that the accuracy with data augmentation was 87.1% and without augmentation was 84.4% . In [19], Ignacio et al. achieved the objective of recognition of blueberries images in the rooting stage in smart farms in Chile. They designed a CNN with 8 layers using TensorFlow. The system was able to detect presence of living plants in tray, absence of living plants in tray and no tray at all. A robot was used at the Adventist University of Chile which contains a carriage that runs along a hot bed with container trays of blueberry plants. It achieved an accuracy of 86% in its task[1]. A framework for Internet of Things-enabled smart farming applications. In 3rd World Forum on Internet of Things (WF-IoT) is developed [15].

V. CONCLUSION

In this paper, the author has surveyed the development of deep neural-based work efforts in the agriculture domain. Analysed the works on the applications of deep learning and the technical details of their implementation. Each work was compared with existing techniques for performance. It has been found that deep learning has much better results than other image processing techniques. Moreover, with the advances in computer hardware, deep learning will receive

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

more attention and broader applications in future research. Neural networks are in a real sense one of the best solutions to a few agriculture problems. Undeniably, the implementation of ANN to precision agriculture plays a crucial role in potential assessment of the idea of precision farming as a viable way of fulfilling the food demands of the planet. Nonetheless, in order to ensure viability of future food demands, armers welfare and economic growth, more work on the impacts of ANN on agricultural problems has to be carried out. This paper aims to encourage more researchers to study dee plearning to settle agricultural issues such as recognition, classification or prediction, relevant image analysis, and data analysis, or more general computer vision tasks. This survey would create interest in other researchers to experiment deep learning in various agricultural issues which involve image classification or prediction related to computer vision and image analysis or more generally to data analysis and identification. The overall benefits of deep learning are encouraging for its further use towards smarter, more sustainable farming and more secure food production.

REFERENCES

[1] Pooja Arora and Amit Jain, The role of deep learning in agriculture: Areview, AIP Conference Proceedings 2555, 050032 (2022

[2] N. Kussul, M. Lavreniuk, S. Skakun, and A. Shelestov, "Deep Learning Classification of Land Cover andCrop Types Using Remote SensingData," IEEE Geosci. Remote Sens. Lett., vol. 14, no. 5, pp. 778–782, 2017,doi: 10.1109/LGRS.2017.2681128.

[3] F. Jiang, Y. Lu, Y. Chen, D. Cai, and G. Li, "Image recognition of four rice leaf diseases based on deeplearning and support vector machine,"Comput. Electron. Agric., vol. 179, no. August, p. 105824, 2020, doi:10.1016/j.compag.2020.105824.

[4] S. Gayathri, D. C. J. W. Wise, P. B. Shamini, and N. Muthukumaran, "Image Analysis and Detection of TeaLeaf Disease using Deep Learning,"Proc. Int. Conf. Electron. Sustain. Commun. Syst. ICESC 2020, no. Icesc,pp. 398–403, 2020, doi: 10.1109/ICESC48915.2020.9155850.

[5] J.-R. Xiao, P.-C. Chung, H.-Y. Wu, Q.-H. Phan, J.-L. A. Yeh, and M. T.-K. Hou, "Detection of strawberrydiseases using a convolutional neuralnetwork," Plants, vol. 10, no. 1, pp. 1–14, 2021, doi:10.3390/plants10010031.

[6] S. H. Lee, H. Goëau, P. Bonnet, and A. Joly, "New perspectives on plant disease characterization based ondeep learning," Comput. Electron.Agric., vol. 170, 2020, doi: 10.1016/j.compag.2020.105220.

[7] A. Fuentes, S. Yoon, S. C. Kim, and D. S. Park, "A robust deep-learning-based detector for real-time tomatoplant diseases and pestsrecognition," Sensors (Switzerland), vol. 17, no. 9, 2017, doi: 10.3390/s17092022

[8] Chengjuan R, Dae-Kyoo K and Dongwon J (2020), "A Survey of Deep Learning in Agriculture: Techniques and Their Applications", Journal ofInformation Processing Systems,Volume 16, No 5 (2020), pp. 1015 – 1033.

[9] Yalcin, H., Razavi, S.: Plant classification using convolutional neural networks. In: 2016 Fifth International Conference on Agro-Geoinformatics(Agro-Geoinformatics), pp. 1–5. IEEE (2016).

[10] Zhang, X., Qiao, Y., Meng, F., Fan, C., Zhang, M., "Identification of maize leaf s using improved deep convolutional neural networks". IEEEAccess 6, 30370–30377 (2018).

[11] Zhang, Y.D., Dong, Z., Chen, X., Jia, W., Du, S., Muhammad, K., Wang, S.H.: Image based fruit category classification by 13-layer deepconvolutional neural network and data augmentation. Multimedia Tools Appl. 78(3), 3613–3632 (2019)

[12] Zhong, L., Hu, L., Zhou, H., "Deep learning based multi-temporal crop classification", Remote Sens. Environ. 221, 430–443 (2019).

[13] Vishva Patel, Applications of Deep Neural Networks in Agriculture, March 2020, https://www.researchgate.net/publication/341353333

[14] Qian Zhang, Yeqi Liu, Chuanyang Gong , Yingyi Chen , and Huihui Yu, Applications of Deep Learning for Dense Scenes Analysis inAgriculture: A Review, Sensors 2020, 20, 1520; doi:10.3390/s20051520, www.mdpi.com/journal/sensors

[15] Abhishek Pandey, Dr. V. Ramesh, A Review on Applications of Deep Learning in Agriculture,International Journal of Modern Agriculture, Volume 10 No. 2, 2021 ISSN: 2305-7246.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

[16] Kamilaris, A, Gao, F, Prenafeta-Boldú, FX and Ali, MI (2016) Agri-IoT: a semantic framework for Internet of Things-enabled smart farmingapplications. In 3rd World Forum on Internet of Things (WF-IoT). Reston, VA, USA: IEEE, pp. 442–447.
[17] Nilay Ganatra and Atul Patel (2020), "Deep Learning Methods and Applications for Precision Agriculture", Machine Learning for PredictiveAnalysis, pp 515-527
[18] Leila Hashemi-Beni and Asmamaw Gebrehiwot, "Deep Learning For Remote Sensing Image Classification For Agriculture Applications".ASPRS 2020 Annual Conference Virtual Technical Program, 22–26 June 2020.
[19] Canziani, A, Paszke, A and Culurciello, E (2016) An analysis of deep neural network models for practical applications. arXiv preprintarXiv:1605.07678
[20] Amara, J., Bouaziz, B., & Algergawy, A. (2017). A Deep Learning-based Approach for Banana Leaf Diseases Classification. (pages. 79-88).Stuttgart: BTW workshop
[21]. Saeed K, Lizhi W and Sotirios V. (2020), "A CNN-RNN Framework for Crop Yield Prediction", Front. Plant Sci., 24 January 2020.
[22] Syamasudha Veeragandham_and HSanthi, A Review On The Role Of Machine Learning In Agriculture , Scalable Computing: Practice andExperience, ISSN 1895-1767, http://www.scpe.org,2020 SCPE. Volume 21, Issues 4, pp. 583–589
[23] Elavarasan D, Vincent PD. Crop yield prediction using deep reinforcement learning model for sustainable agrarian applications. IEEE access.2020;8:86886-86901.
[24] Nevavuori P, Narra N, Lipping T. Crop yield prediction with deep convolutional neural networks. Computers and Electronics in Agriculture.2019;163:104859.
[25] Anami BS, Malvade NN, Palaiah S. Classification of yield affecting biotic and abiotic paddy crop stresses using field images. InformationProcessing in Agriculture. 2020;7(2):272-285.
[26]Khaki S, Wang L, Archontoulis SV. A cnn-rnn framework for crop yield prediction. Frontiers in Plant Science. 2020;10: 1750.
[27] Terliksiz AS, Altýlar DT. July. Use of deep neural networks for crop yield prediction: A case study of soybean yield in lauderdale county,alabama, usa. In 2019 8th international conference on Agro-Geoinformatics (Agro-Geoinformatics). IEEE. 2019:1-4.
[28]Chu Z, Yu J. An end-to-end model for rice yield prediction using deep learning fusion. Computers and Electronics in Agriculture.2020;174:105471.
[29] Khaki S, Wang L. Crop yield prediction using deep neural networks. Frontiers in Plant Science. 2019;10:621.
[30] Sun J, Di L, Sun Z, Shen Y, Lai Z. County-level soybean yield prediction using deep CNN-LSTM model. Sensors. 2019;19(20):4363
[31] Nevavuori P, Narra N, Linna P, Lipping T. Crop yield prediction using multitemporal UAV data and spatio-temporal deep learning models.Remote Sensing. 2020;12(23):4000.
[32] Islam T, Chisty TA, Chakrabarty A. December. A deep neural network approach for crop selection and yield prediction in Bangladesh. In 2018IEEE Region 10 Humanitarian Technology Conference (R10-HTC). IEEE. 2018:1- 6.
[33] Pallab Bharman , Sabbir Ahmad Saad, Sajib Khan , Israt Jahan, Milon Ray and Milon Biswas, Deep Learning in Agriculture: A Review,Asian Journal of Research in Computer Science 13(2): 28-47, 2022; Article no.AJRCOS.83334 ISSN: 2581-8260
[34] Konstantinos G. Liakos, Patrizia Busato , Dimitrios Moshou , Simon Pearson and Dionysis Bochtis ,Machine Learning in Agriculture: AReview,Sensors 2018, 18, 2674; doi:10.3390/s18082674 www.mdpi.com/journal/sensors
[35] Ali, I.; Cawkwell, F.; Dwyer, E.; Green, S. Modeling Managed Grassland Biomass Estimation by UsingMultitemporal Remote Sensing Data—A Machine Learning Approach. IEEE J. Sel. Top. Appl. Earth Obs.Remote Sens. 2016, 10, 3254–3264. [CrossRef]
[36] Pantazi, X.-E.; Moshou, D.; Alexandridis, T.K.; Whetton, R.L.; Mouazen, A.M. Wheat yield prediction usingmachine learning and advanced sensing techniques. Comput. Electron. Agric. 2016, 121, 57–65. [CrossRef]
[37] Kung, H.-Y.; Kuo, T.-H.; Chen, C.-H.; Tsai, P.-Y. Accuracy Analysis Mechanism for Agriculture Data Usingthe Ensemble Neural Network Method. Sustainability 2016, 8, 735. [CrossRef]

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

[38] Russell, S.J.; Norvig, P. Artificial Intelligence: A Modern Approach; Prentice Hall: Upper Saddle River, NJ, USA,1995; Volume 9, ISBN 9780131038059.
[39] Pearl, J. Probabilistic Reasoning in Intelligent Systems. Morgan Kauffmann San Mateo 1988, 88, 552.
[40] Duda, R.O.; Hart, P.E. Pattern Classification and Scene Analysis; Wiley: Hoboken, NJ, USA, 1973; Volume 7,ISBN 0471223611.
[41] Coopersmith, E.J.; Minsker, B.S.; Wenzel, C.E.; Gilmore, B.J. Machine learning assessments of soil drying foragricultural planning. Comput. Electron. Agric. 2014, 104, 93–104. [CrossRef]
[42] Morellos, A.; Pantazi, X.-E.; Moshou, D.; Alexandridis, T.; Whetton, R.; Tziotzios, G.; Wiebensohn, J.; Bill, R.;Mouazen, A.M. Machine learning based prediction of soil total nitrogen, organic carbon and moisturecontent by using VIS-NIR spectroscopy. Biosyst. Eng. 2016, 152, 104–116. [CrossRef]
[43] Nahvi, B.; Habibi, J.; Mohammadi, K.; Shamshirband, S.; Al Razgan, O.S. Using self-adaptive evolutionaryalgorithm to improve the performance of an extreme learning machine for estimating soil temperature.Comput. Electron. Agric. 2016, 124, 150–160. [CrossRef]
[44] Johann, A.L.; de Araújo, A.G.; Delalibera, H.C.; Hirakawa, A.R. Soil moisture modeling based on stochasticbehavior of forces on a no-till chisel opener. Comput. Electron. Agric. 2016, 121, 420–428. [CrossRef]
[45] K Dokic, L Blaskovic, and D Mandusic, From machine learning to deep learning in agriculture – thequantitative review of trends, IOP Conf. Series: Earth and Environmental Science 614 (2020) 012138 2020doi:10.1088/1755-1315/614/1/012138
[46] Chlingaryan A, Sukkarieh S, Whelan B 2018 Computers and Electronics in Agriculture 151 61–69.
[47]Lefteris Benos, Aristotelis C. Tagarakis , Georgios Dolias, Remigio Berruto , Dimitrios Kateris and Dionysis Bochtis, Machine Learning inAgriculture: A ComprehensiveUpdated Review, Sensors 2021, 21, 3758. https://doi.org/10.3390/s21113758 https://www.Mdpi.com/journal/sensors
[48] Harvey, C.A.; Rakotobe, Z.L.; Rao, N.S.; Dave, R.; Razafimahatratra, H.; Rabarijohn, R.H.; Rajaofara, H.; MacKinnon, J.L. Extremevulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. Philos. Trans. R. Soc. B Biol. Sci. 2014,369. [CrossRef]
[49] Chengjuan Ren, Dae-Kyoo Kim, and Dongwon Jeong, A Survey of Deep Learning in Agriculture:Techniques and Their ApplicationsJournal of Information Processing System, Vol.16, No.5, pp.1015~1033, October 2020 ISSN 1976-913X (Print)https://doi.org/10.3745/JIPS.04.0187
[50] J. Ma, K. Du, F. Zheng, L. Zhang, Z. Gong, and Z. Sun, "A recognition method for cucumber diseases usingleaf symptom images based on deep convolutional neural network," Computers and Electronics inAgriculture, vol. 154, pp. 18-24, 2018.
[51] Y. Lu, S. Yi, N. Zeng, Y. Liu, and Y. Zhang, "Identification of rice diseases using deep convolutional neuralnetworks," Neurocomputing, vol. 267, pp. 378-384, 2017.
[52] B. Liu, Y. Zhang, D. He, and Y. Li, "Identification of apple leaf diseases based on deep convolutional neuralnetworks," Symmetry, vol. 10, no. 1, pp. 1-16, 2017.
[53] S. P. Mohanty, D. P. Hughes, and M. Salathe, "Using deep learning for image-based plant disease detection,"Frontiers in Plant Science, vol. 7,article no. 1419, 2016.
[54] Y. Tian, G. Yang, Z. Wang, H. Wang, E. Li, and Z. Liang, "Apple detection during different growth stages inorchards using the improvedYOLO-V3 model," Computers and Electronics in Agriculture, vol. 157, pp.417-426, 2019.
[55] M. Rahnemoonfar and C. Sheppard, "Deep count: fruit counting based on deep simulated learning," Sensors,vol. 17, no. 4, article no. 905,2017.
[56] N. Kussul, M. Lavreniuk, S. Skakun, and A. Shelestov, "Deep learning classification of land cover and croptypes using remote sensing data,"IEEE Geoscience and Remote Sensing Letters, vol. 14, no. 5, pp. 778-782,2017.
[57] R. Gaetano, D. Ienco, K. Ose, and R. Cresson, "A two-branch CNN architecture for land cover classificationof PAN and MS imagery," RemoteSensing, vol. 10, no. 11, article no. 1746, 2018.
[58] G. J. Scott, M. R. England, W. A. Starms, R. A. Marcum, and C. H. Davis, "Training deep convolutionalneural networks for land–coverclassification of high-resolution imagery," IEEE Geoscience and RemoteSensing Letters, vol. 14, no. 4, pp. 549-553, 2017.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 3, Issue 1, January 2023
Impact Factor: 7.301

[59] H. Xing, Y. Meng, Z. Wang, K. Fan, and D. Hou, "Exploring geo-tagged photos for land cover validationwith deep learning," ISPRS Journal ofPhotogrammetry and Remote Sensing, vol. 141, pp. 237-251, 2018.
[60] M. Mahdianpari, B. Salehi, M. Rezaee, F. Mohammadimanesh, and Y. Zhang, "Very deep convolutionalneural networks for complex landcover mapping using multispectral remote sensing imagery," RemoteSensing, vol. 10, no, 7, article no. 1119, 2018.
[61] P. Christiansen, L. N. Nielsen, K. A. Steen, R. N. Jorgensen, and H. Karstoft, "DeepAnomaly: combiningbackground subtraction and deep learning for detecting obstacles and anomalies in an agricultural field,"Sensors, vol. 16, no. 11, article no. 1904, 2016.
[62] K. A. Steen, P. Christiansen, H. Karstoft, and R. N. Jorgensen, "Using deep learning to challenge safetystandard for highly autonomousmachines in agriculture," Journal of Imaging, vol. 2, no. 1, article no. 6,2016.
[63] Z. Khan, V. Rahimi-Eichi, S. Haefele, T. Garnett, and S. J. Miklavcic, "Estimation of vegetation indices forhigh-throughput phenotyping of wheat using aerial imaging," Plant Methods, vol. 14, article no. 20, 2018.
[64] Y. Kaneda, S. Shibata, and H. Mineno, "Multi-modal sliding window-based support vector regression forpredicting plant water stress," Knowledge-Based Systems, vol. 134, pp. 135-148, 2017.
[65] X. Song, G. Zhang, F. Liu, D. Li, Y. Zhao, and J. Yang, "Modeling spatio-temporal distribution of soilmoisture by deep learning-based cellular automata model," Journal of Arid Land, vol. 8, no. 5, pp. 734-748,2016.
[66] Z. Wang, M. Hu, and G. Zhai, "Application of deep learning architectures for accurate and rapid detection ofinternal mechanical damage of blueberry using hyperspectral transmittance data," Sensors, vol. 18, no. 4,Article 1126, 2018.
[67] M. K. Saggi and S. Jain, "Reference evapotranspiration estimation and modeling of the Punjab Northern Indiausing deep learning," Computers and Electronics in Agriculture, vol. 156, pp. 387-398, 2019.

प्रस्तावना –

जगात सर्व देशात विविधतेच्या प्रदेशात आदिवासी समुदायाची वस्ती आहे. विशेषत: आशिया, आफ्रिका आणि अमेरिका हया खंडातील देशात आजही आदिवासी जमात मोठया प्रमाणात आढळते. परंतू आधुनिक काळातही प्राथमिक अवस्थेतील जीवन जगणाऱ्या रहिवाशांचे प्रमाण जितके आफ्रीका खंडात आहे, तितके अन्यत्र कोठेही नाही.

हया जमातीला काही विद्वानांनी, अभ्यासकांनी व सामाजीक कार्यकर्त्यांनी विविध नावे दिली आहेत. या लोकांना अगदी प्राचिन किंवा अगदी मुळचे आदिवासी म्हटले जाते.

1962 मध्ये शिलांग येथे भरलेल्या आदिवासी परिषदेत 'आदिवासी' या शब्दाची व्याख्या करण्यात आली.

व्याख्या -

"एका समान भाषेचा वापर करणाऱ्या एकाच पूर्वजांपासून उतरती सांगणारा, एका विशिष्ट भूप्रदेशावर वास्तव्य करणाऱ्या तंत्र शास्त्रीय दृष्टीने मागासलेला, अद्यप ओळख नसलेला व रक्त संबंधावर आधारित सामाजीक व राजकीय रितीरिवाजांचे प्रामाणीकपणे चलन करणाऱ्या एकत्रितची गटाला आदिवासी समाज असे म्हणतात.

महाराष्ट्रातील एकूण लोकसंख्या आदिवासी लोकसंख्या

अ.क्र.	जनगणना वर्ष	राज्याची एकूण लोकसंख्या	आदिवासी लोकसंख्या
1	1971	504.12	38.41
2	1981	627.84	57.12
3	1991	789.37	73.18
4	2001	968.79	85.77
5	2011	987.80	87.68

जिल्हा निहाय लोकसंख्या

अमरावती विभाग

अ.क्र.	जिल्हयाचे नाव	लोकसंख्या (लाखात)	प्रमाण
1	वर्धा	1237	11.45
2	नागपुर		

Shikshan Prasark Mandal's

Lokmanya Tilak Mahavidyalaya

Wani, Dist Yavatmal (MS), India, 445304

Re-accredited by NAAC with "B" Grade

Affiliated to Sant Gadge Baba Amravati University, Amravati

CERTIFICATE

International Conference on

Multidisciplinary Research and Innovations (ICMRI-2022)

Saturday 7th May 2022

This is to certify that, Mr. Harish Murari Bawangade of Rtmnu Nagpur has presented a paper titled as चंद्रपूर जिल्ह्यातील आदिवासी शेतकऱ्यांच्या उत्पन्नाचे आर्थिक अध्ययन.

Prof. Dnyaneshwar B. Khamankar
Convenor (ICMRI-2022)
Lokmanya Tilak Mahavidyalaya,
Wani [Dist. Yavatmal]

Dr. Sau. Sunanda S. Aswale
Organizing Secretary (ICMRI-2022)
Lokmanya Tilak Mahavidyalaya,
Wani [Dist. Yavatmal]

Prasad A. Khanzode
Principal
Lokmanya Tilak Mahavidyalaya,
Wani [Dist. Yavatmal]

2023.04.26 12:46

National Seminar on

Right to Food Security

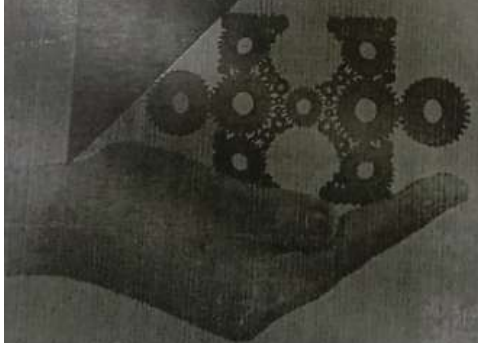
Peer Reviewed Refereed
and UGC Listed Journal
(Journal No. 47023)

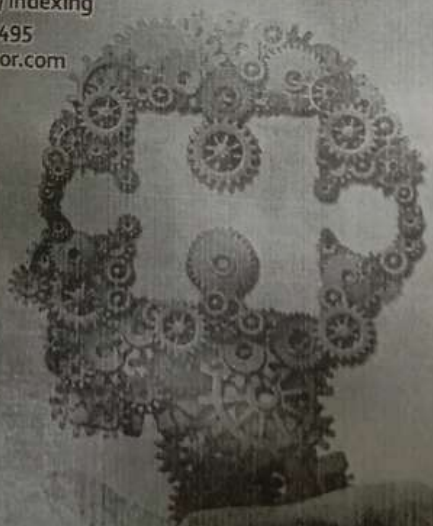
ISSN 2319 - 8508
AN INTERNATIONAL MULTIDISCIPLINARY
HALF YEARLY RESEARCH JOURNAL

GALAXY LINK

Volume - X, Issue - II,
May - October - 2022
English / Marathi / Hindi

Impact Factor / Indexing
2020 - 6.495
www.sjifactor.com





Ajanta Prakashan

2023.04.26 12:46

VOLUME - X, ISSUE - II - MAY - OCTOBER - 2022
GALAXY LINK - ISSN 2319 - 8508 - IMPACT FACTOR - 6.495 (www.sjifactor.com)

CONTENTS OF MARATHI

अ.क्र.	लेख आणि लेखकाचे नाव	पृष्ठ क्र.
१	आधुनिक तन्त्रज्ञानाच्या क्षेत्रात संस्कृत चलचित्रपटांचा प्रवास एक दृष्टिक्षेप **प्रा. दर्शना सायम**	१-४
२	नक्षलवादी चळवळ **प्रा. गणेश ब. माघाडे**	५-७
३	चंद्रपूर जिल्ह्यातील आदिवासी शेतकऱ्यांच्या उत्पन्नाचे आर्थिक अध्ययन **हरिष एम. बावनगडे**	८-११
४	राज्यशास्त्राच्या प्रभावी अध्यापनासाठी उपयुक्त : चर्चा पद्धती **प्रा. डॉ. योगेश दा. उगले**	१२-१५
५	प्रज्ञाचक्षु श्रीसंतगुलाबराव महाराज यांच्या योगदर्शनातील भक्ती प्रकार एक अभिनव विचार **सहा. प्रा. प्रज्ञा विश्वासराव इंगळे**	१६-२२
६	ख्यालगायकीत बदललेली वर्तमान स्थिती **प्रा. दत्तात्रय जोशी**	२३-२८
७	भारतीय डिजिटल लायब्ररी **नितेश गुलाब चामाटे**	२९-३४
८	मानवी जीवनात संगीताचे स्थान आणि आवश्यकता **डॉ. स्नेहल सुनील डहाळे**	३५-३८
९	अटल पेंशन योजनेचे आर्थिक दृष्टीकोनातून अध्ययन **स्वाती र. चौधरी** **प्रो. डॉ. सुनील श्री. केदार**	३९-४३
१०	चिमूर तालुक्यातील आंबेडकरी चळवळीतील शिलेदार **प्रा. प्रफुल्ल एम. राजुरवाडे** **डॉ. बी. आर. मस्के**	४४-४७

2023.04.26 12:46

VOLUME - X, ISSUE - II - MAY - OCTOBER - 2022
GALAXY LINK - ISSN 2319 - 8508 - IMPACT FACTOR - 6.495 (www.sjifactor.com) CC-18

३. चंद्रपूर जिल्ह्यातील आदिवासी शेतकऱ्यांच्या उत्पन्नाचे आर्थिक अध्ययन

हरिष एच. डावरपडे
संशोधक विद्यार्थी

प्रस्तावना

जगात सर्व देशात निरनिराळ्या प्रदेशात आदिवासी समुदायची वस्ती आहे. विशेषतः आशिया, आफ्रिका आणि अमेरिका ह्या खंडातील देशात आजही आदिवासी जमात मोठ्या प्रमाणात आढळते. परंतू आधुनिक काळातही प्राथमिक अवस्थेतील जीवन जगणा-या रहिवाशांचे प्रमाण जितके आफ्रीका खंडात आहे तितके अन्यत्र कोठेही नाही.

ह्या जमातीला काही विचारवंतांनी, अभ्यासकांनी व सामाजीक कार्यकर्त्यांनी विविध नावे दिली आहेत. या लोकांना अगदी प्राचिन किंवा अगदी मुळचे आदिवासी म्हटले जाते.

1962 मध्ये शितांग येथे भरलेल्या आदिवासी परिषदेत 'आदिवासी' या शब्दांची व्याख्या करण्यात आली.

व्याख्या

"एका समान भाषेचा वापर करणा-या एकाच पूर्वजापासून उत्पती सांगणारा, एका विशिष्ट भुप्रदेशावर वास्तव करणा-या तंत्र शास्त्रीय दृष्टीने मागासलेला, अक्षर ओळख नसलेला व रक्त संबंधावर आधारित सामाजीक व राजकीय रितीरिवाजांचे प्रामाणीकपणे चलन करणा-या एकजिन्सी गटाला आदिवासी समाज असे म्हणतात.

महाराष्ट्रातील एकूण लोकसंख्या आदिवासी लोकसंख्या त्यांच्या साक्षरतेचे प्रमाण

अ.क्र.	जनगणना वर्ष	राज्याची एकूण लोकसंख्या	आदिवासी लोकसंख्या	टक्केवारी	साक्षरतेचे प्रमाण	
					एकूण	आदिवासी
1	1971	504.12	38.41	7.62	39.13	11.74
2	1981	627.84	57.12	9.19	47.18	22.29
3	1991	789.37	73.18	9.27	64.87	36.77
4	2001	968.79	85.77	8.85	76.09	52.02
5	2011	987.80	87.68	8.89	77.05	52.08

2023.04.26 12:47

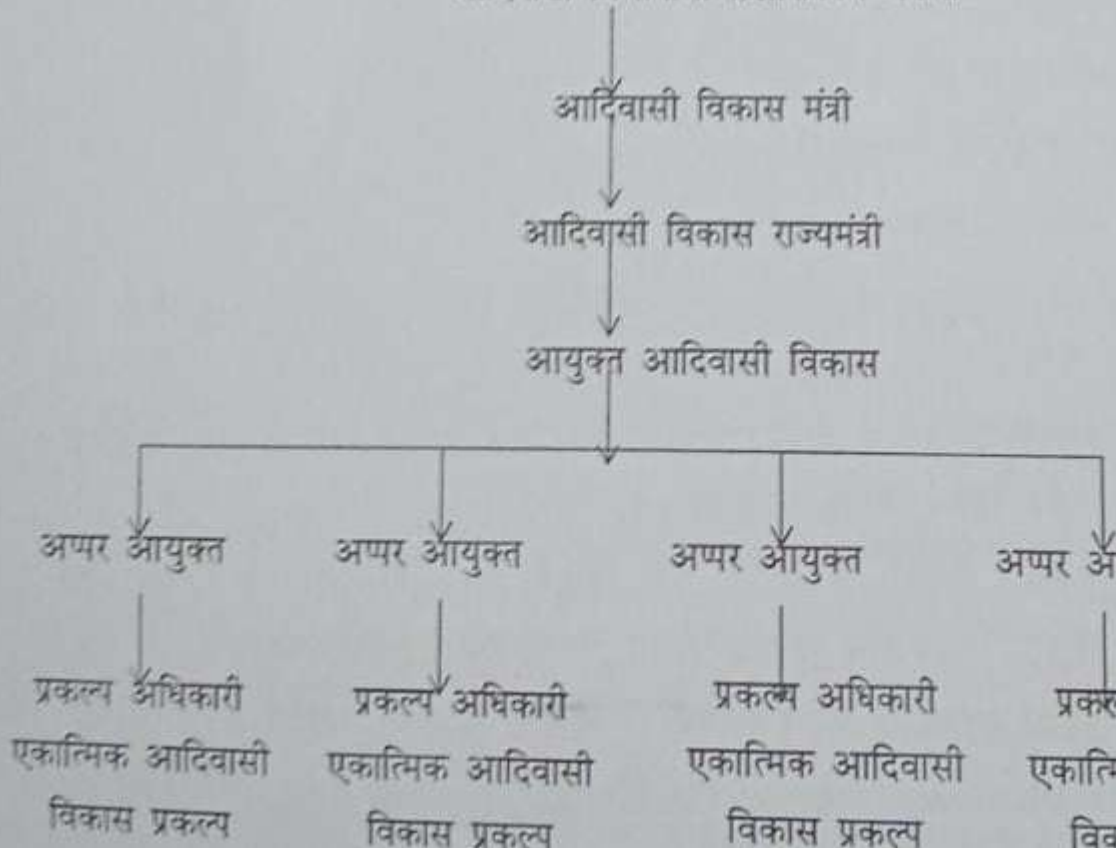
bawangadeharish@gmail.com

प्रस्तावना –

१९४७ मध्ये स्वातंत्र्य प्राप्त झाल्यानंतर स्वतंत्र भारताने २६ जानेवारी १९५० साली नविन राज्य घटना कार्यवाहित आणली सर्व भारतीय नागरिकांना यात समाविष्ठ करण्यात आले. पण आदिवासींचे जीवन अधिक दुर्बल व असहय असल्याने त्यांच्यासाठी काही विशेष तरतुदींची आवश्यकता होती. भारतीय संविधानात समता आणि न्यायाचे तत्व मान्य करून जाती व्यवस्थेच्या आधारावर निर्माण झालेली विषमता दुर करणे तसेच अनुसुचित जमातीचा विकास करण्याच्या दृष्टीने महत्वपूर्ण तरतुदी करण्यात आल्या.

विशेष म्हणजे भारतीय संविधानाच्या अनुच्छेद २७५ (१) नुसार व अधिनियमातील ५ (१) व १९ नुसार विशेष केंद्रीय सहाय्य योजने अंतर्गत आदिवासी शेतकऱ्यांच्या कृषी विकासात कशा प्रकारे वाढ करता येईल. यावर जास्तीत जास्त भर देण्यात आला.

आदिवासी विभागाची प्रशासकीय यंत्रणा



चंद्रपुर जिले के आदिवासी किसानों का दर्द

हरिश एम. बावनगडे
संशोधक छात्र (शोधार्थी)
राष्ट्रसंत तुकडोजी महाराज विश्वविद्यालय, नागपुर

शोध सार : भारत को 1947 को स्वतंत्रता मिली लेकिन स्वतंत्रता के इतने वर्ष बीत जाने के बाद भी चंद्रपुर जिले के आदिवासी किसान कितने संकट से गुजरते हैं। उन सभी के लिए भारत सरकार या महाराष्ट्र सरकार द्वारा विशेष रूप से भारतीय संविधान के अनुच्छेद 275(1) के अनुसार और 19 नुसार विशेष केन्द्रीय सहाय्य निती के अंतर्गत आदिवासी किसान के जीवन मे वृद्धि करने के लिए कुछ प्रयास किऐ गये हैं। फिर भी उनके जीवन के या खेती करने में बहुत सारी समस्या यथावत बनी हुई है।

शब्द संकेत : किसान, खेती, सरकार, योजनाएं

प्रस्तावना :

आदिवासी विभाग की व्यवस्था

▼

आदिवासी विकास मंत्री

▼

आदिवासी विकास राज्य मंत्री

▼

आयुक्त आदिवासी विकास

▼

प्रकल्प अधिकारी

यह सब आदिवासी किसान के जीवन मे और कृषि के विकास करने हेतु व्यवस्था की गई है। इस के माध्यम से भिन्न-भिन्न प्रकार की योजना तैयार की गई है। 1981-82 से न्यूक्लिअर बजट की योजना तैयार की गई है। इसके माध्यम से जिल्हा स्तर से ग्राम स्तर तक आदिवासी किसान का कृषि विकास होने के लिए है।

अनुसंधान के उद्देश्य

1. चंद्रपुर जिले के अंतर्गत आदिवासी किसान का विकास योजनाओं का अध्ययन.
2. चंद्रपुर जिले के आदिवासी किसानो का अभ्यास करना.

चंद्रपुर जिले में प्रशासकीय व्यवस्था

चंद्रपुर जिला

▼

Recent Trends in Mathematical Modeling, Simulation Methods, Computations, and Physical Sciences
International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)

Application of Fuzzy Logic Technique for Oil Drilling Problem

K.Y. Rokde[1], S.S.Shende[2]

[1]Assistant Professor, Department of Electronics, Dr. Ambedkar College, Nagpur, Maharashtra, India
Assistant Professor, Department of Electronics, Sharadchandra Pawar Mahavidyalaya, Lonand, Maharashtra, India

ABSTRACT

In this research paper, we studied a Decision making for Oil Drilling Problem using Fuzzy Logic Technique. In this problem, a geological engineer who has been asked by the chief executive officer (CEO) of a large oil firm to help make a decision about whether to drill the natural gas in a particular geographic region of northwestern new maxico. The first attempt at the decision process that there are only two states of nature regarding the existence of natural gas in the region. The CEO provides the utility matrix table. Further, CEO has asked you to collect new information by taking eight geographical boring samples from the region being considered the drilling. You have a natural gas expert examine the results of these eight tests; get the expert opinion about the conditional probabilities in the form of matrix.

For drilling problem, we have used two methods: Conditional probabilities for imperfect information & Conditional Probabilities of perfect information. From this method, we have calculated the expected utility, prior probabilities, conditional and unconditional probabilities of perfect and imperfect information and value of information is calculated. This totally fuzzy information and we have studied the value of fuzzy information which is less than the perfect and less than the imperfect information.

The problem of Oil Drilling Problem for Fuzzy logic technique is solved using the MATLAB programming software. This paper is totally based on software implementation of MATLAB.

Keywords : Oil drilling, Decision Making, Perfect, Imperfect Information And Uncertainty.

I. INTRODUCTION

1.1 Fuzzy Logic

The real world is complex , complexity arises from uncertainty in the form of ambiguity.“ as the complexity of the system increases , our ability to make precise and yet significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance (or relevance) become almost mutually exclusive characteristics.” These are the words of the LOTFI ZADEH who introduced fuzzy logic in 1965. “ The closer looks at a real world problem , the fuzzier becomes its solution”, observed Dr. Zadeh who published his seminal work “FUZZY SETS” in the journal or information and control.

When there is imprecision (more uncertainty) and inadequate data the fuzzy logic technique is useful.

Copyright: © the author(s), publisher and licensee Technoscience Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited

Secondly, the cost of information increases with precision. But the cost of fuzzy information is far less than the perfect or imperfect information. Thus, there are two – fold advantages of the fuzzy logic technique: Understanding of complex systems becomes easier and analysis makes the system costs effective. He used the linguistic variable and further suggested that set membership function is the key to decision making when there is uncertainty.

The attention currently being paid to fuzzy logic is most likely the result of present popular consumer products such as washing machine, cameras, elevators, air conditioners, rice cookers, automobile, dishwashers etc. The nature of uncertainty in a problem is a very important point that engineers should ponder prior to their.

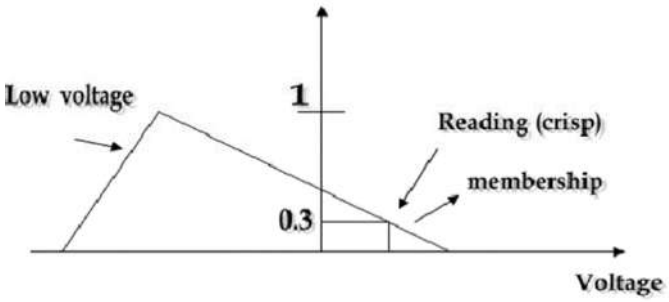


Fig.1.2 Fuzzy sets and crisp reading

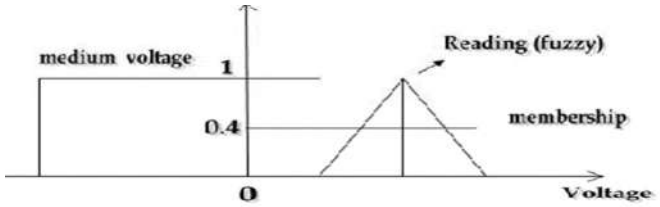


Fig. 1.3 Fuzzy set and fuzzy reading

1.2 Fuzzificaion

Fuzzification is the process of making a crisp quantity fuzzy. We do this by simply recognizing that many of the quantities that we consider to be crisp and deterministic are actually not deterministic at all. They carry considerable uncertainty. If the form of uncertainty happens to arise because of imprecision, ambiguity or vagueness then the variable is probably fuzzy and can be represented by a membership function.

In the real world such as, digital voltmeter generates crisp data, but these data are subject to experimental error. The below fig 1.1 shows one possible range of errors for a typical voltage reading and associated membership function that might represent such imprecision

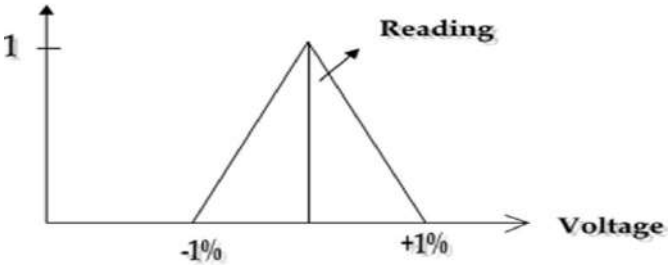


Fig 1.1 Membership function of crisp voltage reading

1.3 Defuzzification

It is the conversion of fuzzy quantity to a precise quantity. The output of a fuzzy process can be the logical union of two or more fuzzy membership functions defined on the universe of discourse of the output variable.

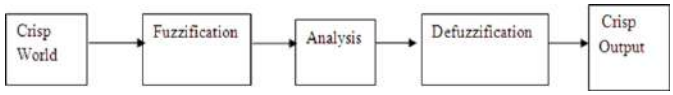


Fig 1. 4 Block diagram of Fuzzy to Crisp Conversion

1.4 Oil drilling concept

A geological engineer who has been asked by the chief executive officer (CEO) of a large oil firm to help make a decision about whether to drill the natural gas in a particular geographic region of northwestern new maxico. The first attempt at the decision process that there are only two states of nature regarding the existence of natural gas in the region. The CEO provides the utility matrix table. Further, CEO has asked you to collect new information by taking eight geographical boring samples from the region being considered the drilling. You have a natural gas expert examine the results of

these eight tests; get the expert opinion about the conditional probabilities in the form of matrix.

II. METHODOLOGY

For solving the oil drilling problem using fuzzy logic technique number of methods are available like Fuzzy Sets, Fuzzy relation, Cartesian product, alpha- cut, Non-transitive ranking methods etc. For oil drilling problem, we have two methods:

1) Conditional probabilities for imperfect information
2) Conditional probabilities of perfect information

From this method, we have calculated expected utility, maximum expected utility, prior probabilities, conditional and unconditional probabilities of perfect and imperfect information and value of the information calculated. This is totally fuzzy information which is less than the perfect and less than the imperfect information.

2.1. Nontransitive Ranking Method

When we compare objects that are fuzzy, ambiguous, or vague, we may well encounter a situation where there is a contradiction in the classical notions of ordinal ranking and transitivity in the ranking. To accommodate this form of nontransitive ranking, we introduce a special notion of relativity.

Let x and y be variables defined on universe X. We define a pairwise function fy(x) as the membership value of x with respect to y

And we define another pairwise function

fx(y) as the membership value of y with respect to x then the relativity function is given by

$f(x/y) = fy(x)/ \max[fy(x),fx(y)]$ (1)

is a measurement of the membership value of choosing x over y. The relativity function f(x/y) can be through of as the membership of preferring variable x over variable y.

To develop the genarl case for many variables, define variables x1,x2,------, xi,xi+1, ……,xn. All defined on universe X, and let these variables be collected in a set A i.e A= {x1,x2,……,xi-1,xi, xi+1, ……,xn}. We then define a set identical to set a except this new set will be missing one element xi, and this set will be termed A'. The relativity function then becomes

$f(xi/A') = f(xi/ \{x1,x2,……,xi-1,xi, xi+1, ……,xn\})$

$= \min\{f(xi/x1), f(xi/x2),……, f(xi/xi-1), f(xi/xi+1), ……,f(xi/xn)\}$ (2)

Which is fuzzy measurement of choosing xi over all elements in the set A'. The expression in equ(2) involves the logical intersection of several variables; hence the minimum function is used. Since the relativity function of the variable with repsect to itself is identity.

$f(xi/xi)=1$ (3)

then

$f(xi/A') = f(xi/A)$ (4)

We can now form a matrix of relativity values. f(xi/xj), where i,j=1,2, n, and where xi and

xj are defined on a universe X. This matrix will be square and of order n, and will be termed the c matrix (c for comaprision). The c matrix can be use to rank many different fuzzy sets.

To determine the overall rnking, we need to find the smallest value in each of the rows of the C matrix; that is,

$Ci' = \min f(xi/X), i= 1,2,……,n.$ (5) Where Ci' is the membership ranking value for the ith variable.

III. EXPERIMENTAL WORK

Program:-

```
% s1 = there is natural gas
% s2=there is no natural gas
% prior probabilities for each state is p=inline('s1=0.5')
p=inline('s2=0.5')
syms ps1 ps2 uji s1 s2 a1 a2 px1 px2 ps1=0.5
ps2=0.5
% probabilities sum to unity
% There are two alternatives
```

% a1=drill for gas
% a2= do not drill for gas
% The CEO provides the utility matrix is given by U=[uji s1 s2;a1 4 -2;a2 -1 2]
u11=4 u12=-2 u21=-1 u22=2
% utility matrix for this situation U1=[4 -2;-1 2]
% the expected utility matrix is E1=ps1*u11+ps2*u12 E2=ps1*u21+ps2*u22
% maximum utility (E=E(u*)) E=max(E1,E2)

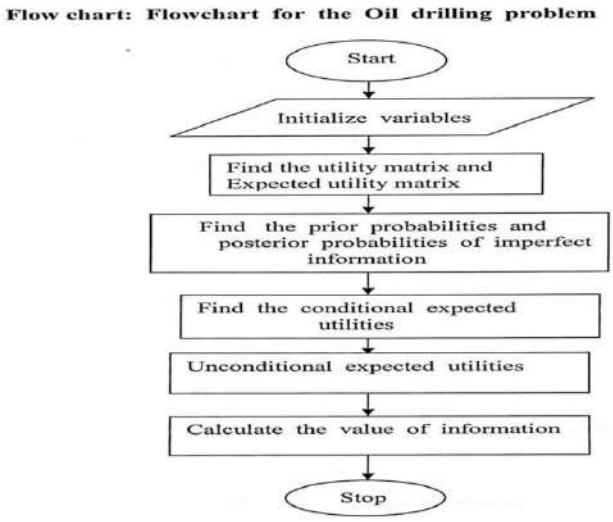


Fig 1.5 Flowchart for oil drilling problem

IV. RESULT AND DISCUSSION

In this example of the oil drilling problem, we studied about the large oil firm to help make a decision about whether to drill for natural gas in a particular geographical region. The prior probabilities geographical region. The prior probabilities of drilling information was

Ps1= p(s1) =0.5
Ps2 =p(s2) =0.5

The expected utility matrixes have been done by using utility matrix and prior probabilities. The eight geographical boring samples from the region have been considered for drilling. The table of imperfect and perfect information was very useful for this problem. The marginal probabilities for the new imperfect information, conditional probabilities, conditional expected utilities for imperfect and perfect information was studied. At last the values of new information have been calculated of both imperfect and perfect information. Some procedure will be happened in case of perfect information.

In this result, the fuzzy information was considered and fuzzy conditional probabilities have been derived. The fuzzy posterior probabilities P(Si/M) and fuzzy expected utilities E(uj/Mt) was done. The maximum conditional probabilities have been calculated and at last the fuzzy information calculated. The fuzzy information is less than the value of perfect information and less than the value of imperfect information. The result of imperfect information and perfect information is as shown in below table.

	X1	X2	X3	X4	X5	X6	X7	X8
p(s1/xk)	0	0.3333	0.2000	0.3333	0.6667	0.8000	0.6667	1.0000
p(xk/s2)	0.05	0.1	0.4	0.2	0.1	0.1	0.05	0
p(xk)	0.0250	0.0750	0.2500	0.1500	0.1500	0.2500	0.0750	0.0250
E(u*/xk)	2.0000	0.6667	1.2000	0.6667	2.0000	2.8000	2.0000	4.0000
aj/xk	a2	a2	a2	a2	a1	a1	a1	a1

Table 1. Posterior probabilities based on imperfect information

	X1	X2	X3	X4	X5	X6	X7	X8
P(s1/xk)	0	0	0	0	1	1	1	1
P(xk/s2)	0	0	0	0	1	1	1	1
P(xk)	0.05	0.1	0.25	0.1	0.1	0.25	0.1	0.05
E(u*/xk)	2	2	2	2	4	4	4	4
aj/xk	a2	a2	a2	a2	a1	a1	a1	a1

Table 2. Posterior probabilities based on perfect information

V. DISCUSSION

One area in which fuzzy set theory has a great potential that in psychology; in particular the psycho logistics which is essential for studying the connection between human communication and decision machines. Today, close to four decades after the artificial intelligence (AI) was born. It can finally be said that intelligent systems are becoming a reality. The soft computing has direct bearing on machine

intelligence. Neuro fuzzy soft computing has a special role in the design of modern intelligent systems.

VI. APPLICATIONS OF FUZZY LOGIC

- Control systems
- Pattern recognition
- Robotics
- Consumer electronics
- Automobiles
- Intelligent systems

VII. FUZZY LOGIC IN CONSUMER GOODS

Cameras , Washing machine , Air conditioners , Luxury cars , Elevators , Rice cookers , Automobile , Dishwashers , Refrigerator , Camcorders , Vac. Cleaner etc.

VIII. SCOPE OF WORK

The scope of further research work is to develop and design some electronic circuits such as speed control motor, automatic control system and some decision making problem like weather forecast. This has been recently used for user-oriented verification of probability forecasts, but there is applied to aid forecast users in optimizing their decision making from probability forecasts.

IX. REFERENCES

[1]. Ross T J , "Fuzzy logic with engineering applications" , MGH,(1997.

[2]. Klir G J , " Fuzzy sets , uncertainty, and information" , PHI, 2002.

[3]. J. E. Colgate and K. M. Lynch, "Mechanics and Control of Swimming: A Review," IEEE Journal of Oceanic Engineering, vol. 29, pp. 660-673, July 2004.

[4]. R. Ramamurti and W. C. Sandberg, "Computational Fluid Dynamics Study for Optimization of a Fin Design," In Proc. of the 24th AIAA , Applied Aerodynamics Conference, AIAA- 2006- 3658, San Francisco, CA, 2006.

[5]. Lee C. C, "Fuzzy logic in control systems", IEEE Trans. On Systems, Man, and Cybernetics, SMC, Vol.20, No.2, 1990, pp. 404-35

[6]. Rudra Pratap, "MATLAB A quick Introduction for Scientist and Engineers", Oxford University Press 2004

[7]. Bernardinis L A, " Clear Thinking on Fuzzy Logic", Machine Design, April 23, 199.

[8]. Engineering(An ISO 3297: 2007 Certified Organization ,Vol. 2, Issue 1, January 2014 p-p 2626-2631

[9]. system and simulation, , IACSIT Press, Singapore, pp. 92–95, Vol.7., 2011 [10]Cooper J A, "Fuzzy algebra uncertainty analysis for abnormal environment safety assessment", J intelligent and fuzzy systems, January vol 3, issue 4, 337-346

WWJMRD 2022; 8(1): 121-125
www.wwjmrd.com
International Journal
Peer Reviewed Journal
Refereed Journal
Indexed Journal
Impact Factor SJIF 2017: 5.182 2018: 5.51, (ISI) 2020-2021: 1.361
E-ISSN: 2454-6615
DOI: 10.17605/OSF.IO/TVJ6B

K.Y. Rokde
Department of Electronics, Dr. Ambedkar College, Nagpur, India.

S.S. Shende
Department of Electronics, Sharadchandra Pawar Mahavidyalaya, Lonand, MS, India.

S.R. Sharma
Department of Electronics, J.M.Patel College, Bhandara, India.

Correspondence:
K.Y. Rokde
Department of Electronics, Dr. Ambedkar College, Nagpur, India.

Implementation of Low-Cost Data Acquisition System for Temperature Measurement

K.Y. Rokde, S.S. Shende, S.R. Sharma

Abstract
This research paper is used to implement a low-cost data acquisition system [DAS] to record physical and electrical quantities for environmental measurement specifically temperature. This system measured temperature using LM 35 temperature sensor and after converting it in digital form by an analog to digital converter with the help of 16- bit ADC (ADC 0808). The 16-bit ADC is designed in laboratory and it is interfaced to the PC by using parallel port C- Programming is used for this purpose.

Keywords: Temperature, DAS, low cost etc.

1. Introduction

The world is digitized now a day's i.e. in every aspect of life, use of computer is increased. Most sensors signals have been digitized at low medium resolution. A method is used to reducing these inaccuracies is to convert analog signal to digital values as early in the process as in practical and then to process the single in digital domain [1].

Taking the manual measurement direct digitalization of detector waveforms have been reported in early 1970's. These system works limited by the available technology to slow particle velocity and low count rate. In 2002 it was reported that a second-generation analog to digital hybrid data acquisition system which retain wide dynamic range and high resolution which data can be acquired to over 30.000 events per second. Now reporting third generation, higher speed data acquisition system which retain the above mutation feature of the original system [2].

The data acquisition system is basically A/D converter coupled with an interface that allows a personal computer to capture the digital output information from conversion. A data acquisition system designed for high performance will work in a very wide range of test and measurement and control application. Depending upon the DAS the analog signals are converted into the digital form. Data acquisition system is used in many different applications to monitor and collect specific type of information [3].

2. Methodology

A. Data Acquisition System

Data acquisition system can be defined as the process by which events in the real world or translated to machine- readable signal. A typical data acquisition system consists of individual sensors with necessary signal conditioning, multiple signals, data conversion, data processing, data handling and associated transmission, storages and displays system [4].

A data acquisition system uses of electronics and mechanical components to monitor and control complex processes. The methodology include following,

1) Possesses sensors that measure such parameters as temperature, pressure, voltage, current etc.
2) Transmitter that convert measurement electrical or pneumatic signals and control.
3) Software provides the computer with instructions and routine.
4) process interface devices such as analog to digital converter.

The various configuration include DAS are

1. Single Channel
2. Multichannel

3. Experimental Work

Block Diagram of Das

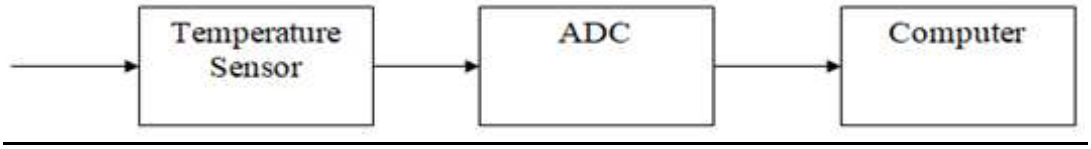


Fig 1.1: Block diagram of DAS.

A. Temperature Sensor

Sensors are the device which sense particular non electrical quantity and converting them into electrical measurable quantity. The used Sensor is LM 35 series are precision integrated circuit temperature sensors. The LM 35 does not require any external calibration and trimming to provide typical accuracies of +_ 3/4˚Cover a full -55˚C to +150˚C temperature rang. The LM 35 is a low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used single power supply; it has very low self-heating, less than 0.1c in still air [5].

B. ADC (Analog to Digital Conversion)

Analog to digital converters is among the most widely used devices for data acquisition. A digital computer use binary values but in the physical world is analog connecting digital circuitry to sensor is simple if the sensor devices is inherently digital. However, when analog devices are involved, interfacing becomes much more complex [6].

.

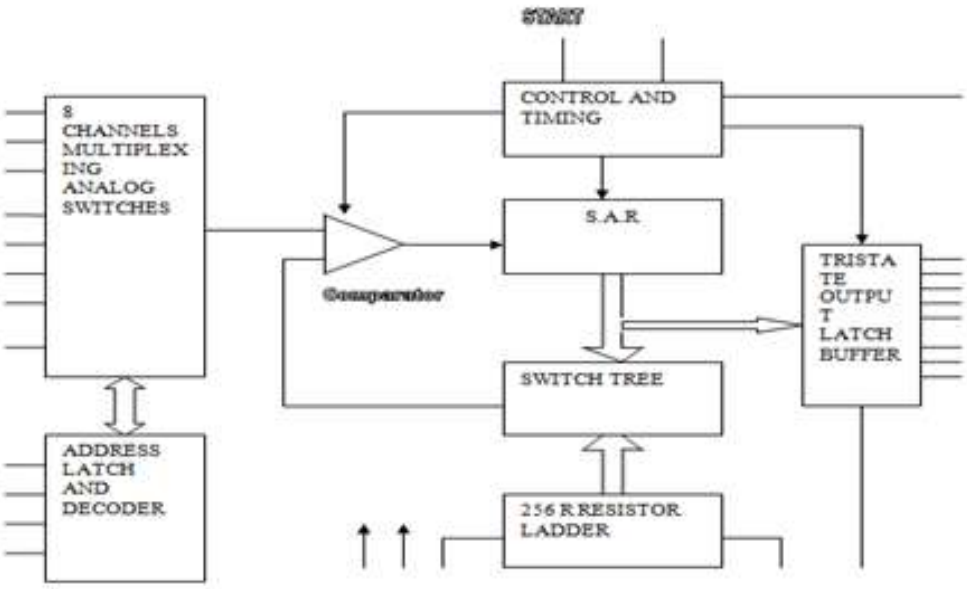


Fig 1.2: Block diagram of ADC 0808.

The ADC 0808 data acquisition component is a monolithic CMOS device with an 8-bit analog to digital converter, 8-channel Multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximations the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register. The device eliminates the need for external zero and full-scale adjustments [7]. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL Tri-state outputs. The ADC 0808 offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeability, and consume minimal power. These features make this device ideally suited to applications from process and machine control to consumer and automotive applications [8].

The Successive approximation register by one, each output of SAR is performing 8 iterations to approximate the input voltage. One switched. SAR is reset on the positive edge of SOC pulse. Conversion starts on falling edge of SOC. If continuous conversion is required, we connect EOC to SOC. However, initially on power up, SOC will have to give externally. The last section is the comparator. It determines the accuracy of the system. A chopped stabilized comparator is used [9].

Circuit Diagram

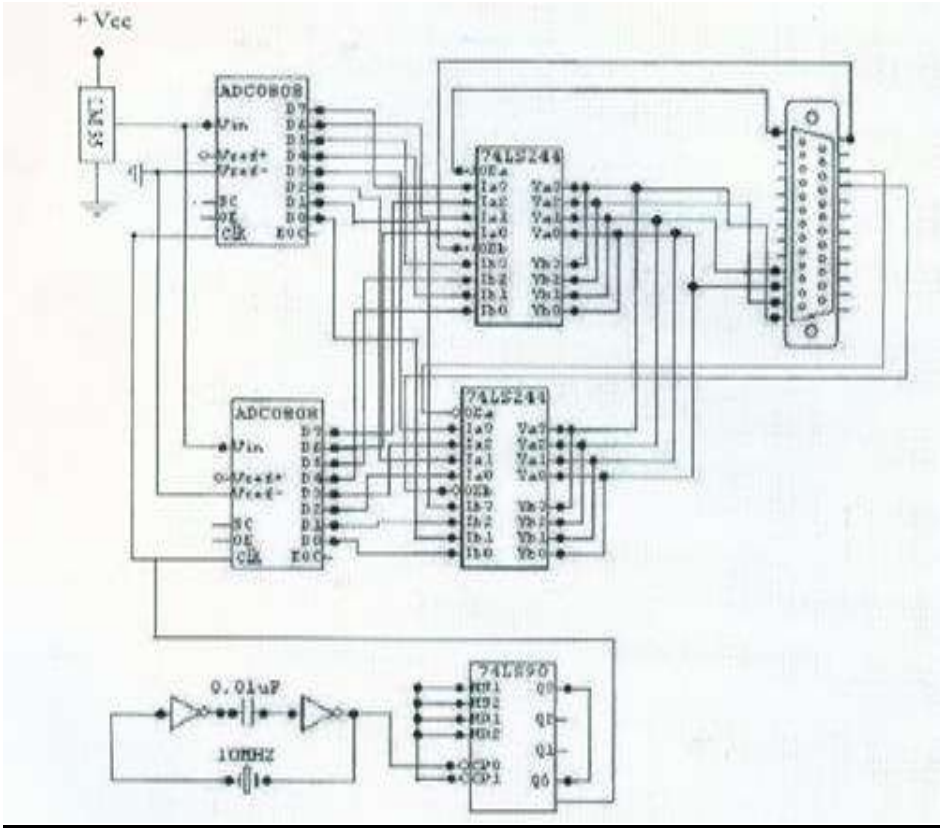


Fig 1.3: Circuit diagram of System.

Flow Chart

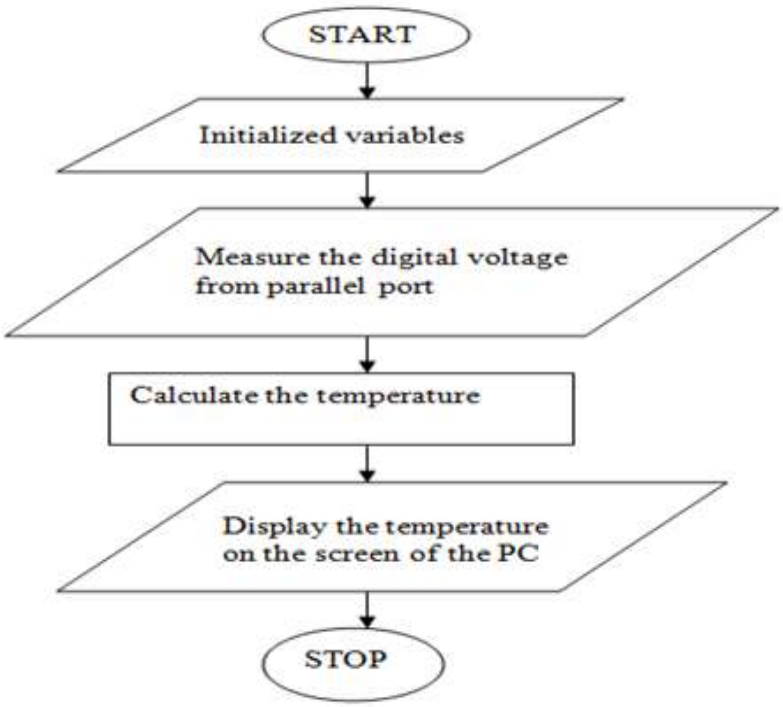


Fig 1.4: Flowchart of circuit.

4. Result and Discussion

The temperature was sensed with the help of temperature sensor LM 35. Its output is in the form of analog voltage which changes as 10 mV for 1˚C temperature range. This analog voltage from the sensor was converted to digital form for further processing with the help of 16-bit ADC. With Vref (+) =+5V and Vref(-)= Gnd, the minimum change that

16-bit ADC can detect was found to be 12mV. As the sensor change 7mV for 1˚C, so that the minimum change that the ADC can detect is 7mV.

So, the temperature sensor was give the output of 16-bit ADC and interfaced to the PC. The output of ADC with the temperature change is given in the table below.

Table 1.1: Output of ADC with temp. Change.

Temp 0°C	Digital Output																Digital Output on PC
	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	
LOW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HIGH	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	65535
100	1	1	1	1	0	0	1	1	1	1	1	0	0	1	1	1	62479
95	1	1	0	1	1	1	1	1	1	1	0	1	1	0	1	1	57303
90	0	0	1	1	0	1	0	1	1	0	1	1	0	1	0	1	27385
85	0	0	1	1	0	0	1	1	0	1	1	1	0	1	1	1	13175
80	0	0	0	1	1	0	0	1	1	0	1	0	1	0	1	1	6599
75	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0	1	1425
70	0	0	0	0	0	0	1	0	1	0	1	0	0	1	1	1	679
65	0	0	0	0	0	0	0	1	1	1	1	1	0	0	1	1	499
45	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	255

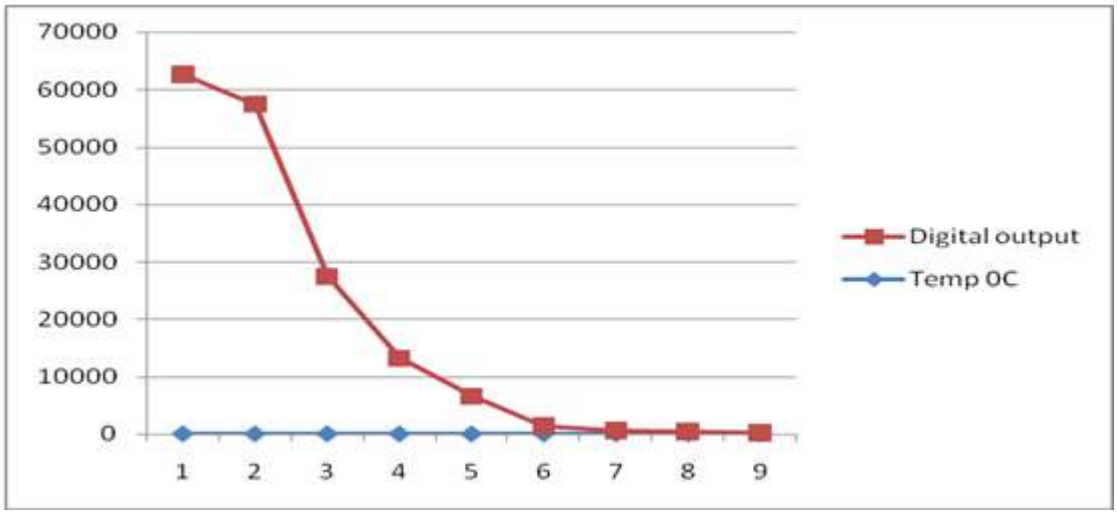


Fig 1.5: Variation of Temperature with digital output.

5. Future Scope

The 16-bit data can be interfaced to a computer by using serial port (RS 232) and it also use in microcontroller-based data acquisition system.

6. Application

1. A multichannel data acquisition can be implemented for interfacing various parameters, using different sensors.
2. High Sampling use in Videos processing and waveform analysis.
3. A ADC and Data acquisition system used in Embedded system for controlling and converting Analog to Digital Converter

References

1. Ayala Kenneth J.”The 8051 Microcontroller”, Published By Penram International (India), Second Edition.
2. Dougherty Kelvin M.,” Analog to Digital Conversion” A Practical Approach, Mc-Graw Hill, Inc.
3. Hall D.V,”Microprocessor & Interfacing Programming Hardware”, Tata Mc-Grow-Hill Edition, 1991, Seventh Reprint1995.
4. Mazidi Muhammad Ali, Mazidi Janice Gillispie,” The 8051 Microcontroller and Embedded Systems” Published by Pearson Education (Singapore) Pvt. Ltd, First Edition.
5. Khan, F. and Bilgainya, R., Synthesis and characterization of metal and metal oxide sponges using Triton X-165 as sacrificial template. Indian J. Chem. A, 2011, 55–59.
6. Jung, J.Y., Lee, J.W.: Improved WBAN Communication at Mental Healthcare System with the Personalized Bio Signal Devices. In: The Proceedings of 8th International Conference Advanced Communication Technology, Korea, pp. 812–816 (2006). 8. Vaudenay, S.: On the need for Multipermutations: Cryptanalysis of MD4 and SAFER. In: Preneel, B. (ed.) FSE 1994. LNCS, vol. 1008, pp. 286–297. Springer, Heidelberg (1995).
7. U. Anliker, J. A. Ward, P. Lukowicz, G. Tröster, F. Dolveck, M. Baer, F. Keita, E. Schenker, F. Catarasi, and R. Schmid, “AMON: A Wearable multi parameter medical monitoring and alerts system”, IEEE Trans. On Inf. Technol., Biomed., vol. 8, no. 4, pp. 415-427, 2004.

8. Istepanian, R.S.H., Jovanov, E., Zhang, Y.T.: M-Health: Beyond Seamless Mobility and Global Wireless Health-Care Connectivity. The Proceedings of the IEEE Transactions on Information Technology in Biomedicine, 405–414 (2004).
9. Hairong Yan, Hongwei Huo, "Wireless Sensor Network Based E-Health System- Implementation and Experimental Results", Member, IEEE Trans. On Consumer Electronics, vol. 56, no. 4, November 2010.

IMPACT FACTOR – 5.61

LangLit

ISSN 2349-5189

An International Peer-Reviewed Open Access Journal

Langlit Latur (MS) India AIPROAJ

MELANG OF CULTURES IN AMITAV GHOSH'S *IBIS TRILOGY*

ANITA TIRPUDE,
Assistant Professor,
Department of English
Dr. Ambedkar College,
Deekshabhoomi, Nagpur

ABSTRACT

Multiculturalism is one of the important aspects of global literature. It is a social theory that bring together different themes such as cultural diversity, hybridity, displacement, identity and conflict. The diaspora literature is recognized as a multicultural literature. Amitav Ghosh is an Indian writer writing in English. His Ibis Trilogy is based on the history of India during Nineteenth century under British colonialism. In his Trilogy, he draws his characters from different geographical regions to focus mainly on various cross-cultural ties. They are from diverse background, come together on Ibis as an indentured labours destined to Mauritius to form a multicultural world. This paper is an attempt to show how multiculturalism forms a global world with peace and prosperity.

Keywords: Multiculturalism, British Colonialism, Girmitiyas, Indentured Labours, Opium Trade, Opium Wars etc.

Introduction

Multicultural society was developed in the twentieth century. It occurred due to immigration to the United States in the early centuries and especially to Europe due to the post-world war II social legacy of toxic ethnonationalism. In 1950 and 1960, the European government in need of labor at the cheaper rate allowed neighboring countries from Northern Africa, Turkey, and the Common Wealth countries like the UK, Canada, Austria, etc. These European nations adopted a Laissez- fair model of society adjusting initially with the immigrants but never integrate with them. These immigrants were not forced to accept European culture which might be taken by them as an act of cultural digression. In the meantime, this multiculturalism co-existence set into lofty conventional wisdom. The basic cause for providing the space and time to the newcomers was to adjust and re-established their self-esteemed and ultimately to join the main flow of the society. This was the basic aim initially. Multiculturalism in the due course of time became problematic which resulted in segregation, fear, suspicion, and then ultimately to conflict. (1)

Multiculturalism

The term 'Multiculturalism' is used in reference to Western nation-states which has achieved a de facto single national identity during the 18th and /or 19th century (2).The countries like Asia, Africa, and America having diverse cultures. They have multiculturalism, in some of these countries, communalism is a major political issue. The policies adopted by these countries are parallel with the western countries' multicultural

policies. Supporters of multiculturalism consider it a fair system that allows one to express freely their own identity. Most of them are of opinion that culture alone is not responsible to bring change in society but there are other factors as well that bring change as the world change.

In its broader sense, multiculturalism refers to "the social and political movement and/ or position that views differences between individuals and groups to be a potential venue of Cultural strength and renewal; multiculturalism celebrates and explores different varieties of experience stemming from social, ethnic, gender, sexual and/or class difference" (Wolfreys 97)

According to Bhikhu Parekh "the term 'multicultural' refers to the fact of cultural diversity and the term 'multiculturalism' refers to a normative response to fact" (128).

In Academic studies, multiculturalism deals with postcolonial literature. Multicultural literature is a subgenre of diasporic literature which gives importance to the experience of different ethnic and minority communities. Multicultural literature emerged as a protest against the canonical literature which favors Eurocentrism that works for marginalized and misrepresented the culture of Africans, Asians, and Native Americans.

Amitav Ghosh is an Indian Writer writing in English.Ibis Trilogy consists of three novels as Sea of Poppies, River of Smoke and Flood of Fire. Ibis Trilogy has a world of multiculturalism where we see characters from different strata of society come together to form a multicultural world on the ship Ibis. They accepted the job on the ship as Grimitiyas i.e. Indentured labours who were compelled either by their own society or British imperialism to leave their countries.

Girmitiyas

Girmitiyas or Jahajis were laboured whom the colonizers sent to Fiji, Mauritius, South Africa and the Caribbean to work on a sugar plantation for the profit of the European. The word girmits means "agreement", an agreement of the British government with Indian Labours. (3)

In 1833, the abolition of slavery in the British Empire led to a shortage of labours. To meet the shortage, indentured emigration began in the 19th century. Thousands of labours from different religions and castes were transported to the Fiji islands. Among these migrants, there were more than one million Indians who shifted to the colonies in the Indian and Atlantic Ocean.

Charles Andrews, a Social reformer and educator and William Win Stanley Pearson were of opinion that the indentured system is parallel to slavery as evil, humiliating, merciless, savage and dehumanizing as slavery in this "Report on Indentured Labours in Fiji: An independent Enquiry" (1916). Amitav Ghosh has also tried to show the connection between two systems i.e. slavery and the history of indentured labours on ship ibis in the Ibis Trilogy. This ship was earlier used to convey 'human cargo' but later it was used to transport the modern and sophisticated version of slavery (SOP 12). The slaves or coolies were exploited by the plantation owners. They had to work for two-third in six days a week. They were paid less and their salary was deduced if they took leave. The women were double exploited i.e. they

were paid less as compared to men and secondly, they were exploited sexually by the plantation owners and sardars.

Ibis Trilogy

Amitav Ghosh's Ibis Trilogy is a historical novel set in the 19th-century opium war between Britain and China. In the first part of the Trilogy, The European powers for their greed made efforts to open the Chinese market for the opium trade in the name of free trade. In Sea of Poppies, the first part of a trilogy, we see the East India Company colonized Bengal and other regions of Eastern India in the 19th century. Colonizerto promotes the opium trade forcibly imposed cultivation of opium in these areas which destroyed native's agriculture and trade. This disturbed the economic condition in rural areas and towns and people are forced to become indentured laborers on Ibis due to the colonizer's opium policy. The farmers including women were forced to become indentured laborers, traveled to Mauritius through the ship 'Ibis'. Thus, they came across each other who are indentured laborers, lascars, and sailors bringing together their varied cultures, languages, race, caste, religion, food habits, traditions, etc. We see a multicultural world on the ship Ibis.

Sea of Poppies is followed by River of Smoke, the second part of the trilogy depicts the story further where the ship Ibis landed on the land Mauritius with few labors. River of Smoke focuses on the trade of opium which is set in the Fanqui town of China. Here we see how from different parts of the world, the traders arrived for the opium trade. The novel starts with Deeti, but then shifted to Bahram Modi, an Indian Parsee opium trader competing with the British traders. Global interaction is shown with the help of indentured laborers and opium trades.

Flood of Fire depicts the stories of indentured labors and their communities and how their life has been disturbed by transnationalism and capitalism. Ghosh Trilogy focuses on the marginal as a leading figure who has been neglected in the past.

With British Imperialism, there is a development in trade, commerce, and industry. The British entered India with the help of the East India Company doing trades. The trades like the opium trade, the slave trade, and Indigo cultivation in Bengal were very oppressive. In the novel Sea of Poppies, we come to know the plans of British trader's behind these trades. In 19th Century India, the East India Company had a complete hold on Bengal and the Eastern Province which was beyond Bengal was under the purview of the company Bahadur's rule. The rule brought havoc in the village and towns enforcing them the policies regarding the cultivation of opium thus destroying the native's agriculture and trade.

Sea of Poppies

In Sea of poppies, a large number of characters come together in Calcutta, a city having varied races and people having diverse faith and creeds to be shifted to Mauritius as an indentured labours on the ship Ibis. The ship Ibis also called a coolie ship is used to transport labours or grimitayas to the British Colonies in Mareech.

They were so-called because, in exchange for money their names were entered on 'girmits'-agreement was written on a piece of paper. The silver that was paid for them went to their

families and they were taken away never to be seen again; they vanished as if into the netherworld (SOP 72).

There are four important characters in Sea of Poppies who are from different cultures and have been a victim of colonial rule. The first is Deeti, a high caste widow married to opium addict Hukum Singh, who is drugged on her wedding night and violated by her brother-in-law to hide the impotence of her husband. She lost her husband and due to growing opium in her field as a part of the company's colonial policy, she is indebted to the moneylenders. In order to survive, she has only one option i.e. to abandon the family's old agricultural tradition and become indentured labour on the ship. Due to old age tradition, she has to face the ritual practice of sati and is rescued by Kalua a chamar. Both of them eloped, signed the agreement as girmits. Neel Rattan Halder, a Raja of Rakshali estate who became a victim of forgery by the British trader Burnham, thus became a prisoner to be sent to Mauritius through Ibis. Neel faced disgrace at the hand of the company, He received very bad treatment as a common criminal which reminds us of the history of colonial Bengal where Raja Nand Kumar got the same treatment by the British. Raja Nand Kumar in the late 18th century lost favor from governor Warren Hasting. He was charged with forgery and kept in prison in a very bad condition like a common prisoner. It was said that Hastings closeness to Sir Elijah Impey, then Chief Justice, saw Nand Kumar to the gallows at a time when forgery was not awarded capital punishment. (Mehta, 525-528; Roberts P.E. 180). Paulette, a French Botanist, adopted by Mr. Burnham after her father's death tried to take advantage of her, she disguised herself as indentured labour on Ibis to start her new life in Mauritius. Zachary Reid, an American mulatto, son of a black American woman and a white father who also faced racial discrimination also joined Ibis as a Carpenter. Ah, Fatt, who is of hybrid origin half Parsee and half Chinese was a prisoner, Baboo Nob Kissan along with other people as Heeru, Ratna, Champa, Sarju, Dookhanee, etc. They form their own society and one culture.

Sea of Poppies exposes the destruction caused by the opium trade in India, the deplorable condition of the indentured labours who are no better than the slaves, and "the experience of enslavement, transportation, or 'voluntary' removal…eroded" their "valid and active sense of self. (Ashcroft et al, The Empire Writes Back 9) and the havoc brought up by the slave trade.

In the Empire Writes Backs, Said Quotes

> *" A valid and active sense of self may have been eroded by dislocation, resulting from, the experience of enslavement, transportation or involuntary removal for the indentured labours or it may have been destroyed by cultural denigration, the consciousness and unconscious oppression of the indigenous personality and culture by a supposedly superior racial and cultural model".(152)*

All these people become indentured labours, leaving their native place and thus they are uprooted from their own place and culture symbolizes the dislocation reminds us the Heidegger's term unheimlich or unheimlichkiet, which literary means unhousedness or people of different culture, religions, castes, and countries come under one roof i.e. the ship Ibis, thus providing the images of cosmopolitanism. They form their own society and one culture and "developed their own distinctive culture(s) which both preserve(s) and often extends and develop their original cultures." (Ashcroft et al 70)

Ibis is a slave ship carrying passengers from different nations, backgrounds, and beliefs. Some are convicts being transported to prisons. All these characters are from different strata of society like Deeti a high caste widow, Kalua a low caste chamar, Paulette a French orphan, Jodu half-brother to Paulette and Neel, bankrupt Raja of Rakshali estate. All they sail for their new lives into the Indian oceans washing away their old familial ties and leading towards lives afresh. For them the ship becomes a new nation creating in them a bond of empathy and they throw off the strictures of caste, class, race, religion, and community and becomes Ship Siblings. The indentured labours after joining Ibis form an unusual relation among themselves like friendly relations between Zachary and Jodu, Neel and Zachary, An affectionate relationship between Zachary and Paulette, Jodu and Munia, Jodu and Paulette. Thus Ibis creates among characters a multicultural panorama

River of Smoke

River of Smoke, the second part of the Ibis Trilogy depicts the era of globalization where people from various countries, societies, cultures, customs come together to do business and get transformed in several ways. Ghosh has constructed all types of characters in River of Smoke like Bahram Moddie, a Parsee trader, Neel an exiled Raja who later becomes Bahram's munshi, Zadig the Armenian watchmaker and traders, Fitcher Penrose, a Cornish botanist who is on an expedition to gather rare plants in China, Paulette Lambert, daughter of a French botanist who accompanies Fitcher on his expedition, and, Ah Fatt or Freddie, an illegitimate son of Bahram and an opium addict, Robert Chinnery, a painter and an Anglo-Indian son of George Chinnery, Charles King, Mr Jardin, Mr Dent, Mr Inning and Commissioner Lin Zexu – an incorruptible Chinese mandarin and a representative of Chinese Emperor.

The novel opens with Deeti's clan "la Fami Colver in the cliffs of Mauritius who are marching a ritual procession to her "Memory Temple". Deeti after serving as indentured labour on Ibis establishes her own multicultural community in Mauritius. River of Smoke starts with Deeti shrine containing pictures of characters in Sea of Poppies. Ghosh then shifts to Canton, a hub for the opium trade and other business. We see Paulette and Neel from the first part of the trilogy appearing again in River of Smoke. Ghosh then introduces a wide range of characters among them is Bahram Modi, a Parsee trader from Bombay who has built his fortune by selling opium to China. He has involved actively in "Free trade, Universal Free Trade" (406).

He confesses:

> *Democracy is a wonderful thing Mr. Burnham … It is a marvelous tamasha that keeps the common people busy so that men like ourselves can take care of all matters of importance. I hope one day India will also be able to enjoy these advantages – and China too, of course. (404)*

Canton has both small and large scale industry and it represents the Cosmopolitical world. River of Smoke studies a Cosmopolitical culture in the early 19th century. Canton is a representation of cosmopolitan and multicultural society. Many people from different part of the world have visited Canton to do trade and earn a profit. We see people from different

countries using languages which is a mixture of Indian, Chinese, French, thus making it look global.

Ghosh represents past, travelling and mobility which resulted from trade commerce, migration and the use of different languages. He examines in the novel the three important transnational networks i.e. Migration of indentured labours through the Indian Ocean, the opium war between Britain, China and India and the chance of exchanging the flora and art. Thus River of Smoke has a theme of globalization which has been achieved through trade bringing the people from different places together via indentured labours or traders. These people come together first on Ibis and later in Fanqui town.

Flood of Fire

The final installment of the Ibis Trilogy is Flood of Fire which is concerned with the opium trade between Britain, India and China in the 19th Century. Followed by the previous two novels, the story continues in 1839 arousing tension between these three countries due to ban on opium smuggling by Beijing and ultimately resulting in the war declared by the colonial government. A ship named Hind, which was requisite for the attack travels from Bengal to China consisted of diverse group of travelers each having their own reason to pursue. Among them is Kesri Singh who joins the British Army as a sepoy against his father's will who wanted him to fight for Mughals. Bhyro Singh defends Kesri's decision and urge his father: "The boy is young and you are his father. You should explain to him that Delhi is not what it used to be; a soldier who wants to rise in the World needs to go to the East India Company's capital—Calcutta. There is no army in Hindus than that can match the terms offered by the British." (FOF 67)

Zachary Reid, after freed from the murder case is working as a carpenter to refurbish boat Anahita bought by Mr. Burnham and later enters the trading business. He has the aim to become rich and earn money at every possible risk. Shireen Modi, wife of late Bahram Modi who has left for Canton to claim for her husband's share in opium profit and also in search of her husband illegitimate son Freddie. The First opium war begins and we find all these characters from different caste, class, race, culture in China brought together as an indentured labours, convicts, soldiers forming a multicultural world and China's defeat in the war. One of the important character is Neel an exile Raja and absconded convict due to the English man Mr. Burnham, lives in Guangzhou and is he need of job. With the possibility of China's opium war with Britain, Neel a man of knowledge is very valuable to China, trading in diplomacy and gathering information.

Thus British monopolized and controlled India by dominating it socially and politically. They very cleverly trapped the young men who were very innocent and were unaware of their future by luring them the job and money and utilized them for fighting against China. One such example is Kesri Singh who joins British army and feels a sense of isolation where he is other against his counterparts, the white officers.

Conclusion

Thus Ghosh with the help of the Ibis Trilogy creates a fictitious world depicting the true condition of India, the exploitation of poor subaltern people by the British Imperialists. The story starts with the ship Ibis carrying indentured laborers, convicts from Calcutta to Mauritius, belonging to different caste, religion, culture, the race having their own outlook. These travelers in the due course of time gain experiences become ship siblings and free themselves from the hegemonic and discrimination done by their rulers. They made their own world and taught their young generation to free from prejudices. Thus, Ghosh has up built the mindset and breaks the barrier of casteism, discrimination, racism, gender biases which have hindered the growth of marginal. In his trilogy, he has created a human community where people from a different religion, caste, ethnicities, nationalities, faith and gender live together in a multicultural world with a broader outlook. This is the only way in this time of unrest and differences to form a global world and live peacefully for the growth of mankind.

REFERENCES

Primary Sources.

1. Ghosh, Amitav. *Sea of Poppies*. Penguin Books, 2008.
2. ---. *River of Smoke*. Penguin Books, 2011.
3. ---. *Flood of Fire. Penguin Books, 2015.*

Secondary Sources

1. Subhash Agrawal . *A Multicultural Society: An Indian perspectives.* Dec 19, 2015.(www.the globalist.com)
2. Genevieve Zarate; Danielle Lavy Claire Kramsch (19 April 2011). Handbook of Multilingualism and Multiculturalism. Archives contemporaries p377 ISBN 978-2-8130-0039-2
3. Girmit history (www.Fijigirmit.org) Retrived 2020-11-10
4. Wolfrey, J. et.al. *Key Concepts in Literary Theories.* Edinburgh: Atlantic Publishers, 2002. Print.
5. Parekh, B. *Rethinking Multiculturalism: Cultural Diversity and Political Theory*. New York: Macmillain, 2006. Print.
6. Ashcroft, Bill; Griffiths, Gareth; Tiffin, Helen. *The Empire Writes Back*. Second ed. London: Routledge, Taylor & Francis Group; 2002.
7. Ashcroft, Bill. Griffiths, Gareth. Tiffin, Helen. *Key Concepts in Post-Colonial Studies*.
8. Mehta, Jaswant Lal. *Advanced Study in the History of Modern India* 1707-1813. New Delhi: Vikas Publishing House, 2005
9. Robert, P.E. *A History of British India.* New Delhi: Oxford University Press, 1978.

ISSN 2231-1629
Knowledge Resonance
A Half Yearly National Peer-Reviewed & Indexing with SJIF Impact Factor Research Journal
IMPACT FACTOR 8.072

Rabindranath Tagore and the English Language

Dr. Priti Singh
Assistant Professor of English
Dr. Ambedkar College, Nagpur.

HHH

Abstract

Rabindranath Tagore India's cultural ambassador and poet laureate grew up at a time when the Tagore family was very creative and intellectually active in Bengal. Tagore records in his autobiography his distaste and dislike for the English language as a boy and also classrooms and rote learning. During his teens he was influenced by the writings of the Romantics, and he became receptive to western influences. He translated the Gitanjali from its original Bengali to English in 1912 and was amazed at the manner in which it was received by the western world. A series of letters reveal his uneasiness as well as his command over the English language. But then Tagore was definitely a creative artist and his contribution to Indian English Writing is remarkable and noteworthy.

Keywords: *Tagore, English, language, influence, creative*

Reverentially remembered as Gurudev, widely acclaimed as India's cultural ambassador, Rabindranath Tagore was a poet of international repute. He was awarded the prestigious Nobel Prize for his collection of poems Gitanjali, which is a bouquet of metaphors at the feet of the Lord. Born on the 7th May 1861, he was the fourteenth child of the spiritually inclined Maharishi Debendranath Tagore and Sarada Devi, and the grandson of Prince Dwarkanath Tagore, one of the most successful Bengali entrepreneurs of his time. In a sense he grew up as an only child, allowed to inhabit a secure but solitary space in a household that was busy in more ways than one, given that the Tagore family was the most creative and intellectually active at the time in Bengal. Tagore had developed a different sensibility that culminated later in a poetry of lyric utterance which was at variance with the epic and grand style of his predecessors.

The present paper explores the initial aversion that Tagore had toward the English language and later he was so influenced by the language that he created a corpus contributing to the wealth of Indian English writing. Tagore's poems launched his international career and contributed to the myth in the West that Tagore was a poet who wrote in English.

In his autobiography Jiban Smriti (written in 1911 and translated into English as My Reminiscences, 1917), Tagore recounts the strong dislike he felt as a boy, for private tutorials, classrooms and rote- learning. He hated English lessons intensely. In his memoirs, Tagore writes of his earliest encounters with that language upon being admitted, at a tender age into the Norman School. He recollects a song he had learnt in class, which was there transformed into the childhood pidgin of a Bengali boy. The bafflement, agony and energy of cultural confusion and intermingling is very well captured in the boy's consciousness thus:

Kallokee pullokee singill mellaling mellaling mellaling.

Tagore informs the boredom and terror he felt as a boy, learning English describing the trepidation with which he and his cousins waited in rainy weather to see if the English tutor Aghore Babu's black umbrella would appear and says several hard things about the language itself.

How well do I remember the day our tutor tried to impress on us the attractiveness of the English language. With this object he recited to us with great unction some lines - -- prose or poetry we could not tell - out of an English book. It had a most unlooked for effect on us. We laughed so immoderately that he dismissed us for the evening (118).

Resistance to the language continued; to Mc Culloch's Course of Reading Tagore recalls the following response: Providence, out of pity of mankind has instilled a soporific charm into all tedious things. No sooner did our English lessons begin than our heads began to nod.' All of this was of course his boyhood experience of English for his sensibility was actually shaped by the writings of the Romantics, and his great receptivity, especially as a composer, to western influences. When Tagore was twelve or thirteen, he read for the first time the great Vaishnava poets, Chandidas and Vidyapati, and was moved by their poems, although, as his biographer J. Kripalani points out, the Brahmoism that Tagore had grown up with had little in common with the world of these devotional songs. He even wrote a sequence of poems called Bhanusingher Padabali under the pseudonym Bhanusingha, in which he attempted to capture in Brajbhasha, something of the

music of the older texts.

Tagore had completed Jiban Smriti, in which he had made those cutting and jocular remarks about English and the English lessons of his childhood, in 1911. In 1912 he translated the Gitanjali he had once found tedious and ridiculous. Amazed at the success of his poems in 1913, the year he was awarded the Nobel Prize, Tagore wrote a letter to his niece Indira Devi in which there is a note of hesitancy regarding the language:

You have alluded to the English translation of the Gitanjali, I cannot imagine to this day how people came to like it so much. That I cannot write English is such a patent fact that I never had even the vanity to feel ashamed of it (3).

He goes on to say: 'But believe me, I did not undertake this task in a spirit of reckless bravado, I simply felt an urge to recapture through the medium of another language the feelings and sentiments which had created such a feast of joy within me in the days gone by' (3-4).

He seems confident enough that the act of translating into English would enable him to "recapture" his "feelings and sentiments"; this comports uneasily with the claim that he feels incapable of responding to a polite social note in that language. However, Tagore continued to deliver his humane, universalist message in the form of lectures and essays, of which a substantial number are in English.

In the long introduction to his 2011 edition of Gitanjali, William Radice translates a subsequent portion of this letter:

In the English language there are all these slippery things like articles, prepositions, "shall" versus "will": they can't be got right with common sense-they have to be learned. I have the notion that they're all living somewhere in my "subliminal consciousness" like worms underground. When I let go of the rudder and sit down to write with my eyes shut, they all come creeping out of the dark to do their stuff-but if I look at them in the light of full consciousness, they wriggle off again all higgledy-piggledy-so in the end I feel that I can't rely on them at all. That's why it's still true to say that I don't know English (Letter 82, 141).

What Tagore is saying here is that he is self-conscious about his English. As long as he doesn't think about it, he manages to wield the language fluently enough; as soon as he begins to reason his way to a conscious understanding of the rules of the language, he loses his way. However, his fluency in the language was never raised as an issue in any of the social interactions he had with English speakers in India, the UK, and the US. Radice discusses the enthusiastic accounts Tagore's audience in London gave of the 1912 evening where he first read out his own translations at a soirée arranged by the painter William Rothenstein. None of the accounts feels the need to make any sort of allowance for Tagore's English; they all suggest that Tagore held his own perfectly well in that language.

Tagore's letters in English read just fine as well. For example, Radice quotes one to Thomas Sturge Moore. Tagore bemoans the poor job he has done with his own translations:

I am convinced that I myself in my translations have done a grave injustice to my own work. My English is like a frail boat-and to save it from an utter disaster I had to jettison the most important part of its cargo. But the cargo being a living one it has been mutilated: which is a literary crime that carries its own punishment (Letter 171, 273).

When E. P. Thompson kept suggesting that he would like to translate some of his works, Tagore responded initially by saying that he liked the idea and wittily confessed his failings in English thus: "You know I began to pay court to your language when I was fifty. It was pretty late for me ever to hope to win her heart" (Letter 162, 254).

Tagore's speeches on various occasions also show a better than adequate command of the English language. In 1917, during a tour of the US, he delivered a lecture on "Nationalism in India". The lecture was written specifically for the occasion, and therefore originally in English. A well-known passage from the essay is thus:

Many people in this country ask me what is happening as to the caste distinctions in India. But when this question is asked me, it is usually done with a superior air. And I feel tempted to put the same question to our American critics with a slight modification, 'What have you done with the Red Indian and the Negro?' For you have not got over your attitude of caste toward them. You have used violent methods to keep aloof from other races, but until you have solved the question here in America, you have no right to question India (II, 428).

The passage is eloquently argued and does not suggest that the writer is struggling to express himself in the English language. But it is in a letter to James Drummond Anderson, a lecturer in Bengali at Cambridge with whom he carried out a correspondence for almost a decade based on great mutual respect that Tagore suggests unequivocally for once that he actually had enjoyed

grappling with the English language in translating his poems. Commenting on "the wonderful power of English prose" and its "magic" qualities, Tagore confides in Anderson that "the clearness, strength and suggestive music of well-balanced English sentences" made it a" delightful task" for him to "mould" his Bengali poems into English prose forms (Letter 121, 196).

As his confidence in his ability to write in English grew, Tagore attempted experiments in the language that are noteworthy. The volume Thoughts from Tagore (1921), for example, consists mostly of brief meditations on various topics. He tries to tackle as concisely as possible some of his favorite themes such as nature and life, God and man, power and egoism and art and music. Tagore's other notable work in English prose, The Religion of Man (1931) is based on lectures delivered by him in 1930 at Manchester College, Oxford.

Hence it can be concluded that Tagore was definitely a creative artist in the best of his English works, be it in prose or verse. Paradoxically, it is his English, the language of his public and international persona, that is shaped by his cultural confusion, personal drives, inspirations and limitations more naturally than his Bengali which the English-speaking world can rediscover and estimate the extent of his achievement as a major thinker and important writer of English.

Works Cited

1 Chaudhari, Amit, "The English Writings of Rabindranath Tagore." Arvind Krishna Mehrotra Ed. A Concise History of Indian Literature in English. New Delhi: Permanent Black Publication. 2008.

2 ---. Gitanjali: Song Offerings. Trans. and intro. William Radice. New Delhi: Penguin, 2011.

3 Das, Sisir Kumar. The English Writings of Rabindranath Tagore (3 vols.) New Delhi: Sahitya Akademi, 1996.

4 Datta, Krishna and Andrew Robinson (eds),. Selected Letters of Rabindranath Tagore. Cambridge UP, 2005.

5 Tagore, Rabindranath. "Genesis of English Gitanjali". Letter to Indiradevi Chaudhurani, 6 May 1913. Trans. Indiradevi Chaudhurani. Indian Literature 2:1 (1958-1959): 3-4.

6 https://www.researchgate.net/publication/43129108_Rabindranath_Tagore's_English_Prose_Some_Qualities_of_Permanence

DRIVEN TO DISCOVER–INDIAN ENGLISH WRITERS

Mr.Manoj Andraskar[1]

This paper is an attempt to show the Indian English contemporary writers and their works of fiction as they deal with the various issues of the Indian society. The Contemporary Indian English Fiction has created its own niche in twentieth century. Most of the well known Indian writers are known for their critical approach toward reality, some of; for their fictions and rest of the writers for installation of the burning issues of the Indian landscape. Indian Diaspora is one of them, the writers, who cited and captured the issues related marginalization, gender equality, woman empowerment, racism, corruption, poverty, unemployment, education, infrastructure, healthcare and so on. Particularly fiction in India is a product of western influence and the novels, short stories, satires and sketches written by the Indian writers are the examples of the creative fictions in India, The writers from Indian landscape are very much accepted and adorn by critics and the common people. This paper is an account of a few most popular writers of fiction and the subjects they have handled and are loved by millions across India as well.

Indian English Literature and Translations:

The introduction of English education in India was inseparable from the process of subjectification under colonialism. Under colonial impact; colonial works are developed through the practices and technologies. And one such apparatus is 'Translation'. It depends upon western philosophical notion of reality, representation and knowledge. Reality is seen as something

1. Assistant Professor, Dr. Ambedkar College, Deekshbhoomi, Nagpur

unproblematic out there, and knowledge involves an actual representation of reality and representation provides direct and unmediated access to the transparent reality. Tejaswini Niranjana, famous writer expressed her views "The European translation of Indian texts prepared for western audience provided to the 'educated' Indian a whole range of orientalist images". India is known as divers, our literature also is divers. It not surprising that the literature of India in recent time has number of literary genres and we have hundreds of hundreds short stories, fictional novels in every language. Earlier the condition was sad that reader hardly get those novels or short stories to read. Now readers no longer have to worry about and shouldn't be excuse for that because there are plenty of translations are available for every single native reader.

In recent time some translations of the novel fiction are very popular. Chander and Sudha' by Dharamvir Bharti. It is love story, set in the Allahabad in the 1940s. His recent best seller 'Gunahao ka Devta' is recent work translated into English by Poonam Saxena and published as 'Chander and Sudha'. Story moves around Chander and Sudha, a daughter of university professor and mentor of Chander. Sudha cannot marry Chander, because her father wants her to marry according to his own choice. It is a story of love longings and how they try to be in touch with each other. The House of Kanooru by Kuvempu is another translation into English. Set in rural Karnataka. This epic takes us back to feudal times in the 1930. A feudal landlord is becoming more demanding while his third wife wreaks havoc in the house and his nephew tries to bring modern ideas which are influenced by the freedom movement to the fiercely traditional village. Sunil Gangopadhyey from Bengal is much more popular novelist for "Those days". Originally known as 'Sei Samay' in Bengal. The novel set in 19th century and spins the tale around 1857 revolt. It is about two wealthy families and about combining romance, Bengal renaissance, history and nationalism. This skillful translation is written by Aruna Chakravarti which is an example of an actual representation of the essence

of the real text. 'Samskara' by U R Ananthamurthy is an incredible novel translated into English by A.K. Ramanujan It is about Brahmin community and cast system and new outlook of the modern values and culture. And very much accepted writer of the time Munshi Premchand's 'Godan- A Novel of Peasant of India' translated by Jai Ratan and P. Lal; is much adorned by the writers and the readers.

Contemporary Indian English fiction has evolved in recent time became one of the dynamic areas of literary interest in India. The Indian anthologies of fiction have fascinating range of topics and various genres which gives us exciting range of reading materials, some of the famous writers of fiction are not afford to miss and Khushwant Singh is one them. He has won 'Sahitya Akadami Award' for his excellent literary career, as well as he is well known for his historical fiction 'Train to Pakistan'. Another works is 'I Shall not Hear the Nightingale' which depicts the human tragedy behind the Partition of India in 1947. Khuswant Singh is also recognized as an erudite Sikh historian.

Khushwant Singh is famous writer of fiction which depicts spirit and passion, torture and the problems of the times. All his novels are actual depiction of the social problems Khushwant Singh has pointed out the drawbacks that plagued India. His literary creation is not merely a literary model but an actual representation of society which engages our attention and it seeks to give us a sense of direction. His well known work Train to Pakistan is based on an account of a period of the partition of India. The impact of time accompanied by savage rioting face by which near about five lakh lives uprooted and ten million people were left their homeland. The theme of the novel is mostly based on two religious lines Hindu and Muslim. People should not be divided along with religious lines. The hopes, aspiration and desires all aspects of sentimentality were destroyed by the poignant attack of religion. Train to Pakistan is political novel but it also deals with socio-religious problems as well. It is well adorned and accepted novel by the critics of the time.

Amitav Ghosh is a prolific writer and has been moved down to India, Bangladesh, Iran and Sri Lanka. His first novel 'The circle of reason' is well written fable and picaresque fiction of Indian protagonist Alu a young master weaver in a small Bengali town who is mistakenly become suspect of being a terrorist. Alu flees away from home and travels through Bombay to Persian Gulf to North Africa. It is remarkable novel with a spinning tales within tales with a great narration. Another much acclaimed novel is 'The Calcutta Chromosome: A Novel of Fevers, Delirium and Discovery'. It is Amitav Ghosh's first science fiction which tells the history of the discovery of parasite that causes malaria. Ghosh later turned away his form of writing toward his earlier novels; the traditional form of storytelling. Ibis Trilogy which take place shortly after the first Opium War includes 'Sea of Poppies', 'River of Smoke', and 'Flood of Fire'. Amitav Ghosh also wrote 'In an Antique Land (1992)', this book can be explained under several genres- travel writing, autobiography, memoir and blurs fiction and nonfiction. It is based on his experiences in a rural Egyptian village in the early 1980s; Amitav Ghosh is versatile writer and having included several themes in his novels. As writer of the fiction novels his name stands among the renowned writers. Amitav Ghosh has brought the new face in novel writing. After the first book 'The Circle of Reason' he wrote to his latest work of fiction Glass Palace (2000), which is based on the research it deals with the sociological and historical aspects which is one the characteristic of his writings. Amitav Ghosh is a winner of Sahitya Academy award for his novel 'The Shadow Lines'. It is an outcome of his traveling, Myanmar, Egypt and Cambodia to research his books. It is also said that the book is his early childhood experience which has taken him all over South East Asia which were also responsible in giving him a broader perspective on issues than one fixed in New Delhi. Unlike his fellow contemporaries, Amitav Ghosh is also popular for his narrative which is stable and at the same time can handle the criticism in an elegant way.

Salman Rushdie; the writer of Satanic Verses which proclaimed him an

apostate for writing The Satanic Verses and sentenced him to death under Islamic law in 1998. He was threatened, accused and blamed because of his free expression of thoughts. Such kind of expressions and thoughts he has poured in 'Shalimar the Clown', in which he talks about past and performs some mental acrobatics that one can find in this fiction. Because of scathing presentation of the expression, fatwa was declared against him. Salman Rushdie is better known in the world of literature better than any other living novelist. But he came under the eclipsed of the political assault. 'Midnight Children' is another much famous work based on the Indian independence era. Amit Chaudhuri argues that "the critical and commercial reception accorded Midnight's Children has erected Rushdie's work as 'a gigantic edifice that all but obstructs the view of what lies behind".

R.K. Nraynan is a famous personality in Indian world of fiction, specially known for 'The Malgudi Days'. A fiction, presented the story of Vasu, an eccentric taxidermist. Malgudi is fictional town describes the postcolonial tale in comic style. This novel illustrates the differences created solely by living under the cast system. Graham Greene has described the intellectuality of the R.K. Naraynan by saying "there are writers- Leo Tolstoy and Henry James to name two –whom we hold in awe, writers- Ivan Turgenev and Anton Checov – for whom we feel a personal affection, other writers whom we respect – Joseph Conrad for example – but who hold us at a long arm's length with their courtly foreign grace.' Narayan (whom I don't hesitate to name in such a context) more than any of them wakes in me a spring of gratitude, for he Hs offered me second home .without him I could never have known what it is like to be Indian". Other novels are 'The dark room', 'The Sweet Vendor', 'Maysor', and 'The Guide' .

Chetan Bhagat is quite famous for his fiction in nowadays. Today's youngsters are quite impressed with his writing. Because, number of his books are best sellers and some of his books are featured in Indian film

industry. The popularity of his novels is the example of his lucid, simple style of writing which attract the readers. It is also because; Chetan Bhagat knows the veins of the readers and their likes and dislikes. He deals with truth and reality which has a mass appeal. 'Three mistakes of my life' is a book on which the famous movie '3 Idiots' is based. '2 States' is another book which got fame and featured into a movie. 'Revolution 2020' is political novel by Chetan Bhagat. Novel dictates the problem like growing corruption in India. As writer of fiction Chetan Bhagat is the most awaited novelist in modern times.

There are so many writers of fiction in Indian English literature which are very much popular like Manju Kapoor, Mulk Raj Anand, Manju Jain, Raj Rao, Rohinron Mistry, Shashi Tharoor,Vikram Seth, V.S. Naipaul and so on.

Indian Women Writers:

Fiction writing by the women novelist is considered as major step in the contemporary Indian English fiction writing. The literature of Indian women Diaspora is the best example. Women novelist like Jumpha Lahiri, Kiran Desai, Chitra Banerjee, and Bharti Mukherjee have made their homeland famous by writing . The migration came into result as a great Diaspora fiction by accepting individual adopted land. At the outset of the diaspora writing the initial stage of writing was autobiographic. They dealt with homelessness, rootlessness, nostalgia, and dislocation. Diaspora fiction is all about difference between 'own place and foreign', and 'familiar and strange'. These contrast imaginations are the basic subjects of the Diaspora fiction. With migration from homeland the cultural transmission and double identification appears in the work of fiction.

The great bulk of women fiction writing can be found in post colonial period .it is to be said that the distinctive force of the Indian women fiction writing is multicultural or bicultural and multicultural. In this sense bilingualism and multilingualism is considered as byproduct of diaspora.

This is the reason why diaspora is recognized as either transnational or expatriates writers. The women writers like Meena Alexander, Anita Desai, Jhumpha Lahiri and Bharti Mukherjee are educated under the western influence who have traveled and lived many countries and now known as multicultural and multilingual.

Chitra Banerjee is Calcutta born and educated in India and America. She has number of novels named after her like, 'The Mistress of Spices (1997)', 'Sister of My Heart (1999)' and 'The Vine of Desire (2002)'. Kiran Desai recognized as daughter of reputed and renowned Diaspora English author Anita Desai. She is author of the two novels, 'Hullabaloo in the Guava Orchard (1998') and 'The Inheritance of Loss (2006)'. She has awarded by the 'Man Booker Prize of 2006'. Jumpha Lahiri is knows as second generation of the Diaspora. She born and educated outside India and attracted towards the Indian culture. She considered herself as citizen of America. Her experience of the relation between America and India is clearly found in short story collection 'Interpreter of Maladies' published in 1999 and received 'Pulitzer Prize' for fiction in 2000. Her famous novel 'The Namesake' is highly based on cultural and ideological differences.

Concept of Identity:

Indian literature has gained worldwide reputation for its wealth and depth of literature. For the treatment on various subjects through the fiction is common acceptance and also known as well accepted method for writings. Concept of identity is a theme, quite handled by the number of writers in their works. In recent time the identity of a common man is questioning because of the issues like racism, tolerance and intolerance, classicism etc. Under these issues for example, people from Manipur and also from the other places are not recognized as Indians, people understand them and accept them as Chinese at first. Then how one can be identified? Likewise people from north side they tries to fake the accent of white people though they are not. Such stereotypes are just some examples for

creating fake identity, as a result of this fake identity, there is common question generally asked that, Why are people failing to understand that India is a diverse land .

Intolerance on intolerance, the words recently created a great disorder in society, nobody knows who has introduced and reminded this word to the mass. Every single person was using it just for a wrong reason, it was taken as personal war against the established rules like choices of food, colours like green for Muslims and saffron for Hindus and started moral preaching which was actually outdated but everyone is being exploited.

Casticism; today it is considered as main weapon for politicians. And they are exploiting it openly, burning of a train and beating up its passengers in Andhra Pradesh is the latest example for this, likewise corruption is biggest problem in India. To pay a constable a bribe far genuine work is fine, but one wears no helmet and the fine(bribe) to pay a reputed government employee is five hundred rupees or more is kind of corruption. Such issues are really need the ways to express, and fiction is one kind of way where one can make and present and mould the character according to the demand of topic. Writer from India like Khushwant Singh, Amitav Ghosh, Manju Kapoor, Arun Joshi, Kamala Markandeya, Salman Rushdie, Kiran Desai, and Anita Desai; they have come into limelight with such issues and created entirely new kind of revolution into the reader's world.

The concept of identity has a long history. The themes of fictional novels have close signification with identity in literary works. Social, political, religious, gender, ethnic, cultural and self identity is creating differences in literary writings. Etymologically the words 'identity' means "sameness and continuity' it is substitute for Latin word "idem" so under these identities the diaspora fiction is based on. Cultural identity of diaspora set on center of the distinctive norms, values, language and symbols. And the writers with the respective identity shares cultural minority among themselves through the fiction and this cultural assimilation of diaspora develops

hybridity.

Indian English Fiction on Global Level:

Because of the emigration or migration the roots of the Indian fiction can be found all over the world. After the independence of India in 1947 the migration from India to England, America and Australia took place. This migration later called as 'Brain drain' means 'voluntary and individual'. Now in 20th century, there are millions of people are found Africa, Jamaica, Malaysia, Canada and other parts of the countries. They left India during 19th and early 20th century. They are identified as NRIs or overseas Indians or expatriates or immigrants. Such migration resulted into fiction of Indian Diaspora. Indian novels have developed a considerable amount of attraction and interest both in India and as well as in all English speaking countries. On both level Indian writers have got good exposure to develop their E- learning. With the help of this E-learning Indian English literature is catching the eyes of readers from all over the world which never happened before.

Indian writers have dialed some issues in their works including nationalism, identity, subaltern representation, diaspora, modernism and the impact of the globalization. The study of these issues is not undermines the values of their fiction but it can be said that, it is an attempt to create sensible correlation inside of the theme of novel. It is new kind of outlook of the Indian English fiction in post-liberalization. To what extent fictions in India and all over the world attracts the eyes of the reader, it depends upon the commercial perception of the media .The new technologies and knowledge are shaping the modern Indian fiction in the post-liberalization period and provides a balanced and systematic approach to the study of Indian novels and the novelist in terms of their global reception.

Indian English fiction is kind of genre where we find an insightful exploration of contemporary Indian writing in English. The works of Chetan Bhagat and Arvind Adiga shows that how the 'New India' is

ISSN 0970-7247

THIRD CONCEPT

English Monthly
Annual Subscription Rs. 200

Vol. 35 No. 410 APRIL 2021 Rs. 20.00

- India-Nepal Border Tussle
- India-Kazakhstan Energy Cooperation
- Japan-India Relations
- Democracy in World Bank

THIRD CONCEPT

An International Journal of Ideas

Vol. 35 No. 410 APRIL 2021 Rs. 20. 00

Third Concept aims at providing a platform where a meaningful exchange of ideas can take place among the people of the Third World. The attempt will be to communicate, debate and disseminate information, ideas and alternatives for the resolution of the common problems facing humankind. We welcome contributions from academics, journalists and even from those who may never have published anything before. The only requirement is a concern for and desire to understand and take the issue of our time. Contributions may be descriptive, analytical or theoretical. They may be in the form of original articles, reactions to previous contributions, or even a comment on a prevailing situation. All contributions, neatly typed in double space, may be addressed to:

Editor	*Consulting Editor*
Babuddin Khan	M. L. Sharma
Deputy Editor	*Managing Editor*
Manoj K. Narula	**R. Prudhvi Raju**
Business Executive	Art Director
R.S.Rawat	**Purba Roy**

Business Executive South-east Asia
Shatrughan Kumar Dwivedi

While the Editor accepts responsibility for the selection of materials to be published, individual authors are responsible for the facts, figures, and views in their articles. However, the Editor reserves the right to edit the articles for reasons of space and clarity.

Published, Printed and Owned by
Babuddin Khan
Third Concept,
LB - 39, Prakash Deep Building,
7, Tolstoy Marg, New Delhi-110 001.
Ph : 23711092, 23712249, Fax No: 23711092.
E-mail : third.concept@rediffmail.com
Website: www.thirdconceptjournal.co.in

THIRD CONCEPT NOW UGC-CARE List

Designed by: **Pt. Tejpal**

INSIDE

Editorial

Alarming Signals! 5
B.K.

India- Nepal Border Tussle: The China Factor 7
Dr. Aparna

India-Kazakhstan Energy Cooperation 11
Narendra Sharma

Democracy in World Bank in the era of Global Governance 15
Dr. Anil Kumar

India's Afghanistan Conundrum: A Third World Perspective 19
Dr. Vijay K. Verma & Sumit K. Bharti

Japan-India Relations 22
Dr. Anilkumar B. Halu

Women in Power Structure 25
Prof. (Dr) Ramesh H. Makwana

B.L Gautam's *Andy Leelu*: A Study 30
Apoorva Hooda

Urban Local Governance in India 33
Shahid M. Zakaullah

Passive Resistance of Landless People in Maharashtra (1959) 37
Dr. Avinash D. Fulzele

Role of Caste Panchayat in the Social 40
Dr. Manishkumar Mansukhbhai Jansari

Appraising Literacy in Urban and Rural..... 46
Dr. H. G. Jagodadiya & Dr. Sanjay A. Pandya

RTI act in top Ten Central Ministries in India (2005-06 to 2018-19) 50
Dr. T. Sadashivam & Dr. Shahla Tabassum

Economics & Globalization 55
Dr. P. Malathy & V. Saravanakumar

Passive Resistance of Landless People in Maharashtra (1959)

Dr Avinash D. Fulzele*

[*Dalits were denied various rights including social, economic and political etc. They didn't have any means of livelihood. So, they had been leading coercive life. Dr Babasaheb Ambedkar strove hard to make Dalits aware and they enthusiastically supported Dr Ambedkar in his movement. Thereafter, this movement was prominently known as Ambedkar movement. This movement raised and organized the struggle for equality. The struggle for land was one of the most significant part of this movement. Republican Party put forward the issues of dispossessed people through this state-pervasive passive resistance. He started passive resistance of landless people in Marathwada, Khandesh, Nashik, and Vidarbha region. Republican Party's leaders conscientiously campaigned and thrived it. Therefore, many people of various castes and religions vigorously participated in this passive resistance. Many people were imprisoned for it. The jails were filled with the landless protestors. It compelled government to heed on it. This passive resistance gave new direction to the society*.]

Though agriculture is the path to lead life prestigiously, the issue of ownership of land was severe one in the contemporary era. Dalits and tribals became agricultural labourers due to unavailability of land. The doors of economic self-reliance were closed for them as they were landless. Vinoba Bhave started Bhoodan Movement (Land Gift Movement) throughout the country during contemporary era. Vinoba Bhave aimed that he would appeal to the landlords to donate excessive land to landless farmers and poor people. Total 20 lakh 69 thousand acres of land was acquired throughout the country till September 1953 from this movement.[1]

But local poor people and especially untouchables were not much benefitted from this movement. It was observed that land acquired in Bhoodan Movement were not distributed among poor untouchables.[2] Dr Babasaheb Ambedkar had organized passive resistance of landless people to get the lands for Dalits and tribals in 1953 in Marathwada region. This passive resistance gave a new direction to the movement.

Passive Resistance of Landless people in Maharashtra

B. S. Murthy, Deputy Minister, Central Society Development Department, appealed to form new laws regarding land reformation to get economic justice to untouchables and other downtrodden communities from the stage of Sixteenth Annual Conference of Indian Dalit Union. He opined, "...Most of the landless and agricultural labours belonged to untouchable communities. The financial condition of Dalits can be improved if the possession of land transferred to the cultivators of the land. But the State Governments are not driving ahead to take bold decisions regarding land reformation acts. It would be wise and better not to procrastinate it for Dalits...Total 32crore acres land is cultivable and 75 percent land is possessed by 5 crore people. Total 8 crore people are landless and agricultural labourers. It is one of the most crucial issue in rural economy. Their thirst for land can't be mitigated by just dressing their thirst...'[3]

Republican Party propagated to give land to the untouchables and tribals who were scattered in the remote areas of India for their emancipation from economic exploitation and social slavery.

There were 18 lakh tribals and 40 lakh New Buddhists and Untouchables in contemporary Maharashtra. The number of agricultural labours was 40 percent in Vidarbha, 30 percent in Marathwada, and 24 percent in Western Maharashtra.[4] As far as the unemployment rate of Western Khandesh, total 11,026 people registered their names for job in employment office till 1st January 1959. Only 926 people got jobs in various sectors.

The area of Eastern Khandesh was 4535 square miles, the numbers of villages were 1384, population was 13,18,000, total land was 2,90,900 acres, forest land was recorded at 40,011 acres while barren but cultivable land was 2,00,000 acres, land under crops was 60,944 acres, horticultural land was 38,000 acres out of which 34,000 acres land was under moth production. This was the condition of agricultural land in Eastern Khandesh.[5]

* Associate Prof., Dept of History, Dr Ambedkar College, Nagpur.

As far as the division of agriculture is concerned, 1 to 5 acres land was owned by 63,000 people, 6 to 15 acres of land was owned by 55,108 people, 16 to 25 acres of land was owned by 19,934 people, 26 to 100 acres of land was owned by 13,533 people, 100 to 500 acres of land was owned by 1285 people while more than 500 acres land was owned by 57 people.[6] There were numerous agricultural labours.

It indicates that how land was centralized in Eastern Khandesh. In this way, the issues of land, industrial crises, unemployment, and inflation were predominant in Eastern and Western Khandesh.

Republican Party declared to organize state-wide protest for the issue of land, though the 1953's passive resistance solved few issues to some extent in Marathwada. Because government had decided to revoke 2000 acres of land which was given to the landless agricultural labours since 1947 in Eastern Khandesh district and also determined to implement this policy in other states.[7] It would culminate into the problem of people's livelihood if it happened so.

So, the struggle of Republican Party was not confined to the Mahar-Mang or Buddhists, it was all-pervasive struggle. Everyone has equal hunger. The problem of hunger was the same for all people. Especially, India is an agrarian country still it imported cereals from foreign countries costing 150 crore rupees per year. Therefore, party demanded for the equal distribution of agricultural land by improving the agricultural system of India.[8] As well as, they suggested the government to confer barren lands to the landless people.

Congress Party put forward the resolution of socialist structure at Awadi which was not implemented by anyone. Republican Party came forward to complete this work assiduously. Party took the stand to organize agitation and passive resistance of landless people if the government somehow failed to confer lands to the landless and poor people.[9]

Total 40 percent land was included in forest as most of the area of Western Khandesh was hilly. Near about 2 lakh acre land was barren in the district except forest land. Not a single tree was planted on that land and it was not productive land. So, 5000 landless agricultural labours were legally demanding above mentioned land.[10] But government intentionally ignored it.

As a result, a group of 150 people under the leadership of Sakharam Natthu Bhamre, one of the members of Republican Party, entered in the barren government land and started passive resistance at Dhandane village of Nandurbar district on 30th July 1959. Total 10 women also participated in this passive resistance joining hands with the men. These landless people took shovel and mattock with them as government could confiscate their plough and started cultivating the land with these tools. These protestors were imprisoned and filed lawsuits as per Forest Act Section 26 and Indian Penal Code 143 and 447. These imprisoned protestors had been punished with strict servitude in the jail for seven days.[11]

The passive resistance had started in Eastern Khandesh and Nashik region. Dadasaheb Gaikwad, a Republican Party's leader, roamed around Shirpur, Shahade, Talode, Nandurbar and Shindkhede region and spread awareness among the people regarding passive resistance for the land. He stated in one of the speeches in Sakri, '... Republican Party has come forward to fulfil the desire of Dr Babasaheb Ambedkar of improving economic condition of many landless agricultural labours, unemployed, and Dalits by acquiring land for them. Many acres of land are barren in the name of forest for many years in the district. Government should confer this barren land to the landless people of production and solve the issue of livelihood by doing so. Therefore, this protest is organized in peaceful manner...'[12]

This passive resistance wasn't confined to untouchables and Buddhist labours. Many landless people, labourers, farmers, Koli, Bhill, Tribals, Muslims and Marathas participated in the passive resistance.[13] Passive resistance of landless people had been spreading rapidly in Marathwada. This protest was at the peak in Aurangabad district's Abal, Paithan, Vaijapur, Bhokardan, Jalana and Aurangabad block. The prominent characteristic of this passive resistance was that not only men but also many young women with their children and old women participated in this struggle without caring for rain.[14]

Police adopted the policy of arresting some people and releasing them after some time while lawsuits were filed against them at some places in the court. Court of Ambad block punished the protestors till leaving courtroom. United Maharashtra Committee, Praja Samajwadi Party, Communist Party participated in the passive resistance organized by Republican Party. Krantisingh Nana Patil, Member of Parliament from United Maharashtra Committee declared in the open conference in Tilak square that, 'I have decided rebel for passive resistance of landless people until government imprisoned me and also decided to go in the jail.'[15]

Many communist workers participated in the passive resistance in Manmad under the stout leadership of Comrade Kusumtai Madhavrao Gaikwad. Near about 70 to 80 women were imprisoned for twenty days in Manmad struggle. Many members of Communist Party's National Council were participated in this protest. Comrade Manohar Taksal, Eknath Nalawade, Tulashiram Patil like members enthusiastically participated in this struggle.[16]

Government strove hard to suppress the protest. Many protestors were perturbed with the news of beating-up the protestors in Central Jail of Aurangabad. Total 3000 prisoners were imprisoned in this jail from Eastern Khandesh, Western Khandesh and Marathwada. Sindhi Jailor was cruelly treating these protestors. Many people demanded probe in this exploitation of the prisoners and attracted the attention of Government into this matter.[17]

Dadasaheb Gaikwad warned the government about the commencement of 'Go Back Chavhan Government' movement in the conference of landless people at Shirpur in Khandesh if government ignored the demands of many landless people.[18] Pagare appealed the people to help the party workers who would roam with seal-packed boxes to raise the fund to intensify it and sending the protestors from Mumbai during 1st to 15th September 1959.[19] So, he decided to spread this passive resistance throughout Maharashtra.

This passive resistance also started in Vidarbha region. Wasudeo Ganar, Patrilinear of Republican Party stated in the open conference in Wardha, '...conferring land to the landless people is the need of today's era. Therefore, passive resistance is legitimate and appropriate in Maharashtra. This passive resistance will not be taken back until the government fulfils their demands.'[20] At the same time, a resolution had been passed in the Mumbai Corporation in support of passive resistance.

Borade, the then Chairman of Mumbai Corporation, stated while speaking on the resolution, '…if government distributes the land among landless people, it will provide means of livelihood for them and they will increase the production of cereals in the farm. So, government should negotiate with the leaders of passive protest and approve the legitimate demands of landless people...'[21] V. D. Deshpande, a leader of Legislative Assembly' committee, declared that all opposition parties will collectively compel the government to solve the issues of landless people if it fails to immediately solve the issues of landless.[22]

Finally, Yashwantrao Chavan, Chief-Minister of Mumbai State approved fourteen demands put forward by the delegation of All Indian Republican Party due to the pressure created by the opponents. As well as, Chavan assured to order the probe in the custodial death of Balaji Gaikwad in Nagpur prison and maltreatment with the protestors in Aurangabad Central Jail.[23] Afterward, Standing Committee of Republican Party declared the retreat of passive resistance which had been going on for years for the rights of landless people. Thus, the passive resistance for the landless people came to an end.

Evaluation

Republican Party gave new direction to the passive resistance of the landless people in Maharashtra. It is necessary to confer land to the untouchables and tribals who are dispersed in the remote areas of India to emancipate them from economic exploitation and social slavery. This idea had been brought forth in the political sphere of Maharashtra through the passive resistance. This struggle was not only symbolizing the discontent of landless people but also signifies the economic, industrial, agricultural and political discontent.

Though the intensity of this passive resistance observed in Marathwada and Khandesh areas, it exposed the issues of landless people throughout Maharashtra. The main motive behind this passive resistance was to encroach on the barren land for permanent settlement and prestigiously earn the livelihood from it. The place of a person was determined on the basis of possession of land in traditional Indian rural society. So, Dalits were also genuinely inclined towards possessing the piece of land. Therefore, Ambedkarite movement organized nation-wide passive resistance of landless people for land.

References

1. Nawakal, Mumbai, Tuesday, 8th September 1953, Year 31st, Issue 137. Pp.1.
2. Janata, Mumbai, Saturday, 31st October 1953, Year 17th, Issue 33. Pp.2.
3. Navshakti, Mumbai, Monday, 2nd November 1959, Year 20, Issue 138. Pp.1.
4. Navakal, Saturday, 10th October 1959, Year 37, Issue 191. Pp.4.
5. Navshakti, Friday, 28th August 1959, Year 20, Issue 75. Pp.2.
6. Ibid.

7. Navshakti, Friday, 3rd July 1959, Year 20, Issue 19. Pp.2.
8. Lokhande, H. G. (Ed.), 'Karmaveer Dadasaheb Gaikawad Yanchi Bhashane', Vol. 1, Karmaveer Dadasaheb Gaikwad Memorial Foundation, Ulhasnagar, Thane, 1993. Pp. 89-90.
9. Prabuddha Bharat, Mumbai, Saturday, 4th July 1959, Year 4, Issue 13. Pp.1.
10. Prabuddha Bharat, 15th August 1959, Year 4, Issue 19. Pp.1.
11. Prabuddha Bharat 8th August 1959, Year 4, Issue 18. Pp.1.
12. Navakal, Tuesday, 25th August 1959, Year 37, Issue 147. Pp.4.
13. Prabuddha Bharat, 8th August 1959. Pp.1.
14. Navakal, Saturday, 3rd October 1959, Year 37, Issue 184. Pp.2.
15. Navakal, Saturday, 26th September 1959, Year 37, Issue 177. Pp.2.
16. Pansare, Govind. 'Parivartanachya Disha', Lok Wangmay Gruha, Mumbai, 2006. Pp.70.
17. Tarun Bharat, Nagpur, Saturday, 24th October 1959, Year 27, Issue 212. Pp.5.
18. Prabuddha Bharat, 15th August 1959, Year 4, Issue 19. Pp.1.
19. Navakal, 29th August 1959, Year 37, Issue 150. Pp.3.
20. Tarun Bharat, Monday, 28 September 1959, Year 25, Issue 256. Pp.3.
21. Tarun Bharat, Saturday, 17th October 1959, Year 27, Issue, 208. Pp.5.
22. Navakal, 10th October 1959. Pp.4.
23. Navakal, Sunday, 18th October 1959, Year 37, Issue 198. Pp.1.

◆◆

Role of Caste Panchayat in the Social Reforms

Dr. Manishkumar Mansukhbhai Jansari*

[*The caste panchayat is especially an important characteristic of lower castes. Although abundant changes have occurred in caste system, caste panchayat in lower castes is still performing specific social functions for the caste and their members. Nowadays they involve some reformative activities which are focus of present research. The principal objective of research is to examine the social structure as well as functions of caste panchayat and to analyze role of caste panchayat in social reformation. Sample survey method has followed to examine above research problem which is of exploratory nature. Overall, 33 respondents were purposively selected to collect primary data, through interview guide, from purposively selected respondents of the 11 caste panchayats of various castes residing at four villages. The major finding is that Koli, Karadiya, Bharwad, Suthar-Luhar, Thakore, and Vankar caste panchayats are more active and effectively control over their caste members which has been involved into many reformative attempts*.]

India is a very vast, complex, and diversified country with long history and inherent culture which comprises diversified states; regions and union territories; cities and villages. Various religions, castes, ethnic groups, regions, languages, lifestyles make it the heterogeneous country which reflects into basic social institutions like, family, marriage, kinship, religion, economy, and entire culture of the Indian society. Ross (1961) noted, "The joint family, the caste, the linguistic group, and the village were the main units which formed the core of the traditional Hindu society. These groups circled each individual Hindu…." (p.03).

* Asst Prof. in Sociology, Shree Bhikhabhai Patel Arts College, Anand, Gujarat.

The caste system is peculiar, unique, and indivisible characteristic of the Hindu society of India. The traditional social system in India was controlled around the caste structures and it divides the Hindu society into various small groups whose relations are regulated by cultural notions of purity and pollution. It is a significant form of social stratification which has two most important features like, social hierarchy and endogamy. The caste panchayat is particularly an important characteristic of the lower castes which is focus of this study.

Caste Panchayat

The caste panchayat is ancient organization and works as a small republic with development of caste system and we can find the evidences of its functioning since ancient Indian literature. Blunt (1931) was the first

Swar Sindhu: National Peer-Reviewed/Refereed Journal of Music
ISSN 2320–7175 | Volume 09, Issue 01, June 2021
http://swarsindhu.pratibha-spandan.org
© The Author(s) 2021
UGC CARE listed Journal

भारतीय संगीत परंपरा में मराठी लोकगीतों का योगदान

Prof. S.Y. Meshram[1], Prof. A.D. Fulzele[2], R. H. Meshram[3]

1 Head, Department of History, R.T.M. Nagpur University, Nagpur, Maharashtra
2 Head, Department of History, Dr. Ambedakar College, Deekshabhoomi, Nagpur, Maharashtra
3 Research Scholar, Department of History, R.T.M. Nagpur University, Nagpur, Maharashtra

शोध सार

किसी भी राष्ट्र का लोकसाहित्य उसकी सांस्कृतिक अस्मिता की पहचान होता है। लोक साहित्य मानव के जीवन का सहज सुंदर प्राकृतिक अविष्कार है। लोकसाहित्य लोक संस्कृति का प्रतिनिधित्व करता है। लोकसाहित्य की एक प्रसिद्ध विधा लोकगीत है। इन लोकगीतों ने सदियों से प्रचलित परंपराएं और धार्मिक विश्वास को बनाए रखा है। मानव जीवन की विकास गाथा को इन मौखिक परंपरा ने भूतकाल से वर्तमान और भविष्य काल तक पहुंचाया है। लोकगीत काव्य और संगीत का सुमधुर मिश्रण होते हैं। जिनमें मनुष्य की संवेदना, मनोवृति का भारतीय संस्कृति में संगीत को एक ऐसा योग समझा जाता है, जो उपासना के रूप में किया जाता। जिसमे कला के माध्यम से मोक्ष की प्राप्ति संभव है। मराठी लोकगीतों में भारतीय संगीत की आध्यात्मिक बैठक स्पष्ट रूप से नजर आती है। सर्वधर्म समभाव तथा आत्मिक उन्नति के लिए संगीत कला की पारंपारिक पद्धति का अवलंबन मराठी लोकसंगीत की विशेषता है। मराठी लोक गीतों को गाने की अपनी स्वतंत्र पद्धति होने के बावजूद मराठी लोकगीतों में रचीबसी संगीत की राष्ट्रीय एकरूपता भारतीय संगीत परंपरा में मराठी लोकगीतों का महत्वपूर्ण योगदान है।

बीज शब्दः मराठी लोकगीत, लोकगीतों की विशेषताएं।

भूमिका

लोकगीतों की मौखिक परंपरा सदियों से लोकजीवन में प्रवाहमान दिखाई देती है। लोकगीतों को लोकमानस की सामुदायिक भावनाओं का अविष्कार कह सकते हैं। इसी कारण यह किसी व्यक्ति विशेष की रचना ना होकर लोकमानस की भावनाओं की स्वर एवं लयात्मक निर्मिती है। लोकगीतों को लोकसाहित्य का आत्मा कहा जाता है। यह लोकगीत मानव की आंतरिक भावना, दुःख, वेदना, आनंदउर्मी, भक्तिभाव से परिपूर्ण होते है। भारतीय संस्कृति विविधांगी है। घाट घाट पर बदलते पानी जैसी वाणी भारतीय संस्कृति की विशेषता है। हर प्रांत की अपनी रूढ़ि- परंपरा, धार्मिक विश्वास है। हर प्रदेश की अपनी समृद्ध लोकसंस्कृति और ऐतिहासिक विशेषताएं हैं। लोकगीतों में सामाजिक, ऐतिहासिक, राजनैतिक, आर्थिक, धार्मिक, व्यावसायिक एवं सांस्कृतिक परिवेश की छाप दिखाई देती है। लोकगीत उस प्रदेश विशेष के लोकजीवन एवं लोकसंस्कृति का दर्पण होते हैं। मौखिक परंपरा से जतन किए हुए इन लोकगीतों में शास्त्रीय संगीत की जड़े विराजमान है। लोकसंगीत की यह सुरीली यात्रा मानव की उत्क्रांति के हर चरण में परिष्कृत होती दिखाई देती है। प्राकृतिक ध्वनियों से प्रेरित होकर शब्द से भाषा तक पहुंचने वाले मानव ने अपनी स्वाभाविक नादप्रियता से अक्षरों को स्वरों में ढाला और संगीत की कला को जन्म दिया।

भारतीय शास्त्रीय संगीत की परंपरा सामवेद के गायन और भरतमुनि के नाट्यशास्त्र से प्रमाणित होती है। मतंगमुनि का बृहदेशी और सारंगदेव का संगीत रत्नाकर ऐतिहासिक दृष्टि से महत्व रखते हैं। जिस प्रकार

Swar Sindhu: National Peer-Reviewed/Refereed Journal of Music
ISSN 2320–7175 | Volume 09, Issue 01, June 2021
http://swarsindhu.pratibha-spandan.org
© The Author(s) 2021
UGC CARE listed Journal

भारतीय संगीत परंपरा वैदिक युग के सामगान की देन है, उसी प्रकार सामगान लोकसंगीत की उत्पत्ति की भी प्रेरणा है। वैदिक काल में संगीत के मनोरंजनात्मक एवं अध्यात्मिक यह दोनों रूप प्रचलित थे। शास्त्रीय संगीत उच्चकोटि का होने के कारण जनसाधारण को समझने में कठिन होता था। इसी कारण संगीत की दो धाराएं निर्माण हुई। वैदिक काल में अध्यात्मिक संगीत को मार्गी और लोक संगीत को देशी कहा जाता था। बदलते समय के साथ जनसाधारण व्यक्तियों का लोकसंगीत देशी और अग्रणी व्यक्तियों का शास्त्र शुद्ध शास्त्रीय संगीत प्रचलित हुआ। वैदिक काल में यज्ञ विधि समारोह में सादर किए जाने वाले गीतों का स्वरूप लोकगीतात्मक था, ऐसे कहा जाता है।

वेदों में गीतों के लिए गाथा शब्द का प्रयोग मिलता है। लोक साहित्य में लोकगीतों की श्रेणी में विशेष महत्व रखने वाले लोक कथागीत महाकाव्यों पर आधारित गाथा होते हैं। पौराणिक काल के लोकजीवन में लोकगीतों का प्रचलन दिखाई देता है। महाकाव्यों में लोकगीत परंपरा का उल्लेख मिलता है। रामायण तथा महाभारत आज भी गाथा शैली में गाए जाते हैं। वैदिक काल में प्रचलित लोकगीतों की प्राचीनता का प्रमाण वैदिक साहित्य, पुराण साहित्य, महाकाव्य तथा संस्कृत साहित्य के आधार पर पाया जा सकता है। प्राचीन काल से सूत, मगध, भाट, चारण, कुलशिव ऐसी लोकगायकों की परंपरा अस्तित्व में थी। जिन्होंने इस लोकगीतों की परंपरा को संजोकर के रखा था। महाराष्ट्र के ऐतिहासिक पार्श्वभूमि पर लोकगीतों की परंपरा का प्रमाण सम्राट हाल की गाथा सप्तशती, यादव कालीन सोमेश्वर नृपति का मानसोल्लास जैसे ग्रंथ देते हैं। सातवाहन कालीन महाराष्ट्री प्राकृत भाषा से ही मराठी का जन्म हुआ है, जो यादव काल में साहित्यिक दृष्टि से और संपन्न हो गई। संत ज्ञानेश्वर महाराज ने क्लिष्ट संस्कृत में लिखी भगवतगीता का मराठी में अनुवाद किया और यहीं से मराठी संत साहित्य की अप्रतिम यात्रा शुरू हो गई। कृष्ण द्वारा अर्जुन को बताए गए अध्यात्मिक विचारों का निचोड़ संतों की वाणी द्वारा साधारण जनता ने आत्मसात किया और अपने जीवन के कष्टों को भूल कर संगीत के माध्यम से परमात्मा में लीन होने का सहज तरीका अपनाया।

संशोधन प्रविधि

ऐतिहासिक संशोधन पद्धति का अवलंब कर उपलब्ध साहित्य का शास्त्रीय दृष्टि से परीक्षण कर मूल्यांकन किया गया है।

गृहीत तत्व

संगीत की दृष्टि से लोकगीत किसी भी वाद्यवृंद के बिना ह्रदय को छेड़ने वाले स्वाभाविक स्वरों का प्रतिनिधित्व करते हैं। मानव की ह्रदय की संवेदनाओं से निकली प्राकृतिक ध्वनि से सुसज्जित लोकगीत वह संगीत है, जो मानव की सभी कष्टों का निवारण करता है। आनंद के क्षणों में साथी होता है। उत्सव में, संस्कारों में, उपासना विधि में लोकमानस के स्वर को ताल और लय देता है, जो संगीत की परिभाषापूर्ण करता है। लोकसंगीत का भारतीय परंपरा में उल्लेखनीय योगदान है। मराठी लोकसंगीत ने भारतीय संगीत की परंपरा में अपनी अलग पहचान बनाए रखी है। महाराष्ट्रीय संगीत की विशेषताएं उसकी उच्च कोटि को प्रदर्शित करती हैं।

Swar Sindhu: National Peer-Reviewed/Refereed Journal of Music
ISSN 2320–7175 | Volume 09, Issue 01, June 2021
http://swarsindhu.pratibha-spandan.org
© The Author(s) 2021
UGC CARE listed Journal

महाराष्ट्र की लोकगीत परंपरा

भारत के अन्य प्रांतों की तरह मराठी लोकगीत प्रादेशिकता, गायक, वर्ण व्यवस्था, आयु की अवस्था, समाज जीवन और विधि संस्कारों पर आधारित होते हैं। महाराष्ट्र के लोकगीतों में पुरुषों के गीत, स्त्री गीत तथा बाल गीतध शिशु गीत प्रसिद्ध है। विधियों पर आधारित गीत मुख्यतः 16 संस्कार और वार्षिक त्योहारों के उपलक्ष में गाए जाते हैं। देवताओं पर आधारित उपासना गीत और बदलते ऋतु पर आधारित त्यौहार गीत मराठी संस्कृति की विशेषता है। महाराष्ट्र के लोकगीत प्रकारों में ओवी, भोंडला गीत, भुलाबाई केगाने, मुहूर्त के गीत, कोली गीत, शेतकरी गीत यह काव्य प्रकार आते हैं। मराठी लोकगीतों से ही वासुदेव के गीत, लावणी, पोवाडा, भारूड यह गीत प्रकार विकसित हुए है। मराठी लोकगीतों में स्त्रियों के गीतगानों की संख्या विपुल है। स्त्री गीतों में ओवी यह पद्य प्रकार प्रसिद्ध है। जो जैन कालीन ब्रुहत् कल्पसूत्र भाष्य में लिखित मौखिक ओवीगीत की प्राचीनता (इसवी सन छठा शतक) का प्रमाण देती है। पुरुषों के गीतों में कृषि काम से संबंधित भलरी गान, शक्ति पूजा से संबंधित गोंधळ, महादेव के गीत प्रसिद्ध है। शिशुओं के गीतो में ताल गीत और लोरी गीत उल्लेखनीय है।

भारतीय संगीत की परंपरा में मराठी लोकगीतों की विशेषताएं

मराठी लोकगीतों पर महाराष्ट्र के संत साहित्य का प्रभाव स्पष्ट रूप से दिखाई देता है। मराठी संतो ने जनजागृति और समाज प्रबोधन के लिए अभंग, भजन कीर्तन जैसे लोक माध्यमों का उपयोग किया। उन्होंने अपने उपदेश अथवा शिक्षा को लोकगीत शैली में गाकर सर्वसाधारण जनता को एकसंघ किया। वर्ण व्यवस्था के कठोर बंधनों से ग्रस्त समाज को मानव धर्म का पाठ पढ़ाया। परंपरागत पुरुष प्रधान संस्कृति की बेड़ियों में जकड़ी मराठी संस्कृति की नारियों ने इन संत महात्माओं की ज्ञानवाणी का खुले ह्रदय से स्वागत किया। इसीलिए मराठी स्त्री गीतों में महाराष्ट्र के प्रसिद्ध ज्ञानेश्वर, तुकाराम, नामदेव, एकनाथ और रामदास स्वामी इनकी शिक्षा के प्रमाण अधिक मात्रा में मिलते हैं।

महाराष्ट्रीय लोकसंगीत का झुकाव अध्यात्म की ओर ज्यादा दिखाई देता है। जो महाराष्ट्र में प्रचलित भागवत धर्मपंथ का प्रभाव स्वरूप है। महाराष्ट्रीय संतकवी अपने अभंगों, भजन–कीर्तन द्वारा लोगों के मन में धार्मिक श्रद्धा और दिव्य भक्ति की प्रेरणा को प्रज्वलित करते थे। संगीत के प्रभावी साधन से मानव ईश्वर के निकट पहुंच सकता है और मोक्ष काद्वार खुल सकता है, यह विश्वास महाराष्ट्र के संतों के विचारों ने साधारण जनता को दिया। मानव के सत्कर्म उसे उसके आराध्य तक पहुंचा सकते हैं। भक्ति रस में डूबा संगीत मनुष्य को जन्म–मृत्यु के फेरों से मुक्त कर सकता है। संगीत से ईश्वर का साक्षात्कार संभव है। प्रकृति के अनाहत नाद से आत्मिक नाद जोड़कर आत्मा को परमात्मा में विलीन करने का सर्वोत्कृष्ट माध्यम भक्ति की आराधना है। भजन, कीर्तन, पौराणिक कथा गायन, ईश्वर स्तुति के गीत यह माध्यम हो सकते हैं। ऐसी अध्यात्मिक सीख मराठी संतों की साहित्यों और उनके ईश्वर भक्ति में उपस्थित थी, जिसका प्रभाव जनसामान्य पर होने के लगा था। मराठी संत परंपरा में जाति व्यवस्था के उच्च स्तर से लेकर निचले स्तर के संतों का समावेश है, जिसका प्रमाण मराठी संतो ने अपने साहित्य में स्वयं भी दिया है। लोकगीतों में भी यह वास्तविकता स्पष्ट होती है। महाराष्ट्र के प्रसिद्ध संत कवि चोखामेळा जो जाति व्यवस्था के सबसे नीचे के स्तर से आते हैं। उन्होंने अपनी रचना में कहा है, हे ईश्वर हीन जाति के कारण समीप न आकर सेवा नहीं कर सकता क्योंकि अछूत का मंदिर में प्रवेश वर्जित है।

Swar Sindhu: National Peer-Reviewed/Refereed Journal of Music
ISSN 2320–7175 | Volume 09, Issue 01, June 2021
http://swarsindhu.pratibha-spandan.org
© The Author(s) 2021
UGC CARE listed Journal

हीन याती माझी देवा कशी घडेल तुझी सेवा

मज दूर दूर हो म्हणतीतुझं भेटू कवण्या रिती (भवालकर, 1990 पृ.124.)

अगली पंक्तियों में लोकगीत इस बात की पुष्टि करता है। विट्ठल मंदिर में पूजा करते वक्त स्त्री कहती है, मेरा यह चौथा दंडवत नामदेव जहां समाधिस्थ हुए, मंदिर की उस सीढ़ि को समर्पित है। मेरे लिए वह जगह भी पवित्र है जहां से चोखामेला ईश्वर को दर्शन देने के लिए खुद बाहर आने को कह रहा है। क्योंकि उसे मंदिर के अंदर आने का अधिकार नहीं है। जैसे ईश्वर के लिए सब भक्त एक समान है। मेरे लिए भी संत नामदेव की भांति चोखा मेला भी सम्माननीय है।

माझ्या चौथा माझा दंडवत नामदेवाच्या पायरी

हाक मारतो विठ्ठलाला चोखामेळा तो बाहेरी (बाबर, 1977 पृ.12.)

यही मानवता का समभाव, जाति निरपेक्ष भक्ति, विचारों का आध्यात्मिक पहलू मराठी लोकगीतों की विशेषता दिखाती है। मराठी संगीत में भक्ति रस इतना घुल चुका था कि राधा कृष्ण के श्रृंगार गीतों मे भी भक्ति की अलौकिक धारा प्रवाह मान दिखाई देती है और कृष्ण की बाल लीलाएं अध्यात्म का सार समझाती है।

ज्याच्या नावे होती संसारात मुक्त

यशोदा बांधीत त्याला दावे (सानेगुरुजी, 2011 पृ.230.)

अर्थ–जिस श्री कृष्ण के केवल नाम स्मरण से ही व्यक्ति का उद्धार होता है। जिसके कारण सांसारिक कष्टों से मुक्ति मिलती है। उस कृष्ण की बाल्यावस्था में उसकी चपलता से, नटखट वृत्ति से परेशान मां यशोदा उसे खूंटे से बांध कर रखती है, जो सब को मुक्त कर सकता है, उसे कौन बांध कर रख सकता है।

महाराष्ट्र में जनसाधारण के जीवन में बसा वैष्णव पंथी भागवत धर्म मराठी लोक संस्कृति का विशेष है। पांडुरंग की भक्ति आराधना इस पंथ की मुख्यधारा है। पंढरपुर मराठी संस्कृति की 'काशी' मानी जाती है। मराठवाड़ा की पावन धरती पर बहने वाली गोदावरी गंगा जैसी पवित्र नदियाँ पावन कहलाती है। महाराष्ट्र के लोकगीतों में पंढरपुर के आराध्य विष्णु के अवतार पांडुरंग और उनकी पटरानी रुकमणी के विवाह से लेकर विरह तक के हर एक क्षण का वर्णन मिलता है। इन गीतों में महाभारत पर आधारित कृष्ण के अद्वितीय व्यक्तिमत्व की, कृष्ण द्वारा बताए गए गीतोंपदेश की झलकियां मिलती है। महाकाव्यों पर आधारित लोकगाथा, उनका गायन तथा पौराणिक कथाओं से प्रेरित होकर की गई रचनाएं मराठी लोकगीतों की एक उल्लेखनीय विशेषता है। मराठी लोक संस्कृति के स्त्रियों ने पौराणिक कथाओं से प्रेरित होकर अपने जीवन में सावित्री, सीता, रुक्मणी, पार्वती इनके आदर्शो को अपनाया और उनकी जीवन पर आधारित प्रसंगो को स्वरों में भी ढाला।

सावित्रीचे व्रत करावे पवित्र

एकावे चरित्र सावित्रीचे (सानेगुरुजी, पृ.218.)

Swar Sindhu: National Peer-Reviewed/Refereed Journal of Music
ISSN 2320–7175 | Volume 09, Issue 01, June 2021
http://swarsindhu.pratibha-spandan.org
© The Author(s) 2021
UGC CARE listed Journal

यमराज से लड़कर अपने पति को मृत्युलोक से वापस लाने वाली सावित्री के पतिव्रत धर्म के आदर्श पर आधारित अगली पंक्तियों में चक्की पर आटा पीसते हुए अपने दुखों से पीड़ित नारी कहती है, सांसारिक दुखों से थकना तुझे शोभा नहीं देता क्योंकि यहां तो सीता जैसी पवित्र नारी को भी बनवास का कष्ट उठाना पड़ा।

सरले दळण दळून दमलीस

सीतेला ही होई संवसारी वनवास (सानेगुरुजी, पृ.314.)

महाराष्ट्रीय लोकसंगीत की सबसे महत्वपूर्ण विशेषता यह है कि, उसका एक रूप राष्ट्रीय संगीत है। महाराष्ट्र के पांच प्रादेशिक रचना और बोली भाषाओं पर आधारित लोकगीतों में राष्ट्रीय एकता का रूप दिखाई देता है। महाराष्ट्रीय लोकगीतों में मानव की संकीर्ण विचार पद्धति नहीं मिलती बल्कि उसमें मानवता का राष्ट्रीय रूप प्रतिबिंबित होता दिखाई देता है। महाराष्ट्रीय लोकगीतों में सभी धर्मों का आदर देने वाले लोकगीत मिलते हैं। एक दूसरों की परंपराओं के प्रति आदर दिखाई देता है। सहज सहचर्य और भारतीय संस्कृति का अभिमान गीतों में झलकता है। अपने धर्म के साथ बाहर से आए धर्म का सम्मान करना चाहिए यह हिंदू संस्कृति की सीख है। महाराष्ट्र के खानदेश कहे जाने वाले प्रादेशिक विभाग से यह लोकगीत पंक्ति है, जहां शब्दों में पिरोया गया हिंदू धर्म का अभिमान इस्लाम धर्म को सम्मान दे रहा है। (अहिरानी बोली) अपनी मुसलमान सखी के माथे पर टीका ना लगाने के नियम को खुले ह्रदय से सन्मान दे रही है। रूढ़ीवादी लोक संस्कृति की भारतीय नारी जिसके लिए सुहाग का टीका ही सब कुछ होता है। (फकीरनी/ मुसलमान)

सई बहीण करू, करूफकीरनीगिरजा

कपायानाकुकु हिना रामनी वरजा (पाटिल, 1990 पृ.191.)

भारतीय संस्कृति कला का आदर करती है। गीत, संगीत को आत्मिक उन्नति का साधन मानती है। मराठी लोकगीतों ने भी इस परंपरा को सदियों से अंगीकृत किया है जो गीतों से स्पष्ट होता है।

मराठा काल की अगर बात करें तो यह बात स्पष्ट होती है कि, लड़ाकू मराठा केवल युद्धों के ही प्रणेता नहीं थे। तो उन्हें भारतीय संगीत का भी अभिमान था। इतिहास बतलाता है कि, शिवाजी महाराज के राज्याभिषेक के अवसर पर सप्ताह भर गीत–संगीत का आयोजन किया गया था, जिसके कलाकार, गायक, वादक सभी लोककला के कलाकार थे और उसमें अन्य भाषाओं के कलाकारों का भी समावेश था। पोवाडा, लावणी, भजन, कीर्तन, लोकगाथागान, लोकगीत इन सभी का भरपूर आयोजन किया गया था। कहां जाता है की, यह सारे गीत शिवाजी की स्तुति और यशोगान पर आधारित थें जो मुख्यतः भैरव राग में गाए गए। (जोशी, 1957 पृ.304.)

भारतीय संगीत में मराठी लोकगीतों का योगदान

संगीत की परिभाषा करते हुए कहा जाता है, गायन, नृत्य और नाट्य कला का एकत्रित सादरीकरण संगीत है। लोकगीत परंपरा में वार्षिक त्योहारों पर आधारित नृत्यगीत और खेल नृत्यगीत प्रसिद्ध है, जो इस परंपरा का निर्वाह करते हैं। महाराष्ट्रीय लोकगीतों में पिंगा, फुगड़ी, जिम्मा, फेर के गाने यह नृत्य– खेलगीत प्रसिद्ध है। जहां सूर, ताल, लय का विशेष ध्यान रखा जाता है।

Swar Sindhu: National Peer-Reviewed/Refereed Journal of Music
ISSN 2320–7175 | Volume 09, Issue 01, June 2021
http://swarsindhu.pratibha-spandan.org
© The Author(s) 2021
UGC CARE listed Journal

माझा पिंगा ग ऽ जातो म्हमई ऽऽ, आणतोसमईऽ पोरी पिंगा ऽऽ

तुझ्या पिंग्याची ऽ माझ्या पिंग्याची ऽऽ, उतरा दिष्ट गऽ पोरी पिंगा ग पोरी पिंगा

(बाबर, श्रावण भाद्रपद , 1968 पृ.26.)

पिंगा गीत गाते वक्त नृत्य का उत्कृष्ट प्रदर्शन हो रहा है इसलिए किसी की नजर लग सकती है। नजर उतारने के लिए मुंबई से दीया मंगवाया जा रहा है।

पुरुष गीतों में उगते सूरज के साथ गांव की दहलीज पर फेरा लगाने वाला वासुदेव रंग–बिरंगी वेशभूषा करता है। उसकी प्रस्तुति में गीत, नृत्य और वादन का प्रदर्शन होता है। यह कथागीत भक्ति और अध्यात्म पर आधारित होते हैं। भिक्षा की याचना करते हुए वासुदेव दानपुण्य की महिमा का गान करता है।

वासुदेव आला ओ वासुदेव आला, दान द्या त्याला दान द्या त्याला

दानासारख पुण्य नाही हो, दात्याला कशाचंच भान नाही हो (कोली, 2005 पृ.35.)

भक्तिगीतों में पारंपारिक वाद्यो का उपयोग संगीत की परंपरा का निर्वाह करता है। जिसमें तंबूरा, झांझ, लेझिम चिमटा, ढोलक, इकतारा, मृदंग प्रसिद्ध है। मराठी संगीत में हिंदुत्व की पवित्र गौरवगाथा का चित्रण मिलता है। हिंदू संस्कृति की पवित्रता का विशेष ध्यान रखा गया है। भारतीय संस्कृति में वाद्य संगीत को मानव की आत्मा का प्रतिरूप माना है। मानव चरित्र को उच्चतम बनाने के लिए संगीत के माध्यम का प्रयोग मराठी लोकसंगीत की विशेषता है, जिसका भारतीय संगीत पर विशेष प्रभाव रहा है, जो द्वैतवाद भारतीय संगीत की आत्मा है उसका सहज प्रयोग मराठी लोकगीतों में प्रायः दिखाई देता है। मराठी लोकगीतों में अनपढ़ नारियों के गानों में भी अध्यात्म के पाठ मिलते हैं। वैवाहिक संसार को चलाने के लिए पति और पत्नी का नाता एक ही रथ के दो पहिए जैसे होते है। एक दूसरे के बिना अधूरा, जैसे ईश्वर और भक्त का नाता, सगुण और निर्गुण का नाता एक दूसरे पर निर्भर होता है।

पती–पत्नीचं नातं द्वैताचं–अद्वैताचं,

एका रथाची चाकं, दोघ असती (कालभूत, 2007 पृ.139.)

भारतीय संगीत रसप्रधान है। सभी रागरागिनी मानव के आंतरिक भावों पर आधारित है। संगीत का मानव से जो आत्मिक संबंध है। वह प्रकट करने के लिए अपने शब्दों को सुरताल में पिरोकर गीत गाया जाता है। यह गाते वक्त मनुष्य के हृदय की पीड़ा, हर्ष, उल्लास, वात्सल्य, प्रीति, अभिमान इन सब का शाब्दिक रूप सामने आता है। जो व्यक्ति के मन में उस समय उठ रहे रसों को अर्थात भावनाओं को दर्शाता है। यही भावनाएं काव्यशास्त्र में रस कहलाती है और संगीत के सुरों का आधार मानी जाती है। शास्त्रीय भाषा में इसे मनुष्य की स्थिर व शाश्वत भावनाओं का स्थायी भाव कहा जाता है। यह स्थायी भाव उत्साह, शोक, रति, हास्य, भय, विस्मय आदि है। इन्हीं के कारण मानव के मन में रसों की उत्पत्ति होती है। (नाट्य शास्त्र के अनुसार)

मराठी लोकगीतों की श्रेणी में समाविष्ट शिशु गान वात्सल्य, ममता के शांत रस में रचित है। विवाह संस्कार, गर्भाधान संस्कार, मखर गान श्रृंगार रस पर ज्यादातर गाए जाते हैं। पुरुषगीत वीररस पर आधारित होते हैं। स्त्री

Swar Sindhu: National Peer-Reviewed/Refereed Journal of Music
ISSN 2320–7175 | Volume 09, Issue 01, June 2021
http://swarsindhu.pratibha-spandan.org
© The Author(s) 2021
UGC CARE listed Journal

पुरुषों के उपासना गीत भक्तिरस में गाए जाते हैं। मराठी लोकगीतों में अध्यात्मिक गीतों का चलन ज्यादा है जोकि भक्ति रस, अद्भुत रस पर आधारित होते हैं।

निष्कर्ष

मराठी लोकगीत परंपरा केवल साहित्यिक दृष्टि से ही महत्वपूर्ण नहीं है। यह लोक गीत सामाजिक, सांस्कृतिक, राजनैतिक, ऐतिहासिक, धार्मिक और कला के क्षेत्र में भी महत्व रखते हैं। मराठी लोकसंगीत का प्रभाव खासतौर भारतीय संगीत पर विशेषता दिखाई देता है। मराठी लोकगीतों में प्रायः राष्ट्रीय एकता की भावना प्रखरता से दृष्टिगोचर होती है, जो भारतीय संस्कृति की मानवतावादी चेतना का समर्थन करती है। भक्ति, अध्यात्म, समर्पण, वीर रस के गीत यह मराठी लोकगीतों की विशेषताएं है जिनका भारतीय संगीत परंपरा पर प्रभाव रहा है। भारतीय संगीत की उच्चतम कोटि को बनाए रखने में मराठी लोकसंगीत का उल्लेखनीय योगदान रहा है। लोकगीतों केगायन के प्रकार और पद्धति, राग और विधाएं भले ही शास्त्रीय संगीत से भिन्न है किंतु मराठी लोकगायकों ने, सर्वसाधारण जनमानस ने भारतीय संगीत की विशेषताओं का विशेष ध्यान रखा है। भोर के समय मंदिर में ईश्वर को जगाने वाली शास्त्रशुद्ध भूपाली और चक्की पर आटा पीसते समय उगते सूरज की आराधना एक ही भावना से प्रेरित दिखाई देती है। सांझ ढले तुलसी वृंदावन में दीया जलाते वक्त ईश्वर का धन्यवाद देने वाली गीतों की पंक्तियां दीपक राग से कम नहीं होती, वर्षा ऋतु के उत्सव गीत, खेलनृत्य गीत मेघ मल्हार जैसे बरसते हैं। वसंत ऋतु में बसंत बहार कृषि गीतों मैंरब्बी के धानों को सहलाता है।वीर पुरुषों के यशगान में राग भैरव दुंदुभी बजाता है। भक्ति के गानों में शांति का रस बहता है। राधाकृष्ण के प्रेम में कजरी महकती है। महाराष्ट्र के आदिवासियों के नृत्यगीतों में दादरा, केरवा, खामटा ताल पकड़ते हैं। मराठी लोकगीतों की प्राचीन परंपरा बनाए रखने वाली ओवी कहरवा ताल में गूंजती है, आरोह अवरोह को साथ लेकर चलती है। ध्रुपद और अंतरे के बीच के अंतर को नापती है। अनाज पीसना खत्म होने पर ईश्वर का धन्यवाद देते हुए ज्ञानेश्वर महाराज की तरह पसायदान भी गाती है। जो कि विश्वशांति के लिए, संपूर्ण मानव जाति के उद्धार के लिए प्रभु की याचना करने का अप्रतिम उदाहरण है। नृत्य, गायन, वाद्य, नाट्य इन सारी कलाओं से परिपूर्ण, उच्चविचार धारा से परिष्कृत महाराष्ट्रीय लोकसंगीत भारतीय संगीत परंपरा में अपना योगदान दर्शाते हुए मानवता का पाठ पढ़ाता है और राष्ट्रीय एकता की प्रेरणा देता है।

संदर्भ ग्रंथ

कालभूत, पुरुषोत्तम. (2007). लोकसाहित्य :स्वरूप आणि विवेचन. विजय प्रकाशन, नागपुर
कोली, विट्ठल. (2005). महाराष्ट्रातील लोकगीते . औरंगाबाद : साकेत प्रकाशन।
जोशी, उमेश. (1957). भारतीय संगीत का इतिहास . फिरोजाबाद : मानस सरोवर प्रकशन महाल।
पाटिल, कृष्णा. (1990). अहिरानी लोकसाहित्य दर्शन,मुंबई : महाराष्ट्र राज्य साहित्य आणि समिति मंडल।
बाबर, सरोजिनी. (1968). श्रावण भाद्रपद, मुंबई : महाराष्ट्र राज्य शिक्षण समिति।
बाबर, सरोजिनी. (1977). विट्ठल रुक्मिणी, मुंबई :महाराष्ट्र राज्य लोकसाहित्य समिति।
भवालकर, तारा. (1990). लोकसाहित्यतील स्त्री प्रतिमा, पुणे : सुगावा प्रकाशन।
सानेगुरुजी. (2011). स्त्री जीवन, कोल्हापुर : रीया पब्लिकेशन।

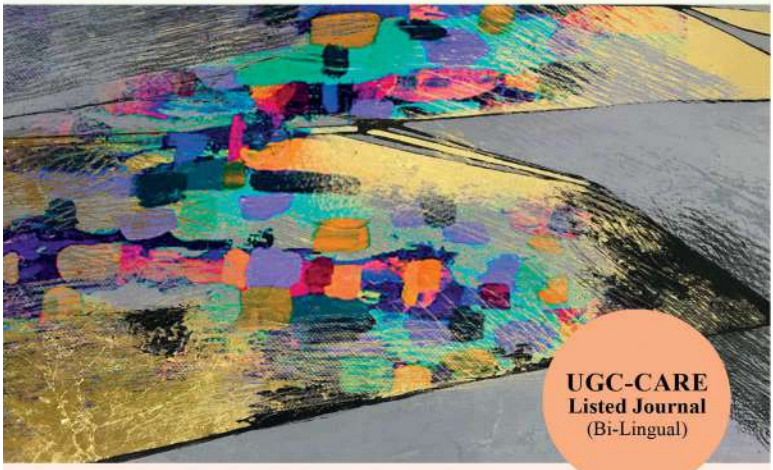
ISSN: 2454-3837

Vol.-VII | Issue-II | September 2021

সম্প্রীতি
sampriti

ৰাষ্ট্রীয় গৱেষণা পত্রিকা

Double Blind Peer Reviewed National
Research Journal of Humanities and Social Sciences



UGC-CARE
Listed Journal
(Bi-Lingual)

ISSN 2454-3837

Editor in Chief
Dr. Dhiraj Patar

Assistant Editor
Dr. Rumi Patar

সম্প্রীতি ISSN : 2454-3837

ৰাষ্ট্রীয় গৱেষণা পত্রিকা

SAMPRITI

DOUBLE BLIND PEER REVIEWED NATIONAL RESEARCH
JOURNAL OF HUMANITIES AND SOCIAL SCIENCES
Vol.-VII, Issue-II, September 2021
UGC-Care listed Journal
(Bi-Lingual)

Editor in Chief
Dr. Dhiraj Patar

Assistant Editor
Dr. Rumi Patar

SAMPRITI PUBLICATION
NEAR GAUHATI UNIVERSITY
ASSAM FOREST SCHOOL-781014

Content

অসম বুৰঞ্জীত প্ৰতিফলিত পুৰণি অসমৰ মাত-কথা আৰু সমাজ ব্যৱস্থা
*সাতসৰী অসম বুৰঞ্জী*ৰ আধাৰত এক আলোচনা
ডঃ সংগীতা শইকীয়া 11-26

গগণ চন্দ্ৰ অধিকাৰীৰ শিশু সাহিত্য ঃ এক অধ্যয়ন
সঞ্জয় আচাৰ্য 27-39

অসমৰ সাহিত্য আৰু সংস্কৃতিৰ উত্তৰণত আহোম স্বৰ্গদেউ ৰুদ্ৰসিংহৰ ভূমিকা
ডঃ মিতালী নাথ 40-47

ভবেন্দ্ৰ নাথ শইকীয়াৰ গল্পত আৰ্থ-সামাজিক দিশ ঃ এক বিশ্লেষণ
ডঃ ধনেশ্বৰ কলিতা 48-53

ভূপেন হাজৰিকাৰ গীতত উত্তৰপূৰ্বাঞ্চলৰ সামাজিক-সাংস্কৃতিক
জীৱনৰ প্ৰতিফলন ঃ এটি আলোচনা
লক্ষণা দত্ত 54-61

কোচ ৰাজবংশী জনগোষ্ঠীয় লোক দেৱতা ঃ এক সমাজতাত্ত্বিক অধ্যয়ন
চক্ৰধৰ ৰায়, ডঃ ৰাতুল ডেকা 62-70

জেহিৰুল হুছেইনৰ হাস্যৰসাত্মক শিশু সাহিত্য ঃ এক বিশ্লেষণাত্মক আলোচনা
ডঃ নৱমী গগৈ 71-76

বস্তি শেনচোৱাৰ চুটিগল্পত লোকপৰম্পৰা
গীতাশ্ৰী দেৱী 77-85

নৱকান্ত বৰুৱাৰ কবিতাত মহাকাব্যিক সমল ঃ সংগ্ৰহণ আৰু পুনঃসৃজন বিচাৰ
ডঃ হৰি প্ৰসাদ বৰুৱা 78-94

জোনাকী যুগৰ চুটিগল্পত বাচিক কলাৰ বৈচিত্র্যময় প্রয়োগ ঃ এটি বিশ্লেষণ
টুটুমণি দাস 95-111

ধান আৰু ইয়াৰ লগত জড়িত অসমীয়া সমাজ
ড° কাকলি গগৈ 112-119

মামনি ৰয়ছম গোস্বামীৰ *দঁতাল হাতীৰ উঁয়ে খোৱা হাওদা* উপন্যাসৰ সমাজ জীৱন আৰু ভাষা প্রয়োগ
বন্দিতা পাটৰ 120-129

নিৰুপমা বৰগোহাঞিৰ উপন্যাসত নতুন নাৰীৰ প্রসংগ (অভিযাত্রী উপন্যাসৰ বিশেষ উল্লিখনসহ)
নিপম কলিতা 130-136

অসমীয়া গীতি-নাট ঃ বিকাশ আৰু বিৱর্তন
ড° বর্ণালী গগৈ 137-153

ভূপেন হাজৰিকাৰ অসমীয়া কাহিনীবিযুক্ত গদ্যৰ শৈলী
পৰেশ খনিকৰ 154-161

শিৰসাগৰ জিলাৰ নগা জনগোষ্ঠীৰ সমাজ আৰু সংস্কৃতিঃ এক ক্ষেত্রভিত্তিক অধ্যয়ন
প্রণৱ দুৱৰা 162-170

পাৰিপার্শ্বিক সাহিত্য সমালোচনাৰ আলোকত সৌম্যদ্বীপ দত্তৰ *অৰণ্যাতুৰ ভ্রমণকথা* গ্রন্থ ঃ এটি অধ্যয়ন
পূৰালী বৰা 171-182

গোৰিন্দ প্রসাদ শর্মাৰ *ডেফডিল ফুল দেখিছা* ভ্রমণ-সাহিত্যত প্রকাশিত কাব্যধর্মিতা ঃ এটি আলোচনা
ৰুবী বৰা 183-192

গাৰো জনগোষ্ঠীৰ বিবাহ প্রথা আৰু ৰূপান্তৰণ ঃ এক পর্যবেক্ষণ
সনাতন মাৰাক 193-199

নগাঁও জিলাৰ শঙ্কৰোত্তৰ যুগৰ নাটৰ ভাষা আৰু সংগীত ঃ এক বিশ্লেষণাত্মক অধ্যয়ন
ড° হিমাশ্রী হাজৰিকা 200-214

ৰামধেনু পৰৱর্তী অসমীয়া ব্যংগ চুটিগল্পত অসমীয়া ভাষাৰ প্রসংগ
শোভাকৃষ্ণা ফুকন 215-225

প্রফুল্লদত্ত গোস্বামীৰ দৃষ্টিত লক্ষ্মীনাথ বেজবৰুৱাৰ সাধুকথা চিন্তন ঃ এটি বিশ্লেষণাত্মক অধ্যয়ন
আভা ভৰালী, ড° উমেশ চন্দ্র ডেকা 226-235

ৰংবং তেৰাঙৰ *ৰংমিলিৰ হাঁহি* উপন্যাসত প্রতিফলিত ক্ষমতাৰ প্রসংগ (সাংস্কৃতিক বস্তুবাদৰ আধাৰত)
প্রার্থনা দত্ত 236-246

অপূর্ব কুমাৰ শইকীয়াৰ গল্পৰ ভিন্ন স্বাদ
ড° লোকেন্দ্র কাকতি, অর্চনা হাজৰিকা 247-254

A preliminary investigation of the sesquisyllabification in Bodo-Garo
Aleendra Brahma 255-262

Weaving Widowhood: Reflections on Life and Literature of Mamoni Raisom Goswami
Dr. Rena Laisram 263-270

Journey of Jhollywood: A Study in the Context of Napuri Cinema
Amit Kumar, Dr. Rajesh Kumar, Rashmi Verma & Dr. Rabindranath Sarma 271-280

Negation in Assamese and Deuri: A Comparative Study
Dr. Dipak Das & Dr. Khirapada Dutta 281-296

The Mising Youth Dormitory: Continuity and Change
Ajit Konwar 297-305

Lai Haraoba: Indigenous Ritual Festival of the Meiteis of Manipur
Dr. L. Anupama Singha 306-313

Participation of Women In Panchayati Raj Institutions (Pris) A Case Study In Dibrugarh District of Assam
Dr. Gitamoni Handique Gogoi 314-322

Nature of Tensions, organizations and movement of the Tiwa Tribe in North East India
Ranjit Bordoloi 323-333

Voting Behaviour of the Tea Garden Women of Monabari and Shakomato Tea Estate: An Analytical Study
Dr. Bipul Das 334-340

Title of the paper: Causes of Rural-Urban Migration in Assam to Outside: An analytical study
Julfair Mazid Kazi 341-350

Introduction of Wet Rice Cultivation In Assam And The Role of The Ahoms: A Vexed Historiography
Anurag Borah 351-358

Shidnak Mahar: An Unknown Warrior Among Untouchables
Dr. Avinash Digambar Fulzele 359-365

An Analysis of the Women's Participation in Economic Activities of India
Anshumi Dutta 366-373

Population Growth and Trend in Assam: An Analysis of Census Data, 1901-2011
Atul Saikia 374-383

Trauma and the Precarious in Prabhat Goswami's *Sukola Hatir Khoj*
Dr. Saurav Sengupta & Mr. Biswajit Kalita 384-392

Role of Public Libraries in promoting Information Literacy in Assam with special reference to Nagaon District
Dipankar Borah & Ratna Kanta Bora 393-403

Nationalist Consciousness in Lakshminath Bezbaroa's Jaymati Kuwari
Dipankar Saikia 404-411

An Analysis of Economic Condition of the MecheCommunity of Nepal
Dr. Dipen Basumatary & Anjan Sarma 412-427

Role of Drama in Teaching-Learning Process : A Review
Dr Runumi Devi 428-432

Locating 'Identity' in Jhumpa Lahiri's *In Other Words*
Dr Rimi Nath 433-439

Arabic Language between Authenticity and Renewal
Dr. Syed Muhamed Ul Hashmi 440-447

Patriarchy, Prison and COVID19 : A sociological study of the impact of COVID19 on Women prisoners
Miss Dwijiri Ramchiary 448-458

Avenues of Open Educational Resources (OER) for Higher Education
Dr. Gouri Sankar Karmakar & Dr. Barsha Rani Duarah 459-464

A Studyon Financial Services Companies Listed Under National Stock Exchange
Gunjan Kumar & Dr. Vandana Mehrotra 465-474

Monasticism and the Tai Khamyangsof Assam: A Critical Appraisal
Dr. Kuntal Sarma 475-482

Historical Significance of Oral Traditions of Assam With Special Reference to Kamakhya Temple and Malinithan
Mrs. Lichamoni Boruah Gogoi 483-488

Sampriti
Vol.-VIII,Issue-II, September 2021
ISSN : 2454-3837
Pages: 359-365

Shidnak Mahar: An Unknown Warrior Among Untouchables

Dr. Avinash Digambar Fulzele
Professor & Head, Department of History,
Dr.Ambedkar College, Deekshabhoomi, Nagpur-10.
E-mail: avi.fulzele@gmail.com

Abstract

Mahar caste was considered as untouchable. Social, economic, and political rights were denied to untouchables. But, King Shivaji Maharaja followed the principle of secularism while establishing Maratha Empire. Mahar had chivalrously fought in his kingdom. Mahar community's people were awarded by Shivaji Maharaja for finding out remote and uncharted routes of the forts. But, their remarkable deeds were sidelined in the history. Moreover, they don't have any history. But, Shidnak Mahar, a gallant from Maharashtra, exposed the facts regarding it. He proved his gallantry and duty by insidiously debilitating the base of casteism. Untouchability was at its peak during the reign of Peshwas. Shidnak Mahar proved his superiority by chivalrously fighting in the battle of Kharda. He had crippled the base of casteism with his noteworthy courage though caste discrimination was stringently observed during the reign of Sawai Madhavrao. The gallantry of Shidnak Mahar couldn't bring forth as this part of history was forlorn. Present research article endeavours to unearth the historical work of Shidnak warrior.

Key words: Shidnak Mahar, Peshwa's Rule, Shivaji Maharaja, Shahu I, Battle of Kharda, Freedom Struggle of Maratha, Military System of Maratha.

Research Methodology:

Historical research methodology has been used for the present research and available literature has been scientifically examined and evaluated in the light of concerned topic.

Hypotheses:

Shidnak Mahar endeavoured to uplift his own and community's stature by his noteworthy chivalric deeds.

Introduction:

A person's history was sidelined or suppressed due to his caste and religion in Indian history though the modern philosophy says that the gallantry has no religion. Shidnak Mahar, a brave warrior from Maharashtra, was a prominent figure among them. Many legendary figures like Shidnak Mahar were ousted from the history prominently due casteism and untouchability. But, Mahar community's peoplewere always upfront in proving their gallantry by paralyzing the age old tradition of slavery if they got an opportunity. Shidnakcompelled contemporary Peshwas to remain silent by breaking the constraints of caste system with his gallantry. He saved the life of Parshuram Patwardhan with his astounding courage in the decisive battle of Kharda with Nizam in 1795.The victory in Kharda's battle was the last victory of Marathas. ShidnakMahar was the grand-son of the closest and committed ally knight of Shahu I. But, Mahar community's people, who were once committed with Marathas, stood with British in the battle of Koregaon in 1818 after twenty three years.Therefore, it is necessary to study the gallantry of Shidnak Mahar.

Present research is divided into two parts. First part reviews the previous history of Mahars during the rule of Marathas while second part deals with the information about the gallantry of ShidnakMahar and the conclusion is provided at the end of paper.

Early History:

Mahar community's people were not considered as untouchables in the military of Shivaji Maharaja. Untouchables participated in the infantry of Maratha Empire as the soldiers. Two soldiers were assigned from infantry to each Maratha cavaliers. One of them looked after the horse and another one managed the food and fodder for the horse. These soldiers were assigned mostly from Mahar community's people(Robertson 60).These pedestrian soldiers were known as 'Paaik'.'Naak' word was prefixed only before the names of Mahar community's soldiers from these Paaik. Later on the word Naikor Nayak which was used for Mahar soldiers is transposed as 'Naak'. Naak wasn't prefixed before the names other ancient communities in Maharashtra. It was only prefixed before the names of Mahars(Jadhao 27).As well as, Matang community's soldiers were titled with Raut appellation (Khairmode 6-7).Mahar and Mang community's soldiers were prominently assigned to put cannons into bullock cart, carrying these bullock-carts on the battlefield, management of the cannons, cauterizing it and firing at the targets(6-7).The service in infantry was like the inherited right for Mahar community's people.

Mahar community was renowned for its valour. Various incidents can be traced regarding the gallantry of Mahars during Shivaji Maharaja's reign. Shivaji Maharaja had awarded a courageous Mahar for finding out a latent way in Raigad fort(Nalawade 57).[5]Taking the cognizance of this valour, Shivaji Maharaja had offered **'Metenaikya'** to many people from Mahar, Mang, and Ramoshi like downtrodden castes. The check-posts near to the vallation of the forts was known as 'Mete'. Metenayakhad to foremostly face the attack on the fort by the enemies. Soldiers in the main fort were informed about the movement of the enemies when Metenayaks were attacked by the forces of enemies. It indicates that Metenayaks were working as the guardian-angels of the fort. Courageous Mahar and Mang community's people were recruited in the gunnery and shielding inside the fort(Ingale 27).Mahars were too honest. They were very committed to their patrons. They never deceived their patron till the last breath of life though their lives were in danger. These gallant Mahars never compromised or surrendered to the enemies though they were imprisoned, lured or persecuted by the enemies (C. B. Khairmode 214).The King always appreciated, awarded, and designated the gallant heroes who had courageously fought on the battlefields during the reign of Marathas. It resulted into the dignified life and economic benefits to the Mahars who were reeling under the degraded conditions. In spite of this, untouchable community's people didn't get enough opportunities in the military forces during contemporary era(Nalawade 27).In the era of social animosity, Mahar battalions got the rights to build the tents during expeditions. But, the company and camaraderie relationship on the battlefield didn't prove useful in uplifting the condition of untouchables in the villages as the tendency of discrimination was deeply rooted in the minds of people in Indian social milieu(Pandit 5).

Maratha Empire's spine had been broken due to the disorder or mayhem after the demise of Chhatrapati Sambhaji Maharaja. Many communities including Brahmins, Marathas and Prabhuunifiedly and concurrently came together for the sake of homeland. All these people sagaciously and courageously fought to raise the broken Maratha Empire. Shankar N. Joshi, a researcher, has published a passage on Saptam Sammelan (Seventh Conference) (News, Pg 54) of Indian Board of History saying Mahars who loved their homeland valorously fought along with Marathas, Brahmins, and Prabhu in various struggles(Shinde 187).Marathas were struggling with the Mughals for their existence during the freedom struggle of Marathas .If Mughals won a fort, Marathas regained other fort from the clutches of Mughals. Rajaram Maharaja said that Mahars can experience the 'Patilaki' (Pileus) if they regain Vairagad (near to Wai) fort which is captured by Mughals for Maratha Empire(187).As per instructed by Rajaram Maharaja, Nagnak Mahar of Nagewadiwon Vairagad fort from Mughals with his remarkable gallantry and attached it with Maratha Empire to save his position(Bahiskrit Bharat 4).It indicates that Mahars had significantly contributed in the freedom struggle of Marathas.

Shidnak Mahar:

In 1900, 'Junya Aitihasik Goshti' (Old Historical Facts) was written by Krushnaji Vishnu Aacharya Kalgaonkar who was a teacher in Kasegaon School

and published by Mr.Parasnis in 'Bharat Varsha' monthly magazine. It is in the archives of Indian Council of History. Its 32nd story is written about ShidnakMahar(Shinde 192).Kalambi is a village in Tasgaon block in Satara district. Shidnak was a Mahar baron in this village. Anarchy was hovering on Maharashtra after Sambhaji Maharaja was killed by Aurangzeb. It lasted for near-about twenty five to thirty years. Shidnak organized a squad of Mahar community's people and created chaos in the empire. It had essentially benefitted to Marathas. Sambhaji Mahraja's son Shahu I entered in Maharashtra to regain his empire from Tarabai when he released from the detention of Mughals.Shidnak was one of those knights who had sided with ShahuI(158).Shahu I granted benefaction as per the capabilities of the knights who were assisted him in regaining the lost paradise. ShidnakMahar was awarded with Kalambi village for his support(Dadu 138).The grandson of Shidnakwas also named after him. He was a contemporary of Peshwa Sawai Madhaorao.

Sawai MadhaoraoPeshwa noted an incident in his diary regarding purchasing two Kunbi women for 140 rupees at Kajbe Pune(Chimnaji, Raobahadur Ganesh & Marathe, Kashinath Balkrishna 249).Kunbi was a caste in Marathas and they valued themselves as thedescendants of high-born Marathas.Kunbi community's women were serving as the housemaids in houses of Peshwas or Brahmins during contemporary era.They were the slaves of Peshwa as he bought them.It estimates and clarifies the miserliness of untouchables.The persecution of untouchables was at the peak during the rule of Peshwas. Untouchables were denied to roam on the road by tying pot in the neck.Even the shadows of untouchable polluted the upper caste people. Mainstream people used to leave the food if they heard the words of untouchables while having food(Janta Weekly 4). ShidnakMahar valorously fought amidst these circumstances.

ShidnakMahar was renowned as a great swordsman(Nawalkar 55).He was a chevalier in the military of Peshwas. He had participated in the battle of Kharda. The tent of Shidnak Mahar wasn't raised far from the others on the expeditions like Mahar community's areas. He raised his encampment near to the tents of other Brahmin-Maratha chevaliers.Other knights discussed this issue with each other and they complained aboutit to SawaiMadhaorao(C. B. Khairmode 212-213). HerojiPatankar, an old Maratha Knight, was seating beside Peshwa.Peshwa heard the complaint and looked at him. HerojiPatankar's remark is noteworthy in this context. He said, "We are gathered here not for the meal but to fight against the enemies. So, we shouldn't worry about the participation of Mahars with us. This is the ground of gallants having swords in their hands. No one should ask for the caste and creed. Gallants are those who courageously fight in the battlefields and they are the real warriors of their community"(Warkhede 24).Patankar's this remark silenced Peshwa. All knight departed for the battle after give obeisance to Peshwa. Shidnak also came to give obeisance. While giving obeisance, he said, "Lord, I am Shidnak Mahar. Some people hate me because of my caste. You just witness how your servant performs in the battlefield" (Awale

and Dixit 47). Thereafter, the battle commenced. Maratha soldiers were lagging behind before the huge Pathan soldiers of Nizam. So, Peshwa was worried about it. The battle was at its climax. Suddenly, a news came to Peshwa that Pathans attacked Parshuram Bhauand get him down from the horse. As soon as Shidnak knows about it, he rushed towards Patwardhans with his soldiers and ruthlessly defeated the Pathans. The army of Shidnakbrutally killed and defeated many Nizamsoldiers (Shinde 158). Shidnak returned Parshuram Patwardhan from the deadly clutches of Nizam. He was admired by the army of Patwardhans (Dadu 158). Victory in the battle of Kharda was the last victory of Marathas. Thereafter, the reign of Peshwas marked its end merely within twenty three years.

In 1818, Shidnak, a Knight of Mahars and Chief Commander, heard the news that the Mahar soldiers will stand with British to fight against the Peshwas. He visited PeshwaBajirao with his soldiers. While propagating the role of Mahars, Shidnakquestioned, "We are unwilling to fight for British. What will be our place in your empire and military if we defeat and chase off British from your empir?"(Awale and Dixit 50).BajiraoPeshwa ironically replied, "Maharswill not get even the lowest position in Peshwa's Empire"(50).Shidnak replied to the inhuman treatment given by Peshwa saying, "Lord! We have been bearing your numerous inhuman treatments. But, time will punish you as soon as possible. Get ready to face it and be patient. We are honest to our homeland. We aren't inclined to fight with the sons of our homeland. It will be sin from your perspective. But, fighting for the justice and our rights isn't a sin instead it is a truth. We will fight against you if you compel us to do so. Consider it as the last warning of the war"(50). Thereafter, Mahar soldiers fought for British in the battle of Bheema Koregaon. Peshwa was completely defeated in this battle. Shidnak was alive for the many years after the downfall of Peshwa Empire. In 1936, Mr. Yashwantrao Narayan Tipnis wrote a drama entitled 'Dakkhanacha Diwa' (The Beacon-Light of South) on the historical deeds of Shidnak and meticulously portrayed the picture of his gallantry(Janta Weekly 4).Dr. Ambedkar went to the inaugural ceremony of this drama as it was written on the gallantry of Shidnak Mahar without taking the cognizance of the historical facts about the drama. It makes us aware about the valour of Shidnak Mahar. But, his remarkable valour was sidelined in the history. Present research endeavours to unveil the sidelined part of the history.

Conclusion:

Shivaji Maharaja had established his empire with the help of people fromthe all strata of the society. He assigned Mahars for the most important works as well as the safety of empire. He had entrusted Mahars for the responsibility of the various check-posts which were established for the safety of the forts.It clarifies the contribution of Mahars in the establishment of Self-Government.Mahars were renowned for their honesty. Various examples are cited about their commitments in the history. They had find out the rare and latent paths of the forts and they were awarded for it by Shivaji Maharaja himself. It represents their valorous nature.

The valour of ShidnakMahar has proven that Mahar community's people had the capability to alter the condition if they got an opportunity in spite of bearing the brunt of inhuman persecution due to social ostracism. Shidnakflabbergasted mainstream people by his historical deeds without caring for the social ostracism. The persecution of untouchables was at the peak during the reign of Peshwa's empire. Amidst these circumstances, ShidnakMahar's tent in the middle of entire cantonment is an epitome of his valour during the battle of Kharda.Shidnak courageously fought in this battle which compelled Patwardhan to adore him.Those who had proven untouchables as wretched and inferior by birth were praising the gallantry of Shidnak. This incident reveals the greatness of Shidnak. Mahars were far from the mainstream society prominently due to the social ostracism imposed on this community's people. So, their numerous legendary deeds were hidden due to social ostracism. Their sagas had been deliberately suppressed by the mainstream historians.Consequently, Shidnak like many legendary warriors of Mahar community are still buried in the graves of unsung history.

Notes & References:

Awale and Dixit. *Nagvanshiy – Ambedkari Chalwalitil Maharanche Yogdan, Marathi.* Nagpur: S. K. Publication, 1998. Print

Bahiskrit Bharat. Bahiskrit Bharat Fortnightly, Marathi 20 May 1927. Print

Dadu, Miya. *Dalitanche Rajkaran*, Marathi. Mumbai: Majestic Book Stall, 1974. Print

Ingale, Ramchandra Thamkaji. *Maharancha Sanskrutik Itihas*, Marathi. Nagpur: Vishal Publication, 1992. Print

Jadhao, V T. *Maharashtracha Mahar*, Part-I, Marathi . Mumbai: Usha Bharati Publication, 1956. Print

Janta Weekly. Janta Weekly, Marathi 28 March 1936. Print

Khairmode, C B. *Dr. Bhimrao Ramji Ambedkar-Biography*, Marathi. Vol. IX. Mumbai: Maharashtra State Board of Literature and Culture, 1987. Print

Khairmode, Changdeo. *Asprushyancha Lashkari Pesha*, Marathi. 3rd. Mumbai: Maharashtra State Board of Literature and Culture, 2002. Print

Khairmode, Changdeo Bhawanrao. *Dr. Bhimrao Ramji Ambedkar-Biography*, Marathi. Third Edition. Vol. I. Mumbai: Pratap Publication, 1978. Print

Nalawade, M D, ed. *Asprushyanche Aarthik Jeewan*, Part-I, Marathi. PrintAurangabad: Yuvraj Publication, 1984. Print

Nawalkar, Harishchandrarao Narayanrao. *Shriyut Shivram Janba Kamble Yanche Trotak Charitra Aani Parwati Satyagrahacha Itihas*, Marathi. Pune: S. J. Kamble Publisher, 1930. Print

Pandit, Nalini. *Swatantryottar Kalatil Dalitancha Prashna*, Marathi . Pune: Sadhana Publication, 1973. Print

Robertson, Alexander. *The religious life of India, The Mahar Folk, A Study of Untouchable in Maharashtra.* Calcutta: Y.M.C.A. Publishing House, 1938. Print

"Satarkar Maharaj Va Peshwe Yanchi Rojnishi, Part-8." *Sawai Madhaorao Peshwe Selective Passages*. Ed. Raobahadur Ganesh Chimnaji and Kashinath Balkrishna Marathe. Vol. III. Pune: Deccan Vernacular Translation Society, 1911. Print

Shinde, Vitthal Ramji. *Bharatiya Asprushyatecha Prashna*, Marathi. Nagpur: Office of Navbharat Book Series, 1933. Print

Warkhede, Ramesh, ed. *Maharaja Sayajirao Gaikwad Yancha Bhashan Sangrah*, Part-2, Marathi. Vol. II. Aurangabad: Secretary, Maharaja Sayajirao Gaikwad Biographical Literature Publication Committee, 2017. Print

ISSN 0970-7247

THIRD CONCEPT

English Monthly
Annual Subscription Rs. 200

Vol. 35 No. 416 OCTOBER 2021 Rs. 20.00

- **China *versus* United States**
- **Gandhian Thought**
- **Smaller State Politics**
- **Relevance of Panchayati Raj**
- **On Bad Bank**

THIRD CONCEPT

An International Journal of Ideas

Vol. 35 No. 416 OCTOBER 2021 Rs. 20. 00

Third Concept aims at providing a platform where a meaningful exchange of ideas can take place among the people of the Third World. The attempt will be to communicate, debate and disseminate information, ideas and alternatives for the resolution of the common problems facing humankind. We welcome contributions from academics, journalists and even from those who may never have published anything before. The only requirement is a concern for and desire to understand and take the issue of our time. Contributions may be descriptive, analytical or theoretical. They may be in the form of original articles, reactions to previous contributions, or even a comment on a prevailing situation. All contributions, neatly typed in double space, may be addressed to:

Editor	*Consulting Editor*
Babuddin Khan	**M. L. Sharma**
Deputy Editor	*Managing Editor*
Manoj K. Narula	**R. Prudhvi Raju**
Business Executive	Art Director
R.S.Rawat	**Purba Roy**
Business Executive South-east Asia	
Shatrughan Kumar Dwivedi	

While the Editor accepts responsibility for the selection of materials to be published, individual authors are responsible for the facts, figures, and views in their articles. However, the Editor reserves the right to edit the articles for reasons of space and clarity.

Published, Printed and Owned by
Babuddin Khan
Third Concept,
LB - 39, Prakash Deep Building,
7, Tolstoy Marg, New Delhi-110 001.
Ph : 23711092, 23712249, Fax No: 23711092.
E-mail : third.concept@rediffmail.com
Website: www.thirdconceptjournal.co.in

THIRD CONCEPT NOW UGC-CARE List

Designed by: **Pt. Tejpal**

INSIDE

Editorial
From Quad to AUKUS 5
B.K.
Dynamics of China's Growing Strength vis-à-vis USA 7
Alok Kumar Gupta
Regime Change and Democracy in Maldives 11
Anilkumar B. Halu
Bad Bank and Management of Stress Assets 14
Dr. D. M. Mahapatra & Dr. S. K. Baral
Impact of Upanishads on Gandhian Thought 17
Dr. K.L.N. Murthy
Anxiety, a Variable in Affective Filter 20
Mrs. R. Brindha & Dr. P. Malathy
Vocational Education in National 23
Gagan Singh & Gopal Datt
Teacher Enthusiasm, Organizational 28
Manju Bala & Poonam Punia
Accessibility of PDS Products in 31
Dr. P. Natarajamurthy & Dr. A. Janata Selvi
Plight of Small Tea Growers in India 34
Dr. Abdul Hannan
Trauma and Postmodernism..... 38
Dr. V. Vinod Kumar & Gayathri S
Relevance of Panchayati Raj Institutions 41
Dr. Vikram Singh
Dr Ambedkar and Formation 46
Dr Avinash Digambar Fulzele
National Education Policy..... 50
Dr. Reenu Rani Mishra
Political Empowerment of Women 53
Santi Saya Boruah Dr. Lanu Devi
Educational Institutions of Christians in India 57
Mitali Brahma

Dr Ambedkar and Formation of United Maharashtra

Dr Avinash Digambar Fulzele*

[Today, Maharashtra is on the verge for its completion of sixty years of formation. Dr. Babasaheb Ambedkar played significant role in the formation of United Maharashtra. As well as, he suggested to divide Maharashtra into three parts and stressed on the formation of three states. He also recommended the division of Uttar Pradesh into three states, Bihar into three, and Madhya Pradesh into two states. Dr. Ambedkar backed the demand of united Maharashtra when the division of Mumbai from Maharashtra got momentum. He instructed his party members to participate in this movement. As far as the progression of Maharashtra is concerned, the demand of independent Vidarbha and Marathwada state has been getting impetus from the formation of Maharashtra. Vidarbha and Marathwada are still lagging behind from the expected standards of development as compared to other regions of Maharashtra.]

The demand of linguistic reorganization of states had been increasing during British rule in India. British Government had taken some steps towards it. Congress Party propagated its agenda in this context in the 1920s conference. Government gradually inclined towards the linguistic reorganization of the states as per the increasing demand of the people. Dr. Ambedkar kept himself aloof from the regional conflicts. But he strongly advocated linguistic reorganization when he felt its necessity. He supported linguistic reorganization of the states to maintain regional balance. He had also shown his willingness to form many states on the linguistic basis.

Many small states have been recently formed i.e., Jharkhand, Chhattisgarh, Uttarakhand, and Telangana. The demand of separate state is spurring in various states of India such as Vidarbha in Maharashtra, Gorkhaland in West Bengal, Harit Pradesh in Uttar Pradesh, Bodoland in Assam and Naga state for Naga tribals. Dr. Ambedkar's thoughts regarding reorganization of the states are significant in this context. Therefore, it is necessary to understand the role of Dr. Ambedkar on this issue and its usefulness to solve existing issues of various states in the country. Thus, it is essential to retrospect his thoughts in this context.

Demand of Linguistic Reorganization

The necessity of linguistic reorganization of the states had been the matter of discussion since 1903.[1] The demand of linguistic reorganization of every state had been stirring-up in India since pre-independence era. In 1917, Prof. V. W. Tamhankar of Jaipur in his 'Lokshikshan' periodical had proposed the idea of connecting Marathi speaking people's regions in Hyderabad princely state and Warhad Central Province, with the Marathi speaking districts in Mumbai state.[2] Thereafter, the demand of linguistic reorganization of Karnataka had been advocated in 1938. At that time, Dr. Ambedkar opined that it was the inappropriate time for linguistic reorganization of the country. In his mouthpiece entitled Janta, he stated that the separation of Karnataka from Mumbai or Madras region would be resulting into the unpredictable consequences of linguistic reorganization movement in Maharashtra as well as Gujarat regions.[3]

Dr. Ambedkar stated while about division of Karnataka that, "...the people of these three prominent provinces have been happily residing in Mumbai area since last 115 years... I never discriminate between any region as well as never feel proud to be Maharashtrian. I also never inclined towards the discrimination between any language, region and culture. I also reject the principle of 'firstly, I am Hindi then I am a Hindu or Muslim'. I approve to be a Hindi, firstly and lastly and this is the only tendency which is congenial for the freedom struggle. Therefore, I strongly condemn the division of Karnataka."[4] Thus, Dr. Ambedkar had sternly rejected the idea of dividing Karnataka from Mumbai-Madras regions.

Demand of Independent Vidarbha

The demand of independent Vidarbha was stirring-up from the Marathi speaking areas of Central Province-Warhad. In 1940, many activists of Congress from Vidarbha established 'Mahavidarbha Sabha' and started the movement for independent Vidarbha.[5] G. T. Madkholkar, President of Marathi Sahitya Sammelan (Marathi Literary Convention) organized at Belgaon in 1946, passed a resolution regarding the demand of Maharashtra. As per the resolution, the committee was formed including the members like Datto Waman Potdar, Shankarrao Deo, Keshavrao Jedhe, S. H. Naware, and G. T. Madkholkar.[6]

Gopalrao Dalavi, a renowned Maratha leader in Nagpur, in his article in Tarun Bharat newspaper dated 23rd June 1946 appealed that, "Kunbi, Mali, Teli, Koshti, Untouchables, Kalar, Bhandari community's people in Maharashtra should come together considering themselves as Maratha".[7] Thereafter, Congress activists in Maharashtra established Council for United

* Prof.& Head, Dept of History, Dr Ambedkar College, Deekshabhoomi, Nagpur.

Maharashtra on 28th July 1946 to form United Maharashtra encompassing Vidarbha, Marathwada, and Mumbai regions and started its movement accordingly.[8]

Role of Dr. Ambedkar on the issue of United Maharashtra

Schedule Caste Federation was a prominent organization which was fighting for the issues of downtrodden people in Mumbai province. The members of United Maharashtra Committee realized that they couldn't organize the movement without participation of Schedule Caste Federation on the issue of United Maharashtra. So, Madkholkar and other prominent leaders including Shripadrao Naware went to meet Dr. Ambedkar in Siddhartha College in August 1946. At that time, Dr. Ambedkar suggested to committee's members, "...convey this issue to Dadasaheb Gaikwad by visiting him at Nashik as you have told it to me."[9] But, it was totally futile. Thereafter, Schedule Caste Federation had to face the defeat in 1952's General Elections.

It resulted into the idea to support other parties with the same ideologies. The demand of independent Vidarbha was the biggest hurdle in united Maharashtra movement. So, the leaders of united Maharashtra movement tried to dissuade the leaders from independent Vidarbha movement by approving some privileges to them and signed 'Nagpur Pact' on 28th September 1953.[10] It paved the way for the formation of United Maharashtra. Schedule Caste Federation Party endeavoured to participate in United Maharashtra Movement and it could be observed in contemporary epistolary.[11]

Dr. Kailashnath Katju proposed a bill regarding independent Andhra Pradesh in Upper House of the Parliament on 1st September 1953. Dr. Ambedkar expressed his views on this Bill on 2nd September 1953. He said, "...vernacularism is another form of casteism in our country. We handover the power of administration to a particular community which is most populous in the particular region when we form the separate linguistic province. It can be observed from the administration of many provinces. This community has started the system of casteism by exaggerating their sacred existence. It is widely known as the discrimination. This discrimination paves the way for injustice and this injustice creates malignant feelings among the people. Our vernacularism can't prove harmful for us if it is not marred by the casteism."[12]

But it happens prominently due to the dominance of casteism over vernacularism. Upper caste people treat untouchables like the slaves. That bill hadn't provisioned equal political, religious, social and economic rights of all castes. Therefore, Dr. Ambedkar raised his voice against the bill.

Dr. Ambedkar austerely expressed his views regarding linguistic reorganization of the states. He recommended to divide Maharashtra into three states. In this context, he said, "...the first historical evidence regarding Maharashtra is identified during the reign of Emperor Ashoka. It is mentioned in the book entitled 'Mahavansh'. Ashoka sent many apostles for spreading Buddhism across India and this reference is cited in this regard. The reference of three Maharashtra is cited in the Pali literature as *'Trayi Maharashtrika'* which stands for three Maharashtra. This reference is the solid evidence of the existence of three states of ancient Maharashtra. It clearly indicates that the concept of Maharashtra's three states dates back to the ancient era."[13]

There is the reference of four Marathi provinces in Mahanubhav literature. These four provinces include Falenana means the Southern region, second encompasses the region till the end of Balaghat, third comprises the region of Godavari and Vainganga and the fourth was Warhad region.[14] As stated by Dr. Ambedkar, it clearly indicates that Maharashtra was not a particular state since ancient era. Its ancient traditions, social and economic condition, and contemporary lifestyle were completely different from each other. The population of Marathi speaking people were recorded at 3 crore 30 lakh 80 thousand at that time and the area of Marathi people was 1 Lakh 74 thousand 514 square miles.[15] It was so large area that it could not be merged in a single state and administer on it.

In this context, Dr. Ambedkar said, "...the Maharashtrian people who are demanding for the united Maharashtra haven't tried and trusted the massive area and population of Maharashtra... I can't understand the ideology behind the demand of united Maharashtra. There are two aspects which are totally different from each other. First one is independent state of Maharashtra and another one is a united state of Maharashtra. I support the different state of Maharashtra from Gujarati and Hindi speaking people. But I never support the united nature of independent Maharashtra. Maharashtra's people haven't rebelled against the Northern regions for which they need undivided alliance of Maharashtra..."[16] In this way, Dr. Ambedkar rationalized the issue of united Maharashtra.

But, the supporters of united Maharashtra stated, "If the education and daily administration of the state is governed by the language of majority of the community, then the state must be formed on the basis of vernacular aspects. If the state is multilingual, it gives rise to the problems. The medium of education and communication can be bilingual or multilingual. Therefore, it will be appropriate to reorganize the state on the basis of language. It is observed that the culture of the people changes according to their language, they have their own traditions, and specific literature. Linguistic reorganization of the state helps for the all-pervasive development on the basis of these things."[17]

'One Language, One State' was the sole concept of United Maharashtra with Mumbai movement. The main motive behind was to include the people who speak one language

in a particular state without considering or tolerating others' regions, population and dissimilarity of condition. This theory proves completely erroneous and unjustified as there is not a single instance in the history in the support of this theory. So, this theory should be thrown away.[18] That's why Dr. Ambedkar recommended to form multiple states of a particular language speaking people. Large states dominate smaller ones. According to Dr. Ambedkar, Maharashtra should be divided into four parts to maintain the balance in administration.[19] He suggested division of Maharashtra in Maharashtra City State including Mumbai, Western Maharashtra, Central Maharashtra and Eastern Maharashtra. Dr. Ambedkar was Marathi by language and he was proud to be a Marathi. Still, he remained aloof from the regional conflicts.[20]

State Reorganization Commission published a report on 10th October 1955. Commission vetoed the demand of independent Maharashtra including Mumbai. At that time, Bhai Dange and Acharya Atre went to Dr. Babasaheb Ambedkar to discuss the issue of United Maharashtra. Dr. Ambedkar clarified, "…I feel very proud of Maharashtra than others. But you should be Indian first and then whatever you wish to call yourself." But State Reorganization Commission formed flawed and inappropriate states for governance. Though the principle of 'One language of One State' has been enacted, injustice has been imposed on Maharashtra by tagging it as a bilingual state. We should collectively cast off this injustice.[21]

Thereafter, Central Government declared its verdict on 16th January 1956 stating Mumbai city as a Union Territory and remaining other regions would be considered as United Maharashtra. While condemning the decision, Dr. Ambedkar said, "Is there any place India worthier than Mumbai where people are politically powerful? And you are telling that you will bring them under the dominance of Central authority? Maharashtra and Mumbai's self-esteemed people will not tolerate this humiliation. You cannot compare Mumbai's people with Delhi and Manipur."[22] He was absolutely sure that Mumbai is an integral part of Maharashtra.

In this context, he said, "...Marathi people are too generous by heart. If Mumbai falls under Maharashtra, the rights of Non-Maharashtrians will not be grappled regarding the use of harbour. Mumbai's trade and industry is not flourished by Gujarati people, it was enhanced by Europeans and the officers of East India Company. Gujaratis were brought to Mumbai as the brokers or mediators necessary for the trade. They never came to Mumbai as traders... Maharashtra has supplied water and electricity to Mumbai. Separation of Mumbai from Maharashtra may dilapidate and endanger the financial structure of Mumbai... Mumbai is a part of Maharashtra. Marathi people have their rights over Mumbai. Even, Brahma can't separate Mumbai from Maharashtra."[23]

Dadasaheb Gaikwad asked Dr. Ambedkar regarding the role of Schedule Caste Federation amidst these circumstances. Dr. Ambedkar replied Dadasaheb Gaikwad, "...they should compel the government to stop the administration of Local Governance Institutions..."[24] He instructed Dadasaheb that Schedule Caste Federation should pass a resolution regarding the resignation of all party members elected on Bombay Municipal Corporation as the protest against the status of Union Territory given to Mumbai by Central Government.[25] While stating in the Upper House against the decision given by Central Government, Dr. Ambedkar said, "For the integrity of the country, Uttar Pradesh should be divided into three states, Bihar also into three and Madhya Pradesh into two states. Mumbai city and Marathwada also should be declared as the independent states. But Government is trying to impose the status of Nicobar on Mumbai. So, I will change my mind and stout-heartedly stand with Maharashtra's people to fight against this conflict..."[26]

As per the statement Dr. Ambedkar, Members of United Maharashtra Committee felt that he would participate in the movement. Amidst these circumstances, K. C. Thakre published a letter in a weekly Marathi newsletter entitled 'Jay Maharashtra' on 25th July 1956, requesting Dr. Ambedkar to participate and accept the leadership of Maharashtra.[27]

Committee enthusiastically worked after United Maharashtra Committee had decided to fight the general elections of 1957. A meeting of United Committee's members was organized in Mumbai to discuss about the participation of other parties. Mr. S. M. Joshi telegraphed Dadasaheb Gaikwad inviting him as a representative of Federation for the meeting.[28] In this meeting, Dadasaheb demanded committee members for allocating reserved seats as well as a general seat at every district for Schedule Caste Federation. Dr. Ambedkar conveyed Dadasaheb Gaikwad to arrange a meeting with committee's members at his house in Delhi in November 1956 regarding the agenda of forthcoming elections.[29] United Maharashtra Committee approved all the conditions of Schedule Caste Federation which included allocation of general seats to the candidates of Schedule Caste Federation and supporting them in winning it, all the reserved seats should be given to Schedule Caste Federation, committee should strive hard for the educational, social, political and economic development of the untouchables to eradicate atrocities or injustices meted out to them in the villages.[30]

Thereafter, Dr. Ambedkar entrusted all the rights to Dadasaheb Gaikwad regarding their role towards the movement initiated by United Maharashtra Committee. Then, Schedule Caste Federation rightfully entered in United Maharashtra Committee on 30th November 1956.[31] But, Dr. Ambedkar died on 6th December 1956 yet Schedule Caste Federation vigorously participated in the struggle for United Maharashtra and gave their remarkable contribution for it. Then, Schedule Caste Federation had been dissolved and Republican Party was

established on 3rd October 1957. This party also supported the movement led by United Maharashtra Committee. So, this newly established Republican Party was divided into two groups regarding their participation in United Maharashtra Movement.

Conclusion

Maharashtra has been formed with Mumbai on 1st May 1960. But the principles of linguistic reorganization hadn't been truthfully followed while forming Maharashtra. So, Marathi speaking Dang district has been attached to Gujarat and some part of Belgaon had been included in Karnataka. It culminates into enraging discontent in these regions. Today, Maharashtra is on the verge to complete its sixty years of establishment. But these Marathi speaking regions are still alienated from Maharashtra. These regions are enthusiastic to come under the ascendency of Maharashtra and they are incessantly revolting for it. After thoroughly studying this entire duration, it can be observed that Maharashtra hasn't accomplished the expected standards of equal development purported by Dr. Ambedkar. The regional imbalance has been increasing rapidly as per the passage of time.

Vidarbha's people changed their minds for 'One Lingual' state by leaving behind the issue of independent Vidarbha for the sake of development, but they are still deprived of the development that they dreamt about. The backlog of Vidarbha has been increasing rapidly according to the passage of time. Therefore, the voice of independent Vidarbha is rejuvenating again with new spirit. The demand of separate state is also enraging in Harit Pradesh in Uttar Pradesh, Gorkhaland in West Bengal, Bodoland in Assam and Naga state for Naga tribals. Amidst these circumstances, the concept of small states propagated by Dr. Ambedkar is equally justifiable and can prove beneficial for the all-pervasive development of the state.

References

1. Navshakti, Mumbai, Saturday, 2nd November 1946, Year 7, Issue 118, Pp. 3.
2. Phadke, Y. D., 'Keshaorao Jedhe', Shrividya Publication, Pune, 1992, Pp.246.
3. Janta, Mumbai, Saturday, 2nd April 1938, Year 7, Issue 7, Pp.6.
4. Janta, 9th April 1938, Year 7th, Issue 8, Pp.7.
5. Khairmode, C. B., 'Dr. Bhimrao Ramji Ambedkar', Vol.10, Maharashtra State Board of Literature and Culture, Mumbai, 1989, Pp. 54.
6. Pardeshi, Pratima, 'Yoddha Jansatyagrahi Dadasaheb Gaikwad', Dignag Publication, Pune, 2002.
7. Shende, Nishikant, Meshram, W. N. (Ed.), 'Dalitanche Jag: Wedna aani Shishtai', Sunil Publication, Nagpur, Second Edition, 1978, Pp. 38.
8. Khairmode, Vol.10, Pp.54.
9. Dangle, Arjun (Ed), 'Karmaveer Dadasaheb Gaikwad', Lokrajya Special Issue, Directorate General of Information and Public Relations, Government of Maharashtra Press, Mumbai, October 2001, Pp.8.
10. Khairmode, Vol.10, Pp. 55.
11. A letter written to Bhaurao Gaikwad by Mr. B. C. Kamble dated 20th August 1954, Personal Collection of Ramesh Shinde, Mumbai.
12. Khairmode, C. B., 'Dr. Bhimrao Ramji Ambedkar', Vol.11, Maharashtra State Board of Literature and Culture, Mumbai, 1990, Pp.51.
13. Ambedkar, B. R. & Jadhav, V. T. (Trans.), 'Bhashik Rajya Punarrachana Mimansa', Published by Y. B. Ambedkar, Mumbai, 1955, Pp.28.
14. Navshakti, 2nd November 1946, Pp.3.
15. Ambedkar, Pp.29.
16. Ibid.
17. Dharmadhikari, Bhau & Dastane, Dattoba (Ed), 'Sanyukta Maharashtra Aandolan Mr. Shankarrao Deo Yanche S. M. Andolan Vishayak Daptar', Published by Devkinandan Narayan, Pune, 1979, Pp.60.
18. Ibid, Pp.34.
19. Prabuddha Bharat, Mumbai, Saturday, 16th July 1960, Year 5, Issue 13, Pp.3.
20. Dadumiya, 'Dalitanche Rajkaran,' Published by Keshav Vishnu Kothawale, Majestic Book Stall, Mumbai, 194, Pp. 71.
21. Prabuddha Bharat, 16th July 1960, Pp.3.
22. Janta, 28th January 1956, Year 19, Issue 39, Pp.1.
23. Dadumiya, Pp.73-74.
24. Kharat, Shankarrao (Ed), 'Karmaveer Bhaurao Krushnarao urf Dadasaheb Gaikwad Yana Dr. Babasaheb Ambedkaranci Patre', Thokal Publication, Pune, 1961, Pp. 341.
25. Pendse, Lalji, 'Maharashtrache Mahamanthan', Sahity Sahkari Sangh Publication, Mumbai, 1965, Pp.40.
26. Ibid, Pp.431.
27. Prabuddha Bharat, 4th August 1956, Year 1, Issue 24, Pp.5.
28. A letter written to Dr. Ambedkar by Bhaurao Gaikwad dated 21st October 1956, Personal Collection of Ramesh Shinde, Mumbai.
29. Prabuddha Bharat, 10th November 1956, Year 1, Issue 36, Pp.1.
30. Prabuddha Bharat, 15th October 1960, Year 5, Issue 25, Pp.6.
31. Pendse, Pp.549.

◆◆

VOLUME 26 | SEPTEMBER, 2021 ISSN 2456-9704

AN ASSESSMENT OF THE ROLE OF DISASTER MANAGEMENT AUTHORITY AND COMMUNITY DURING COVID -19 OUTBREAK IN INDIA

By Vaishali A. Sukhdeve
Assistant Professor (Law) from Dr. Ambedkar College, Department of Law, Deekshabhoomi, Nagpur, Maharashtra

ABSTRACT:

A disaster is a severe interruption of the functioning of a society involving widespread human, material, economic or environmental losses and impacts, which go beyond the ability of the affected community to cope using its own resources. Disaster management also known as emergency management is the creation of plans through which vulnerability to hazards can be lessen down, either by the State machineries or by group of people at large. Developing countries suffer the greatest costs when a disaster hits. Within the vulnerable groups, elderly persons, women, children, migrant labours— especially women rendered destitute, children orphaned on account of disasters and differently abled persons are exposed to higher risks. The mounting number of disasters and their impacts on human life has urged the need for a framework that addresses the responsibilities of states and other agencies in disaster situations.

In 2019, WHO proposed interim name of the novel virus as COVID-19. Since the first cases were reported, WHO and its partners have been working with Chinese authorities and global experts to learn more about the virus, including how it is transmitted, the populations most at risk, the spectrum of clinical disease, and the most effective ways to detect, interrupt, and contain human-to-human transmission. This strategic preparedness and response plan outlines the public health measures that the international community stands ready to provide to support all countries to prepare for and respond to COVID-19. Infectious disease outbreaks and spread of antimicrobial resistant diseases, some with no vaccination or prevention options, are inevitably tied to rapidly increasing populations, poverty, dietary changes of people in emerging economies, poor antibiotic use and a narrowing human-animal interface. This disease has potentially resulted in millions of fatalities and astronomical costs, and have many other significant consequences in social, security and political sectors.

Training, awareness and knowledge will help the community to start actions in right earnest to save lives and help geographical expansion. Just as an all-hazard approach works best in disaster management, the focus of public health preparedness must be on all-hazard external health threats. Whole-of-community preparedness and prevention plans have to be ready and practiced well before epidemics occur. There are a number of existing international protocols drawn up for contingencies eg, quarantining hotels and public places. Surge capacities required in all kinds of resources are well documented after painful lessons learnt from previous pandemics and the outcome of two waves of Corona virus witnessed not only by our country but worldwide. The researcher in this paper is going to emphasis on the issues in terms of regulatory concerns, which include regulatory hurdles, such as governmental

delays in decision making and implementing it effectively.

Keywords: Covid-19, Disaster Management, NDMA, SDMA, DDMA.

Introduction:

Disaster can be Man-made or Natural disaster. Whether Covid -19 is a man-made disaster or natural one is really a debatable topic, which can be discussed in some other forum.

Disaster management also known as emergency management is the creation of plans through which vulnerability to hazards can be lessen down, either by the State machineries or by group of people at large. Developing countries suffer the greatest costs when a disaster hits. Within the vulnerable groups, elderly persons, women, children, migrant labours. The mounting number of disasters and their impacts on human life has urged the need for a framework that addresses the responsibilities of states and other agencies in disaster situations.

In 2005, the Government of India took a significant step by legislating the Disaster Management Act, 2005, which provided for the creation of the National Disaster Management Authority (NDMA), State Disaster Management Authorities (SDMAs) and District Disaster Management Authorities (DDMAs), to forefront and adopt an integrated approach to Disaster Management. The National Disaster Response Force (NDRF) is a specialized force constituted "for the purpose of specialist response to a threatening disaster situation or disaster" under the Disaster Management Act, 2005. There is also a National Policy on Disaster Management, 2009 to cope with disasters.

In December 2019, World Health Organisation warned to a cluster of pneumonia patients in Wuhan City, Hubei Province of China. One week later, on 7 January 2020, Chinese authorities confirmed that they had identified a novel coronavirus as the cause of the pneumonia. The proposed interim name of the virus is COVID-19. Since the first cases were reported, WHO and its partners have been working with Chinese authorities and global experts to learn more about the virus, including how it is transmitted, the populations most at risk, the spectrum of clinical disease, and the most effective ways to detect, interrupt, and contain human-to-human transmission.

This strategic preparedness and response plan outline the public health measures that the international community stands ready to provide to support all countries to prepare for and respond to COVID-19. Infectious disease outbreaks and spread of antimicrobial resistant diseases, some with no vaccination or prevention options, are inevitably tied to rapidly increasing populations, poverty, dietary changes of people in emerging economies, poor antibiotic use and a narrowing human-animal interface. This disease has potentially resulted in millions of fatalities and have many other significant consequences in social, security and political sectors.

Training, awareness, and knowledge will help the community to start actions in right earnest to save lives and help geographical expansion. Just as an all-hazard approach works best in disaster management, the focus of public health preparedness must be on all-hazard external health threats. Communication channels to higher levels must be reliable and robust. Whole-of-

community preparedness and prevention plans must be ready and practiced well before epidemics occur. All local programs must be aligned to national and international plans, norms, and protocols.

The preparedness for this disease requires a strong community health system which includes among others adequate and quality manning, simple and sound infection control protocols, a good supply chain and effective surveillance systems. Its response capabilities in a crisis include control centers with situational awareness and data boards, trained emergency responders, protective equipment, well equipped ICU's, PPE kits, vaccines, etc.

There are several existing international protocols drawn up for contingencies e.g., quarantining hotels and public places, Government institutions etc. Surge capacities required in all kinds of resources should be well documented after painful lessons learnt from previous pandemics. The researcher in this paper is going to emphasis on the issues in terms of regulatory concerns, which include regulatory hurdles, such as governmental delays in decision making and implementing it effectively.

National Disaster Management Authority (NDMA):

The NDMA, responsible for setting policy on the lockdown, made its call in a letter to India's interior ministry, which was expected to issue detailed guidelines. India had recorded more than 91,000 COVID-19 infections, with a death toll exceeding 3000. In pursuance to this, India's National Disaster Management Authority (NDMA) has urged the government to extend the country's nationwide lockdown to May 31 2020 in efforts to further curb the spread of COVID-19. In spite of this measure, second wave could not be prevented and till date India has recorded more than 3.27 Crore cases of COVID-19 infections, with a death toll exceeding 4.38 lacs.

NDMA has given following guidelines to cope up with the disaster of COVID pandemic:

1. **Social distancing guidelines :**

It was on 24th March, 2020, the National Disaster Management Authority directed the Ministries/Departments of Government of India, State Governments and State Authorities to take measures for ensuring social distancing so as to prevent the spread of COVID 19 in the country. Detailed guidelines and addenda were issued by National Executive Committee from time to time under section 10(2)(1) of the Disaster Management Act 2005. Keeping in view, the fact that strict social distancing measures need to be implemented for a further period to contain the spread of COVID 19, the National Authority, in exercise of powers under Section 6 (2) (i) of the Disaster Management Act, 2005, directs the Ministries/Departments of Government of India, State Governments and State Authorities to continue the same measures for social distancing. In this regard the guidelines/orders issued by NEC shall continue to be applicable throughout the country. The Authority further directs NEC to issue modifications in the guidelines as necessary, keeping in view the need to contain the spread of COVID 19.

But we can see this is not implemented properly either due to lack of awareness or the lightly attitude of citizens, which is

required to be answered and well assessed as India has lost millions of lives resulting in disturbances of family due to either death of a sole earner in a family or a wife/ husband. In some districts the entire family has been deceased due to this Corona virus.

2. Guidelines regarding tracking of those who came from Foreign countries:

The NDMA has vide Letter No.1-137/2018-Mit.ll (FTS-10548), Dated, 1st March, 2020 had directed to all Chief Secretaries/UT Administrators for Tracking of people who have arrived from specified Countries, in the context of Coronavirus where Government of India had progressively tighten the entry and screening mechanism.

Apart from this the Bureau of Immigration was involved in the process of giving the data in respect of the Indians and foreigners who have arrived, it was suggested that the following parallel approach could be considered by the State Governments in the overall interest of reducing risk.

An Order was issued by the district administration under Section 33 of Disaster Management Act, to all the local residents, with adequate publicity that people who have arrived from the specified countries from 1st January, 2020 should proactively contact the local authorities for follow up on their well-being. Mechanism was put in place to curb the spread by quarantining them and through the medical examination of such suspected persons. Involvement of the local NGOs/ reliable members of the civil society organizations in helping this process, was hailed. The assistance of the FRO and District Superintendents of Police was taken to ensure that this process of tracking is done diligently.

But, due to lack of unawareness and casual approach such tracing and contacting was not at all diligent which further lead to erratic outspread as witnessed by all of us.

3. Guidelines for Sanitation Workers and Supervisors for COVID – 19

In current situation of COVID-19 outbreak wherein the public fear touching surfaces, sanitation workers are performing duties at the very site of infection. The sanitation workers as part of their various routine activities such as disinfecting hotspots, sanitizing the houses of infected persons, collection of household garbage, cleaning public places and disposal of highly infectious biomedical wastes increases the risk of exposure to Covid -19. The transmission of COVID-19 virus through respiratory droplets and fomite surfaces is well-proven; therefore, anyone dealing with disposal of waste of any kind should take necessary precautions.

4. Guidelines for Frontline Workers and DM Professionals

Disaster Management Professionals and Frontline Workers involved in the preparedness, control and relief services pertaining to the outbreak of the Novel Coronavirus (COVID-19) Pandemic are susceptible to stress associated with physical, mental, and social problems including fatigue, occupational burnout, anxiety, depression and other mental health problems that may impact productivity and efficiency at work and negatively impact their well-being.

It is therefore very crucial to take steps to protect the psychosocial well-being of the frontline workers and professionals in the disaster management sector which will range from self-care guidance to provision of access to specialized services for serious mental health problems. However, the overall focus should be on enhancing coping and personal resiliency which can be achieved though. Apart from this we have seen the instances where the Frontline workers were abused and victimized by some anti-social elements and in turn the provisions of National Security Act, 1980 were imposed on them. Howsoever, such a measure taken by State Governments is really a debatable issue.

Coordination with NGOs/CSOs:

NDMA has made Coordination with NGOs/Civil society Organisations to mitigate the spread of COVID-19 vide Letter No. 1-137/2018- dt. 5 March. 2020. In view of the emerging threatening disaster situation of COVID 19, Chief Secretaries of the States/UTs were requested by the letter referred above to direct District Disaster Management Authorities (DDMAs) to hold coordination meetings with credible NGOs and other Civil Society Organisations (CSOs) to enhance community cooperation. Accordingly, we can see number of NGOs involved in relief camps, distribution of food etc. About 11,500 NGOs have been organising food camps and 3,900 NGOs have set up temporary shelter homes for the stranded.

However, it can be seen that, there was lack of co-ordination among the NGO'S who were distributing Food kits in the same locality to same set of persons resulting in hoarding of Food kits by such persons and others from different locality who had nothing to eat had to suffer. These things could have been managed and coordinated at ground level for effective working, but it failed to do so.

Guidelines for Industrial Units after release of Lockdown in some zones:

In early response to COVID-19, nationwide lockdown was ordered as well in later phase district wise Zone were demarcated taking into consideration the death rate and positivity rate of the COVID - 19. As the lockdown is being gradually released in some zones, certain economic activities are being permitted as per NDMA orders No.1-29/2020-PP dated 1st May 2020 and MHA order No. 40-3/2020-DM-I(A) dated 1st May 2020.

Due to several weeks of lockdown and the closure of industrial units during the lockdown period, it is possible that some of the operators might not have followed the established SOP. As a result, some of the manufacturing facilities, pipelines, valves, etc. may have residual chemicals, which may pose risk. The same is true for the storage facilities with hazardous chemicals and flammable materials.

When Lockout/Tagout procedures are not in place, many energy sources can prove to be hazardous to operators/supervisors who are servicing or maintaining electrical, mechanical or chemical equipment. When heavy machinery and equipment are not maintained periodically, they can become dangerous for the operators/engineers. Combustible liquids, contained gaseous substances, open wires, conveyor belts and automated vehicles make manufacturing facilities a high-risk

environment. Improper enforcement of safety codes and improperly labelled chemicals can further pose serious health hazards. When an unexpected event occurs, managing rapid response becomes challenging. To minimize the risk and to encourage a successful restart of the industrial units, the guidelines are being issued.

State Governments shall also ensure that the off-site disaster management plan of the respective Major Accidental Hazard (MAH) units are up to date and preparedness to implement them is high. It is also advised that all the responsible officers of the district shall ensure the Industrial On-Site Disaster Management Plans are also in place and cover Standard Operating Procedures for safe re-starting of the industries during & after COVID 19 lock down.

Role of States and SDMA:

It **is** required to note that while medical and pharmacological response activities are performed by the State health departments under the guidance of Ministry of Health and Family Welfare, the aspects of Situation Awareness and Resource Awareness have to be handled by the SDMAs and DDMAs. The response activities must be coordinated in a planned manner with this awareness.

SDMA is the nodal point of information and management of the disaster, with particular reference to non-medical matters which should be manned 24x7 and should be in constant communications with Districts. Receive, analyse, collate and disseminate information to all stakeholders in time and send a Situation Report to **NDMA** as per the specified frequency and format.

- **Inter-agency Coordination:**
- **Community Awareness:** Much work needs to be done to improve community awareness, while implementing the social distancing order. Additionally, awareness of details of Government orders and schemes need to be actively percolated especially to the weaker sections of the society, as well as to migrant labourers and tourists, who may be stranded.
- Proactive planning: The SDMAs/Relief Commissioners need to anticipate emerging criticalities and undertake proactive measures. They should share preparedness plans as they are evolved, the action taken and envisioned, gaps in the response to assistance needed from central agencies, etc.
- Coordination with neighbouring States: A number of inter-state issues are being referred to MHA for resolution. Proactive coordination with neighbouring States, particularly at State-to-State and contiguous District level. will help resolve these problems faster.
- Issues relating to migrant workforce and stranded tourists: SEDC must act as a single point of contact on all migrant workforce related issues. These persons must be taken care of as per the NDMA Guidelines for temporary shelters, with the modification of maintaining physical distance of at least one metre between any two persons.
- Humane Approach: It is recommended that the Police and the

administration adopt a humane approach in dealing with the public, particularly those who are left adrift by the lockdown. Enforcement of laid down restrictions must be tempered with compassion and a sense of duty of care for our citizens.

- There is also a need to ensure communicating that contacting COVID-19 must not be treated as a stigma.
- Health and Well-being - Personnel of the Administration: This is of paramount importance. While performing their duties, all officers and staff must follow the 'do' s and don'ts' for preventing the spread of COVID-19.

The government's roadmap for how the lockdown will be eased included more autonomy to states in defining red, orange and green zones for Covid-19. The states were also be allowed to restart several economic activities within the red zones. The National Disaster Management Authority (NDMA), however, has cautioned the states to not rush into opening economic activities as it could cause a spurt in Covid-19 cases. Based on the directions of NDMA, the home ministry announced a gradual easing of lockdown, including opening up of more markets and economic activities outside the containment zones, while keeping some measures in place to check the spread of Covid-19.

Role of District magistrate (DM):

District Officers draw powers from two laws — The Disaster Management Act of 2005 and the Epidemic Diseases Act of 1897 — the Centre has invoked to tackle the coronavirus pandemic. Both the laws have been used sparingly earlier and so many of its clauses have not been sections open for interpretation and at the discretion of the district magistrate.

The reality today is that an order signed by a district magistrate (DM) is apparently more effective on the ground than one cleared by, say, the principal secretary to a Chief Minister. The laws leave little space for a local MLA or MP to exert any pressure on a district officer on duty. The Disaster Management Act gives DMs adequate powers to implement central and state guidelines. The DMs are further empowered as the head of the District Disaster Management Authority.

The second legislation DMs frequently use today is the Epidemic Diseases Act, an ancient yet stringent law. Besides, the DMs have resorted to some provisions of the Indian Penal Code to enforce their order. For example, the DMs are invoking Section 188 of the IPC to levy Rs 500 as fine on those not wearing masks in certain states. The district magistrates are now using their discretion to judge which law will fit better for a situation before issuing an order. "For example, to requisition a hotel, the Disaster Management Act is used. For shutting shops, the officers use the Epidemics Diseases Act."

There are enough reasons to put more responsibility on the executive during a crisis. When there is an emergency-like situation, the powers in a district must be bestowed upon an officer and not on the local MLA or minister. One needs to trust an executive more during crises. But if any DM turns arrogant and misuses her power, there

are enough checks and balances built into the system itself.

While every order issued by a DM mentions the relevant law, the police personnel enforcing those might add more miseries to the citizens. An example of this was seen when police asked people who violated the lockdown to do squats or humiliate them through Artis or showering flowers, etc. though such moves have no legal sanctity. As India starts easing lockdown restrictions, the official orders are likely to vary from one district to another. Local conditions may appear similar, but the DMs are empowered enough to interpret those differently.

No wonder, the authority in Gautam Buddha Nagar, a red zone district in Uttar Pradesh, has refused to grant permission for resumption of railway work at Dadri for almost a month now. However, five other red zone districts have allowed construction work on the dedicated freight corridor project. Similarly, Tukaram Mundhe, DM from Nagpur didn't allowed to open Liqour shops inspite of Central Government directions. The power of the DMs cannot be challenged it appeared for a while. But due to political agendas and vendetta the District magistrates could not work efficiently and are either suppressed or transferred which is a genuine problem of bureaucracy in our country.

Role of communities:

More than 1.27 lakh individuals and 5,300 organisations have so far registered themselves as volunteers with the Prime Minister Narendra Modi-led National Disaster Management Authority (NDMA) for the fight against COVID-19. The NDMA has also received donation offers for more than 8.35 lakh items including digital infrared thermometers, digital thermal scanners (full body), masks, gloves, sanitisers, and personal protective gear. The donated articles, besides the medical equipment and other goods being produced by the public and private sectors, are being supplied to the States as per requirement. The Authority, through its subordinate and State bodies, is monitoring all the operations associated with the measures being taken at the ground level. The NCC students have been helping the local administrations in extending help to the needy and spreading awareness about the preventive measures to be taken to arrest the spread. Over 30,000 Civil Defence volunteers have also been engaged in carrying out relief works and maintaining order in the affected areas.

Conclusion and Suggestions:

India needs to realise that Covid-19 is a disaster, not a law-and-order problem. If India wants to create a meaningful response to the crisis, we need to pool in and mobilize all the resources we have in the country. This needs to start at the top with the government, and penetrate down to cover every public, private, and civil society actor. To be able to do this, there needs a framework of engagement, wherein Civil society, Non-Governmental Organizations aid the Governments efforts at a systematic level. During the Second wave of Covid-19 spread out, many NGO'S were instrumental in arranging the Oxygen cylinders and it was of great help to those lucky patients in contrast to those who died due to lack of timely aid just because of shambolic governmental measures. Thus, it can be inferred that the work done by civil society is sporadic and dependent on the relationships one has with

the local authorities, but for this a government directive is essential. Apart from this the Officers from UNICEF, UNDP, CRS, Helpage India, Childfund, IRCS are working and co-ordinating with the NDMA'S, SDMA's and DM's.

The old saying '*PREVENTION IS ALWAYS BETTER THAN CURE*' is true for COVID-19 as well. But with respect to novel disease Covid 19 due to relatively less understanding of its spread and cure this maxim seems to be not as much of accurate. In India in spite of the best preventive efforts, the public health system was rapidly overwhelmed with a large number of people needing isolation, testing, and treatment. Even the developed countries were unable to deal with such a massive number of cases. This is a key lesson for the future development of public health systems around the world which need to be flexible, with the capability to take appropriate measures and restructure its public health system to mitigate such a large-scale disaster. This can be achieved by enhancing of COVID-19 units, testing facilities, medical equipment and supplies of oxygen, and expansion of health care workforce and sincere efforts to increase the vaccination drive specifically taking into consideration the size of India's population which is a huge challenge.

References:

1. https://economictimes.indiatimes.com/news/politics-and-nation/ask-govt-about-disaster-management-plan-kapil-sibal-urges-judiciary/articleshow/75168719.cms
2. https://economictimes.indiatimes.com/news/politics-and-nation/covid-19-how-two-laws-have-vested-unusual-powers-with-the-district-magistrates/articleshow/7577925
3. https://economictimes.indiatimes.com/news/politics-and-nation/ndma-cautions-states-against-rushing-to-open-up-economic-activities/articleshow/75749507.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
4. https://economictimes.indiatimes.com/news/politics-and-nation/cabinet-to-take-up-proposal-to-amend-disaster-management-act/articleshow/73602754.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst
5. https://www.osdma.org/news/review-meeting-with-civil-societies-on-covid-19/
6. https://scroll.in/article/957923/india-needs-to-realise-that-covid-19-is-a-disaster-not-a-law-and-order-problem
7. https://www.ndma.gov.in/en/
8. https://ndma.gov.in/sites/default/files/PDF/covid/COVID-19-Indian-Experience.pdf
9. https://ndma.gov.in/Resources/awareness/covid

*****

EFFECTS OF CLIMATE CHANGE ON PUBLIC HEALTH IN INDIA: A CONCERN OF 21ST CENTURY

DR. SANDHYA P. KALAMDHAD

INTRODUCTION

Climate change, a major concern at the end of the 20th century, remains a significant problem in 21st century. Extreme climate and weather events are increasingly being recognized as key aspects of climate change. Although some of these pollutants are also produced by nature, the main environmental problems results from human activities. Waste gas is one of the main emission pathways of many industries and production processes. These pollutants can affect our health in many ways with both short-term and long-term effects. Climate change causes significant detrimental direct[1] and indirect effects[2] on human life, highlighting the importance of improving knowledge of its impact.[3]

Climate change is a global environmental issue. Climate change results from emissions of a suite of gases called greenhouse gases that slow the escape infrared radiation (heat) from the surface of the earth into space. Such a warming process results in change in monsoon patterns, heat waves, rise in sea level and increase in range of several disease vectors. This would result in large changes in ecosystems, living conditions and human health.

There are numerous studies which significantly shows the relationship between climate change and health. Available literature shows how different diseases like, Zoonotic diseases, water born diseases, Food borne diseases, malnutrition, Extreme weather related health diseases, Respiratory, Cardiovascular and other illnesses are the result of climate change. Examples of short-term effects include irritation to the eyes, nose and throat, and upper respiratory infections such as bronchitis and pneumonia.

The World Health Organization estimates loss of 150,000 lives every year due to changes in climate warming and precipitation. The WHO warns that the risk of death and disease from climate change will double in the next 20 years. Diseases such as malaria, yellow fever, dengue and cholera are all sensitive to climate change due to effect on the viability and the geographical distribution of the mosquitoes and micro-organisms, which prefer a wetter, warmer world. Deaths from heart diseases and respiratory illness during heat waves and malnutrition from crop failures add to the toll.

Thus, both in the global context and in India, health hazards due to climate change are of highest concern. Therefore, the United Nations Framework Convention on Climate Change (UNFCC) came into force in 1994. India has undertaken some initiatives in pursuance to the obligation implied by UNFCC. Despite of all these efforts, Climate change is a major concern in the 21th century, it remains a significant problem to be solved

[1] Direct effects: Effects resulting from high temperatures, low temperatures, floods, droughts. An increase in direct effects such as injuries and fatalities are observed following extreme weather events, including heat waves.

[2] Indirect effects: These include infectious diseases, issues pertaining to food (malnutrition) and water security. Long-term effects include population displacement, geopolitical instability, conflict and mental health consequences.

[3] Osama T, Brindley D, Majeed A, *et al*. Teaching the relationship between health and climate change: a systematic scoping review protocol. *BMJ Open* 2018;8:e020330. doi:10.1136/ bmjopen-2017-020330, downloaded from http://bmjopen.bmj.com/ on 23 May 2018

today. This paper includes a brief overview of impacts of climate change on health in India and also focuses upon the strategies adopted in India, to deal with this menace. This paper also tries to study how climate change, acting in combination with other factors and stressors like natural and human made influences human health.

IMPACTS OF CLIMATE CHANGE ON HEALTH

Human health has always been influenced by climate and weather changes. The influences are significant and varied. They range from the clear threats of temperature extremes and severe storms to connections that may seem less obvious. For example, weather and climate affect the survival, distribution & behaviour of mosquitoes, ticks and rodents that carry diseases like West Nile Virus, Lyme disease. Climate and weather can also affect water and food quality in particular areas, with implications for human health.

Extreme heat elevates the rate of death from illnesses like heart attack, heat stroke, organ failure and more. The climate crisis touches every aspect of our lives- in India and all over the World. Climate change has transforming India's environment and future. It has become a major concern in many areas. A more pressing concern in India will come from diseases spreading as insects travel farther and farther as our climate changes.

A) Direct Impacts of Change in Climate and Weather on Health[4]:

Changes in temperature and precipitation and occurrence of heat waves, floods, droughts and fires directly impact health of people.

1. **Heat- and Cold-Related Impacts**

The IPCC Special Report on Extreme Events (SREX) concludes that it is very likely that there has been an overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights, at the global scale. If there has been an increase in daily maximum temperatures, then it follows, in our view that the number of heat-related deaths is likely to have also increased. The connection between weather and health impacts is often sufficiently direct to permit strong inferences about cause and effect[5]. The early studies are supported by more recent experimental and field studies[6] and meta-analysis[7] that show significant effects of heat stress as body temperatures exceed 40°C, and heightened vulnerability in individuals with pre-existing disease.

2. Floods Storms and Drought

Flooding windstorms and drought adversely affect health through drowning, injuries, hypothermia, hyperthermia, respiratory illness and infectious diseases (e.g., diarrheal disease, leptospirosis, vector-borne disease, cholera[8]. It affects peoples' two to five times higher mental health problems like psychological distress, anxiety, and depression[9]. The attribution of deaths to flood events is complex; most reports of flood

[4] Reference for Direct and Indirect Impact taken from: National Action Plan for climate Change & Human Health (NAPCCHH), Ministry of Health & Family Welfare Government of India, Draft Version dated 30.06.2016.

[5] Sauerborn and Ebi, 2012.
[6] Ramsey and Bernard, 2000; Parsons, 2003.
[7] Bouchama et al., 2007.
[8] Schnitzler et al., 2007;Jakubicka et al., 2010.
[9] Neria,2012, Paranjothy et al, 2011.

deaths include only immediate traumatic deaths, which means that the total mortality burden is underreported.[10]

3. Ultraviolet Radiation

Ambient ultraviolet (UV) levels and maximum summertime day temperatures are related to the prevalence of non-melanoma skin cancers and cataracts in the eye.

B) Indirect Impacts of Climate and Weather on Health:

Indirect impacts are due to ecological disruptions, rising sea level, changing temperatures and precipitation patterns which leads to crop failures, shifting patterns of disease vectors, water-borne disease, vector-borne disease. Climate dependant diseases particularly affecting the vulnerable populations include the following:

1. **Vector-borne diseases** such as malaria, dengue, chikungunya, Japanese encephalitis, kala-azar, and filariasis are likely to be affected by change in climate and weather[11]. Shifts in the geographical range and duration of the transmission window for Plasmodium falciparum and Plasmodium vivax malaria are predicted for India[12].Unplanned urbanisation has contributed to the spread of chikungunya, malaria, and dengue in India[13].

2. **Waterborne diseases** such as typhoid, hepatitis, dysentery, and others caused from micro- organisms such as Vibrio vulnificus and Vibrio cholera, E.Coli, Campylobacter, Salmonella, Cryptosporidium, Giardia, Yersinia, Legionella are some climate-dependant infectious diseases that are likely to change in occurrence with disease exposure in India[14]. Existing literature reports events such as floods in West Bengal have led to large cholera epidemic and increase occurrence of diarrhoeal disease in India.

3. **Foodborne diseases** from salmonellosis, campylobacteriosis may rise or shift in peak infection rates as a response to rising global air and water temperatures[15]. Extreme heat and weather events contribute to decline in crop yields resulting in increase of food prices, leading to increase hunger and malnutrition[16].

4. **Malnutrition** and consequent disorders, like retarded child growth and development have been identified as one of the health threat by the Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change[17].Drought occurrence diminishes dietary diversity and reduces overall food consumption, and may therefore lead to micronutrient deficiencies. For India a pro -active approach is critical as close to half (48 percent) of children aged less than five are chronically malnourished and more than half of women (55 percent) and almost one-quarter of men (24 percent) are anaemic.

5. **Heat stress and air pollution** adversely affects morbidity and mortality particularly from non-communicable diseases including respiratory, cardiovascular, circulatory diseases. Eighteen heat-waves were reported in India between 1980 and1998, with a heat-wave in 1988 affecting ten states and causing 1,300 deaths. Heat-waves in Orissa, India during 1998 to 2000 caused an estimated more than two thousand deaths and heatwaves in 2003 in Andhra Pradesh, India, caused more than 3000 deaths.

[10] Health Protection Agency, 2012).
[11] Singh and Dhiman, 2012.
[12] Bhattacharya et al., 2006.
[13] Akhtar et al. 2002; Dhiman et al., 2012.
[14] Panic and Ford, 2013
[15] Panic and Ford, 2013; Ian Lake, 2015
[16] Rudolph L, 2015
[17] Confalonieri, U.,2007

6. **Ozone** is a secondary pollutant, formed via sunlight-driven photochemical reactions involving precursor hydrocarbons and oxides of nitrogen. Ozone pollution is projected to increase because warmer temperatures enhance these reactions. Both ozone and airborne particles are associated with premature mortality and a wide range of other adverse health effects of both clinical and public health significance[18]. Another report says[19] cardio-respiratory morbidity and mortality associated with ground-level ozone will increase with projected trends in climate-change and related exposures. Nearly 80% of Indian rural households continue to use biomass and cow dung as cooking fuel (NSS 68th Round). Though urban households using clean fuel (LPG) has increased from 44.2% (1999-2000) to 68.4% (2011-12), nevertheless, in urban households India, dependence on firewood and chips for cooking is still noted, with highest in Odisha (36.5%) closely followed by Kerala (36.3%) and Chattisgarh (34.7%)[20].

RESEARCH DOCUMENTED THE RELATIONSHIP BETWEEN CLIMATE CHANGE AND HEALTH

Many countries have conducted studies on relationship between climate change and vector born disease and other infectious diseases. One such study[21] shows that, the increasing dengue incidence worldwide is caused by several factors and one of them, which is our primary focus, are the meteorological factors. Change in these factors is believed to influence people's health through the spread of vector-borne diseases. For example, meteorological factors such as temperature, rainfall, and humidity influence the life stages of female adult Aedes mosquitoes. A warm temperature is important to adult mosquitos' behavior and maturation, especially the larval development rate is shortened. In addition, rainfall provides plenty of breeding sites for mosquito vectors such as puddles, while humidity affects the adult mosquitoes' survival and biting frequency.

Another study[22] states, Asia and its Hindu Kush Himalayan (HKH) region is particularly vulnerable to environmental change, especially climate and land use changes further influenced by rapid population growth, high level of poverty and unsustainable development. The study have documented an increasing threat of vector borne diseases in Asia because of the high abundance and wide distribution of human-biting mosquito vectors, climate change, poverty.

WHY SHOULD INDIA BE CONCERNED?

In developing countries like India the health of human populations is sensitive to shifts in weather patterns and other aspects of climate change, owing to high population, rapid industrialisation, large scale rural to urban migration resulting in chaotic and unplanned urbanization, depletion of forest cover, high energy consumption, variation in food production, clean air, vector borne diseases, potable water supply, sewage & waste management and access to health care.[23]

[18] Pope and Dockery, 2006; World Health Organization 2006
[19] Confalonieri, U. et al., (2007)
[20] NSSO,Report 567, 2011-12.
[21] Jesavel A. Iguchi, Xerxes T. Seposo and Yasushi Honda, "Meteorological factors affecting dengue incidence in Davao, Philippines" et al. BMC Public Health (2018) 18:629 https://doi.org/10.1186/s12889-018-5532-4, published on 15th May 2018..
[22] Meghnath Dhimal1,2* , Sushma Dahal1, Mandira Lamichhane Dhimal and others,Threats of Zika virus transmission for Asia and its Hindu-Kush Himalayan region, Dhimal et al. Infectious Diseases of Poverty (2018) 7:40 https://doi.org/10.1186/s40249-018-0426-3, published on 15th may 2018.
[23] National Action Plan for climate Change & Human Health (NAPCCHH), Ministry of Health & Family Welfare Government of India, Draft Version dated 30.06.2016.

The latest high-resolution climate change scenarios and projections for India, based on the Regional Climate Modeling system, known as PRECIS, developed by the Hadley Centre and applied for India using IPCC scenarios A2 and B2, show an annual mean surface temperature rise by the end of the century, ranging from 3 to 5°C under the A2 scenario and 2.5 to 4°C under the B2 scenario, with warming more pronounced in the northern parts of India. A 20% rise in all India summer monsoon rainfall and further rise in rainfall is projected over all states except Punjab, Rajasthan, and Tamil Nadu, which show a slight decrease. Extremes in maximum and minimum temperatures are also expected to increase and similarly extreme precipitation also shows substantial increases, particularly over the west coast of India and west central India. Rapid mountain glacier retreat has been documented in the Himalayas, meltwater from the Himalayan glaciers contributing a sizeable portion of river flows to the Ganges, Brahmaputra, Indus, and other river systems. Public health, to a large extent, depends on safe drinking water, sufficient food, secure shelter, and good social conditions. A changing climate is likely to affect all these conditions.[24]

India being a highly populous country undergoing industrialisation, with large scale rural to urban migration resulting in chaotic and unplanned urbanization, depletion of forest cover along and high energy consumption is more vulnerable to impacts of climate change. Until mid-century climate change will act mainly by exacerbating health problems that already exist. However, new conditions may emerge under climate change, and existing diseases (e.g., food-borne infections) may extend their range into areas that are presently unaffected. The health effects may occur either due to direct or indirect causes of climate change or extremes of weather.

Lack of social hygiene and an anti-science attitude among Indian people is bringing back several infectious diseases that were eradicated decades ago in Kerala, said public health activist Dr B Eqbal. “While everybody is focusing on Nipah, there are cases of dengue, rat fever, chicken pox, and even malaria, which were eradicated from the state in the 1960s, being reported from every district,” said Dr Eqbal. Local media reports claim that 76 people have lost their lives to fever and other epidemics in the first five months of 2018 in Kerala. There were 615 cases of dengue, 15,579 cases of chicken pox, and 1,091 people were diagnosed with rat fever. A public health official, requesting anonymity, said dengue cases are being reported from the northern districts in the state, with most cases coming from Kasaragod, Malappuram and Kannur. “In the coming days, vector density will explode. Dengue will affect thousands,” the official added. Rajeev Sadanandan, additional chief secretary (Health), said that lack of social hygiene is the primary reason for the spread of vector-borne diseases. “Waste management is in a bad state. Till that is not resolved, the disease cannot be contained,” he added[25].

[24] J. P. Majra and A. Gur, Climate Change and Health: Why should India be concerned, Indian J Occup Environ Med. 2009 Apr; 13(1): 11-16, available at 10.410310019-5278.50717PMCID:PMC2822161PMID:20165606.

[25] http://www.firstpost.com/india/kerala-apart-from-nipah-other-diseases-like-dengue-are-returning-to-state-due- -an-anti-science-approach-4493059.html

EPIDEMICS IN INDIA DUE TO CLIMATE CHANGE TOGETHER WITH HUMAN MADE STRESSORS

India is endemic to many diseases such as Malaria, Kala-azar, Cholera, Tuberculosis. These erupt in epidemic form when conditions are favourable for their spread. Epidemics are disasters by themselves but these can emerge in the aftermath of other disasters as well. In the recent past, two epidemics, viz., plague and dengue inflicted the Indian population very badly at Surat and Delhi, respectively. However, these occurred by themselves and were not the result of any other natural disaster[26].

Some of the largest disease burdens due to climate change together with human stressors:

The Surat (Gujarat) Plague Epidemic -1994

Following the sudden increase in the number of admitted cases with acute onset of fever, chest pain, cough, hemoptysis and deaths between 19th and 20th September, 1994 in different city hospitals, a sense of deep concern arose. As no history of rat fall could be elicited and typical bubonic cases were not seen, primary pneumonic plague outbreak was considered a possibility. The clinical presentation and the course of the disease pointed towards the pneumonic plague.

Though stray cases were reported from other parts of the city, the major concentration of the reported cases came from the two adjacent localities of Ved Road and Katargam where the population were by and large Maharashtrians, the sanitation was very poor and the localities were highly congested slums. Furthermore, these areas are situated adjacent to river Tapti which was flooded between 7 and 9th September, 1994 due to heavy rains. About five lakh cusecs of water was released from the Ukai reservoir which led to the heavy water logging of the area. When the flood water started receding on 14 and 15th September, 1994, the people of the localities started cleaning the areas and perhaps many of them handled dead wild rodents and animals. The Ganapati festival was observed with pomp and grandeur on 18th September, 1994, when a large procession passed through the area and thereby getting infected probably.

During the period of the outbreak, 52 deaths were recorded from Surat city of which majority occurred before 25th September, 1994. A total of 1088 cases were suspected, about 146 were presumptive cases and 52 deaths due to plague took place during the period from 19th September, 1994 giving an overall case fatality rate of 4.8%.

A study was carried out in Surat city during 8-19 November, 1994. Several identifiable risk factors were studied like occupation of the people, their visits outside Surat during the incubation period, exposure to a case, participation in the Ganapati procession festival, participation in cleaning operation, any associated illness, consumption of antibiotic, which could be accountable for the sporadic spread of the epidemic. The surprising thing was that the National Capital Delhi was also hit by the plague soon thereafter, although located faraway at about 1000 km. from Surat.

[26] www.preservearticles.com/201101143271/major-types-of-epidemics-in-india.html.

Dengue Epidemic in Delhi - 1996

Dengue epidemic struck the Capital from mid-August to end-November, 1996, with Dengue Haemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS), the worst ever in India's history. The virus, viz., Type II Dengue was identified as the causative agent in a number of clinical sanipies. There were in all about 10,000 cases with nearly 400 deaths as reported from all parts of the city.

The following reasons were identified for the dramatic emergence in India of Dengue/DHF as a major public health problem: 1) Ineffective Mosquito Control Programmes 2) Major demographic and social changes, the most important being uncontrolled urbanization, excessive population growth and urban decay characterised by substandard housing and inadequate water and waste disposal systems; and 3) Inadequate medical and health services.

Dengue fever is caused by the bite of a mosquito known as Aedes Aegypti which profusely breeds in coolers, storage tanks, earthen pots and other receptacles with rainwater or stored clean water. There are a large number of other possible breeding places of Aedes Aegypti, viz., flower vases, neglected cups of jugs, household collection of water, neglected features of buildings, uncovered cisterns, wells, roof gutters, cracks in the masonry, traps of drains, flush tanks, ant traps, water receptacles of various kinds, rain filled empty cans or food tins, leaking water supply, water meters, sluice water chambers, water for birds, broken bottles, garden tanks, tree chambers, tree holes, fountains, troughs, a variety of dumps for engineering goods, trees, scraps and many more.

Over the last 50 years, dengue incidence has increased by 30-fold and around 2. 5 billion people live in areas where dengue is endemic. Moreover, an estimated 50–200 million cases of dengue infections occur annually in the world. The spread of dengue may be partly due to the increase of international travel, unplanned urbanization, rapid increase in population growth, lack of effective vector management, climate change and extreme weather events, and poor socio-economic status[27].

CONCERN OF 21ST CENTURY IN INDIA

We are witnessing the climate change. The impact of climate change on health is real. So now the need is to create the circumstances which will dissolve or at least to reduce the impact of climate change on health. But, we human beings are doing exactly reverse. We are creating circumstances which will further accelerates the growth of different bacteria, viruses, contamination of water. Because of lack of awareness and insensitivity towards this issue, we are complicating the things further.

Climate change together with other natural and human made stressors, threatens human health and well-being in numerous ways. Some of these health impacts are already being experienced in the India. Yet we have not learn anything from the past experiences. For example, though smoking rate has gone down especially due to Murli Deora's Judgement, cigarette butts are seems to be everywhere. A recent study in US shows that, worldwide, about 4.5 trillion cigarettes are littered each year and cigarette waste causes great hazard to environment and in turn to public health. This study further states that, cigarette contains more than 7,000 chemicals such as arsenic (used to kill rats) and formaldehyde (used to preserve dead animals and

[27] Jesavel A. Iguchi, Xerxes T. Seposo and Yasushi Honda, "Meteorological factors affecting dengue incidence in Davao, Philippines" et al. BMC Public Health (2018) 18:629 https://doi.org/10.1186/s12889-018-5532-4.

humans too). Littered cigarette butts leach toxic chemicals into the environment and can contaminate water. In India, cigarette butts are often cast onto the sidewalk, where they often end up in drains and then out to lakes and seas, causing real threat to health.

The major problem with Indians are, we Indians are more aware with personal cleanliness than public cleanliness. We very often observe that, Indians keep their houses very neat and clean and throws all the garbage in public places.

In the year 1994, Surat City was shattered by the epidemics of Plague and Dengue fever. Due to which most of the countries stopped their flights to India. Literally they ostracized India. This had happened mainly due to garbage in public places. But after this horrifying incidence, Municipal Corporation took some initiative and started some new projects, one of them was to start a "Ghanta Gadi" to pick the house hold garbage from home to home.[28] After this initiative, Surat became clean city.

Today almost in every city this facility has been introduced, still the question remains is it successful? If you have empty plot beside and behind your house, you find almost every person will throw garbage there instead of giving it to "Ghanta Gadi". Every city in India must learn a lesson from Surat for public health.

The recent movement by the present government in respect of Swacha Abhiyan , "Swacha Bharat" is really appreciable. But government alone cannot solve this problem. There should be public awareness. Even we can see the efforts on the part of government to create awareness, despite of this people are not understanding their duties. There is need for awakening 'self-consciousness', the need is of self-introspection!

Once in an interview, the famous Ex-muncipal Commissioner of Mumbai, Mr. Tinkaikar, had a point to make. He said, "Rich people's dogs are walked on the streets to leave their affluent droppings all over the place and then the same people turn around to criticize and blame the authorities for inefficiency and dirty pavements. What do they expect the officers to do? Go down with a broom every time their dog feels pressure in his bowels? In US every dog owner has to clean up after his pet has done the job. Same is applicable in Japan. Will the Indian citizen do that here?"

Of course the answer is in negative. However let the author cite here the example of Shegaon. It's a pilgrimage place near Akola in Maharashtra, where Lakhs and lakhs of pilgrims come to visit and pay their homage to Shree Gajanan Maharaj, a great saint. There number of persons offer their services to keep premises clean and neat. Not to surprise, these 'sevakas' of Shree Gajanan Maharaj keeps broom 24 hours in their hands and with smiling face cleans the surroundings. It's an area of about 1000 (including Anand Sagar) acres, where you will find complete cleanliness and calmness. There generally, even visitors co-operates and uses dustbins kept there. It is famous for its clean, neat, tidy environment and polite and respectful behaviour of the sevakas of Gajanan Maharaj Trust who works there just for seva. Why not to adopt this policy for the whole country? In India rich blames poor and poor blames rich people. Instead of this, if we place dustbins everywhere in public places and starts at least from our self, there might be a sea change, as this will definitely be followed by our next generation.

[28] Earlier "Kuda dan" was there but it was over flooded with garbage and Municipal authorities and staff did not have a time to clean it, leaving tones of garbage on road.

There is a need to have some changes into the existing legal procedure as well. We need to be more stringent about the actions against persons who contribute to the pollution thereby causing great threat to the health of public in general. Right to health is considered as a Fundamental Right, then why not to take very stringent actions? The excerpts from the speech of then president Dr. Abdul Kalam may be referred her, "Judiciary has to take the cognizance of some lacunas in the procedure. As Supreme Court only says that right to clean environment is there and violation of it is against the humanity. Then why it is obligatory to send notice of 60 days to the polluter who is already polluting. This is like sending the thief a notice after committing theft that we will file a complaint against you if you will not stop your habit of theft. If both are the offences then why such discrimination is there?"

Another major concern is lack of willingness and foreseeability on the part of authorities. Let take another example from Maharashtra. Almost every year in Monsoon Mumbai city suffers a lot. Few years back thousands of people died and number of diseases spread, due to heavy rain. Though it is agreed that, that was the heaviest rain recorded in the last hundred years, but at the same time we were not prepared to deal with such calamities. These causalities were mainly due to blockings of drainage system. There is total failure on the part of Corporation to plan proper drainage system and keep it safe. This happens every year still no thoughtful action even before Monsoon. Lots of blockages were due to plastic bags. Fortunately steps are taken this year to ban plastic bags in Maharashtra. But unfortunately implementation is so poor, that we all Maharashtrians knows, there is no impact of this ban.

Another concern is faith against science. According to Dr Eqbal, an anti-science attitude among people in the state is a major hurdle in containing the spread of viral and bacterial infections. "There are several instances in the state where people are against vaccination; besides, some people have started to believe that cow urine can cure diseases. Such views are dangerous and must be eradicated. But sometimes, governments and politicians can be seen favouring such actions," said Dr Eqbal.

Thus to the already exiting problem of climate change other major concerns are population growth, migration from rural to urban areas, poverty, lack of education and awareness, lack of foreseeability and accountability of government officials and corruption. Corruption is so rooted that finances which need to be diverted for the effective implementation of environment protection and for the cause of public health are not diverted and utilised to the fullest.

STRATEGIES ADOPTED INTERNATIONALLY[29]

Since climate change is not restricted within the bounds of any particular state nor the factors causing the same being the sole activities of any state in particular, the need arises to tackle its damaging effects with a co-operative approach.

It is in this context that the concept of INTRA-GENERATIONAL EQUITY could play very important role. It signifies equity within and between the countries and is a condition precedent to achieve intergenerational equity. The problem of INTRA-GENERATIONAL EQUITY must be approached in the light of different economic, environmental, cultural and political circumstances prevailing within and between the countries.

[29] Reference for NAPA review: Manga, L., Bagayoko, M., Meredith, T. and Neira, M., 2010. Overview of health considerations within National Adaptation Programmes of Action for climate change in least developed countries and small island states. http://www.who.int/phe/Health_in_NAPAs_final.pdf

The United Nations Framework Convention on Climate Change (UNFCC) came into force in 1994 wherein 195 countries participated including India with objective of Green House Gas stabilization at level to prevent dangerous impact on health. This was followed by first Conference of Parties (COP) that took place in Berlin. The *Kyoto protocol* in 1997 refers to the international legal framework for climate change process wherein internationally binding emission reduction targets were set by UNFCC to its Parties. The *Cancun Agreement* forms the pillar of the largest collective efforts the world has seen to reduce the emission in respect of capturing plans to reduce Green House Gas Emission, and to help developing nations to protect themselves from climate impact and to build their own sustainable futures through a) Mitigation, b) Transparency, c) Technology, d) Adaptation, e) Forest, f) Capacity building and g) Finance. The Conference of the Parties (COP) to the Convention meets annually to negotiate and discuss the international climate change agenda and related commitments from countries. The sustainable development Goal 13 (SDG 13) also emphasises to "take urgent action to combat climate change and its impacts."

UNFCCC, Article 1, paragraph (1) states need to minimize adverse effects on "*natural and managed ecosystems or on the operation of socio-economic systems or on* **human health and welfare***"*.

World Health Assembly Resolution WHA/61.R19, and Executive Board Resolution EB124.R5, request WHO to **develop capacity to assess the risks from climate change for human health and to implement effective response measures**, and support countries through **Awareness raising, Partnerships, Evidence, and health system strengthening**.

This was followed by number of International efforts. For example almost 193 countries endorse WHA resolution calling for action to protect health from climate change. 95% (39/41) of National Adaptation Programmes of Action (NAPAs) from least developed countries identify health as a priority sector affected by climate change. 73% (30/41) of the NAPAs have included health interventions within adaptation needs.

There was awareness drive at international level with the help of WHO among **health leaders**: WHA resolution, backed by regional Ministerial declarations and frameworks for action. **Among health and metorological professionals**: Workshop series, covering over 50 countries across all WHO regions. **Among climate leaders**: Representation of health in the UNFCCC, formation of "Friends of Public Health" network of negotiators and NGOs. **Among the general public**: World Health Day 2008 on "Protecting health from climate change, supported by advocacy products and key messages.

There are good number of clooaborations and partnerships working together at international level to combat climate change like, UNFCCC provides international framework for climate action, with health as a key justification. UNFCCC operational mechanisms include health; Nairobi Work Programme on Adaptation, Social Dimensions of Climate Change. "One-UN" country teams implementing health adaptation projects. There is an establishment of networks of health NGOs campaigning on climate change.

Specific important partnerships: Awareness raising partnerships: Establishment of "Friends of Public Health" network, coordination with major health NGOs. **Policy partnerships**: Representation of health in UNFCCC negotiations and support mechanisms; co-convenor of UN task team on Social Dimensions of Climate Change. **Scientific and technical partnerships**: Representing health on IPCC, technical guidance with WMO and UNEP. **Operational partnerships for health adaptation**: Projects implemented through UN country teams; with UNDP and GEF; with bilateral aid agencies.

Not only this but there are god evidences showing how these international bodies got good responses like over 1000 papers on health and climate change in peer-reviewed journals. Good number of research covering risks, costs, cobenefits of mitigation, resource requiremennts and evaluations of health risks in three IPCC assessment reports.

Because of these research benefits of healthy mitigation measures got documented[30] like sustainable urban transport – could cut heart disease and stroke by up to 20%. Improved stoves could save 2 million lives over 10 years in India alone, and reduce warming from black carbon. Health benefits from actions to reduce greenhouse gas emissions could substantially offset mitigation costs.

STRATEGIES ADOPTED IN INDIA

India is a non-Annex I country under the Kyoto Protocol and thus has no binding target for emissions reduction. It is an active participant in the Clean Development Mechanism (CDM) established by the Protocol. India has pledged to reduce the emissions intensity of its GDP by 20-25% below 2005 by 2025. Efforts include improved energy efficiency, increased use of renewable and nuclear power, expanded public transportation and energy pricing reform.

Rather than integrative binding legislation, India is developing a policy process to specifically target climate change. It adopted a "National Action Plan on Climate Change" (NAPCC) in 2008 & 2016 outlining existing and future policies and programmes directed at climate change mitigation, adaptation and knowledge management. The focus of the NAPCC is on promoting understanding of climate change, and action on adaptation, mitigation, energy efficiency, and natural resource conservation while pursuing overall economic growth.

The plan identifies eight core "national missions" running through 2017. After the 21st Conference of Parties (COP 21) under the United Nations Framework Convention on Climate Change (UNFCCC) concluded in Paris, Prime Minister Mr Narender Modi broadened India's response to climate change, by introducing four new missions including one for "Health". In this background, the proposed 'Mission on Health' under the 'National Action Plan on Climate Change' was undertaken by Ministry of Health & Family Welfare.

The NAPCCH aims to provide policy frame work to protect health of citizens of India against climate sensitive illness, especially among the vulnerable like children, women and marginalized population.

LEGISLATIVE SCHEME IN INIDA

The Finance Bill 2010-11 and the Clean Energy Rules, 2010

The Finance Bill 2010-11 provided for the creation of a corpus called the National Clean Energy Fund to invest in entrepreneurial ventures and research in the field of clean energy technologies. The cabinet Committee on Economic Affairs has approved constitution of a 'National Clean Energy Fund' (NCFE) in the public account of India along with the guidelines as well as modalities for approval of projects to be funded from the Fund. An Inter-Ministerial Group has been constituted to approve the projects/schemes.

[30] Haines, A. et al., 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers. Lancet, 374(9707): 2104-14. Chan, M., 2009. Cutting carbon, improving health. Lancet. 374(9707).

Electricity Act, 2003 Amended in 2007

The Electricity Act, 2003 sought to better co-ordinate development of the power sector in India, providing a comprehensive framework for power development. Objective include: Consolidating laws relating to generation, transmission, distribution, trading and the use of electricity; promoting competition in the industry; and promoting environmentally benign policies.

Energy Conservation Act, 2001 amended in 2010.

The act empowers central government to grant energy savings certificates to designated consumers whose energy consumption is less than the prescribed norms and standards and consumers whose energy consumption is more than the prescribed norms and standards shall be entitled to purchase the energy savings certificate to comply with the prescribed norms and standards. This Act requires large energy consumers to adhere to energy consumption norms; new buildings to follow the Energy Conservation Building Code; and appliances to meet energy performance standards and to display energy consumption labels. Under the Act, large energy-consuming industries are required to undertake energy audits and an energy-labelling programme for appliances has been introduced.

EXECUTIVE SCHEME IN INIDA

National Electricity Plan (Generation) Jan. 2012

This Plan aims to ensure reliable access to electricity. The Plan's 4th chapter deals with initiatives and measures for GHG mitigation, and aims to keep CO2 intensity declining while massively expanding rural access and increasing power generation to meet the demands of a rapidly growing economy. The main initiatives are in technological improvements of power stations – increase of unit size, introduction of clean-coal technologies (super-critical technology; ultra-super-critical technology; CFBC- Circulating Fluidised Bed Combustion technology; IGCC- integrated gasification combined cycle technology); renovation and modernisation of thermal power plants; renovation, modernisation and uprating of hydro-electric power projects; retirement of old and inefficient thermal plants; generation and energy efficiency measures; efficient use of resources (including combined cooling heating and power); distributed generation; coal quality improvement.

National Policy of Biofuels, December 2009

In October 2007, India's cabinet made a series of announcements regarding ethanol production and proposed an indicative target of 20% blending of biofuels, by 2017, both for bio-diesel and bio-ethanol.

A National Policy on Biofuels outlining the same target was approved by government in December 2009. In order to avoid a conflict between energy security and food security, the policy promotes only fuels derived from non-edible plants, waste, degraded or marginal lands. The policy offers farmers and cultivators a minimum support price for non-edible oil seeds, as well as a minimum purchase price for fuel. The government is formulating a national policy on biofuels to introduce financial incentives, develop R&D for production and commercialisation of ethanol and establish a national biofuel development board.

National Action Plan on Climate Change, 2008

India's National Action Plan on Climate Change (NAPCC) outlines existing and future policies and programmes directed at climate change mitigation and adaptation.

These National Missions will be institutionalised by respective ministries and will be organised through inter-sectoral groups that include, in addition to related Ministries, the Ministry of Finance and the Planning Commission, experts from industry, academia and civil society. The Mission recommends implementation in three stages, leading to an installed capacity of 20,000 MW by the end of the 13th Five-Year Plan in 2022. It also sets the objective of establishing a solar research centre, increased international collaboration on technology development, strengthening of domestic manufacturing capacity and increased government funding and international support.

The Indian Solar Mission is a large-scale solar energy programme that will run from 2010 to 2022. Given the major policy focus of the Indian government to provide wider energy access in rural areas, the project promotes electricity generation from both small- and large-scale solar plants.

In January 2008, the federal minister responsible for renewable energy announced that the Indian government would provide a subsidy for solar power plants to help develop renewable energy infrastructure. The government has also made available other incentives for solar power.

Other missions include the National Water Mission to improve efficiency in water use by 20% through pricing and other measures*;* the National Mission for Sustaining the Himalayan Ecosystem, with targets for biodiversity, forest cover and other ecological conservation in the Himalayan region; and the National Mission for Sustainable Agriculture, supporting adaptation to climate change in agriculture by developing climate-resilient crops and adapting agricultural practices, as well as the expansion of weather insurance mechanisms.

Energy Conservation Building Code, 2007

The Energy Conservation Act of 2001 mandated the creation of the Bureau of Energy Efficiency (BEE), established in March 2002. The BEE was mandated with establishing an Energy Conservation Building Code (ECBC).

A National building code (NBC) was developed by the Bureau of Indian Standards, and last revised in 2005. However, it does not specifically address energy efficiency issues. Rather, it promotes the use of new and innovative technologies and methods. This code serves as a building block to achieve the Sustainable Habitat mission of the National Climate Action Plan.

Tarrif Policy, 2006 amended in 2011

In January 2006, the Ministry of Power announced the Tariff Policy, in continuation of the National Electricity Policy of 2005. The Tariff Policy included certain provisions regarding renewable energy and cogeneration.

Under the Electricity Act 2003 and the National Tariff Policy 2006, the central and the state electricity regulatory commissions must purchase a certain percentage of grid-based power from renewable sources.

In January 2011, the Tariff Policy was amended to align with the National Solar Mission strategy. State electricity regulators to purchase a fixed percentage of solar power. This will be supported by a Renewable Energy Certificate (REC) mechanism.

Integrated Energy Policy, 2006

At the direction of the Prime Minister and Deputy Chair of the Planning Commission, an expert committee was established to develop a comprehensive energy policy in 2004. The Integrated Energy Policy, released in August 2006, addresses all aspects of energy, including energy security, access and availability, affordability and pricing, efficiency and the environment.

The Policy aims to meet energy demand "at the least cost in a technically efficient, economically viable and environmentally sustainable manner". It contains a number of policies that contribute to avoiding GHG emissions. It received Cabinet approval in 2008.

National Electricity Policy, 2005

Among other goals, this policy stressed the need for the promotion of non-conventional energy sources. The policy noted the need to reduce the capital cost of projects based on non-conventional and renewable sources of energy; stressed the importance of promoting competition among renewables projects; provided for state electricity regulatory commissions to increase progressively the share of electricity that must be purchased from non-conventional resources, and further provided that the purchase of such electricity should be conducted via a competitive bidding process; suggests tax neutrality across energy sources; states that "maximum emphasis" would be put on the development of hydro-power. It also calls for the need for conservation and demand-side management including a national awareness campaign.

National Auto Fuel Policy, 2003

The National Auto Fuel Policy (2003) mandated that all new four-wheeled vehicles in 11 cities meet Bharat Stage III emission norms for conventional air pollutants (similar to Euro III emission norms) and comply with Euro IV standards by 2010.

National Action Plan for Climate Change and Human Health, 2016 (NAPCCHH)

The plan includes, Strengthen/ development and coordination of early warning and surveillance systems in specific areas (e.g. heat waves, health effects of flooding, air pollutants, ultraviolet radiation, vector borne and infectious diseases) through an integrated disease surveillance system, feedback mechanisms to other ministries responsible for several ecological determinants of health particularly- air, water, food, fuel and human resource, development of risk maps for climate sensitive diseases like Chikungunya, Dengue, Malaria, West Nile Virus, Tick-borne Encephalitis, and Lyme disease etc. Strengthening and enthusing action through innovative strategies/ new technological approaches to bring equity/ improve access in health across income groups. (Pilot test innovative approaches to increase access through internet based technologies to provide early health care advice/ referral ; Online system to help-identify availability of care provider, register patients in Government hospitals; introduce long term health tracking system incorporating *Aadhaar* card number to assist surveillance and generate trends). And to undertake case studies in climatically sensitive locations to pilot test new approaches aimed at building resilience.

Important Target of NAPCCHH: Raise the awareness level for climate variability and its impact on health among vulnerable population, health care providers and other related stakeholders. Development of training materials and guidelines specific to climate sensitive diseases. Involvement of decision makers, leaders at national, state and local along with community partners in raising awareness for climate sensitive illnesses/ diseases and prevention & treatment EX. Number of health care personnel trained to combat the ill-effect of

climate change on human health. Universal Access to effective, safe and affordable case management and efficient medicines to the affected individuals EX. increase number of % of vulnerable population having access to affordable health care, essential drugs etc on sustainable basis. State specific climate sensitive diseases have to be listed and guidelines to be issued for each. Identification of experts, researchers and institute to develop training modules for health care personnel to manage climate sensitive illnesses. To define the roles and responsibilities of stakeholders for implementation of guidelines for Climate sensitive illnesses. Ex. Identification of institute/ organization to ensure implementation of the above. To develop/ strengthen the monitoring and surveillance systems for climate sensitive diseases. To assist states to assess their health vulnerabilities in the context of climate change and accordingly build capacities to adapt and mitigate the vulnerabilities Ex. Identification of state specific climate sensitive diseases and development of Guidelines by State. To identify and enlist departments/ institutions/ organisations working in the area of climate change. To strengthen monitoring, surveillance and research capacity about impact of climate change on human health, and develop a mechanism to fill the gap in the evidence based health policy. To develop centres of excellence on different aspect of climate change and health Ex. Partnership with non-health department for transmission of simple data along with analysis required for prediction of diseases. Identify best practices in implementation of measures to combat the effect of climate change.

Apart from this National plan, special mention of Surat is required here. Aftermath of plague havoc at Surat, primary health workers in Surat visits almost every house and asks, "Does anyone from your home have fever?" If the answer is yes, she takes a blood sample using the 'fever kit', and sends it to be tested for malaria. If the test is positive, the health worker gives the patient a full course of pills for malaria. If it is something else, she refers the patient to a doctor. Apart from asking people about fever, they also looks at possible mosquito breeding sites in the house[31].

This is part of Surat's vector borne disease surveillance, the first of its kind, real-time mosquito surveillance programme in the country that aims to track and prevent a disease before it spreads. This, along with many other innovative solutions, makes the Surat Municipal Corporation a pioneer in public health management in the country.[32] Surat, once infamous for its filth and the plague outbreak in 1994, has transformed to become a leader in sanitation and public health.

SUGGESTIONS

1. Education: Through the acquisition of knowledge and skills, education represents a key asset to combat climate change. According to the UNESCO, successful mitigation and adaptation may be achieved through scientific teaching and learning. Education will play a pivotal role in the achievement of the Paris Agreement and the Sustainable Development Goal (SDG) 13 which strives to 'take urgent action to tackle climate change and its impacts'. For example, epigenetics has demonstrated that environmental conditions can lead to modifications in the DNA of individuals adapting to changing climates; instruction and training can be an enabler to assist in such transitions to anticipated climates. Education creates a platform for learners to make

[31] http://www.firstpost.com/india/gujrat-what-surat-can-teach-other-india-cities-about-public-health-management-4258095.html
[32] Ibid.

informed decisions and build communities of practice centred on these issues, thereby strengthening, in the long run, resilience to climate change.[33]

2. Thoughtful landscape and drainage design: The growth, survival and behaviour of mosquitoes and ticks are highly sensitive to environmental temperatures which, in turn are influenced by urban heat island effects. This means temperatures in urban areas are higher than in the surrounding rural areas. Efforts to mitigate heat island effects by creating more green and blue places such as parks and lakes could promote replication of mosquitoes, especially if combined with climate warming. This may also be exacerbated by pools of stagnant water associated with particular types of landscape and drainage design in both urban and suburban areas.[34]

Climate change is likely to drive the emergence and re-emergence of diseases in India. However, the degree to which the Indian public will be at risk from these diseases will be determined, at least in part, by how we design, build and manage urban and suburban environments[35] and how do we change our behaviour in respect of public cleanliness.

3. Addressing Social Determinants of Health: Increasing global temperatures are a major risk factor for the expansion of emerging VBDs to countries with temperate climates. Strategies include addressing social determinants of health (especially in low- and middle-income countries), reducing heat island effects and urban sprawl, and promoting urban design principles that enhance healthy living while minimizing opportunities for vector breeding.

4. Surveillance on Epidemics: Increased surveillance of currently endemic VBD such as Lyme disease and West Nile virus, close monitoring including both human surveillance and vector surveillance, of possible oncoming VBDs in areas at risk for emergence and rapid case-detection for travel-related arrival of exotic VBDs needs to be prioritized.

5. Public Awareness: A strong communication strategy should be developed for the public on risk reduction, and for physicians on diagnosis and treatment. Messaging about personal protection measures also needs to be adapted to take into account changing urban populations and urban millennials' response to risks and threats.

6. Better Vector Control Methods: There is an urgent need to evaluate and further develop vector control methods. For example, pyrethriod insecticides, larvicides and other chemicals are in use, but data on their effectiveness and safety are limited.

7. Expansion in Research: There is an urgent need for enhancing interdisciplinary and multi-sector collaborations for research in this area. Foe example encourage to study the drivers of VBD emergence and transmission to devise better intervention programs; Study the interplay of climatic and social determinants

[33] Osama T, Brindley D, Majeed A, *et al*. Teaching the relationship between health and climate change: a systematic scoping review protocol. *BMJ Open* 2018;8:e020330. doi:10.1136/ bmjopen-2017-020330, downloaded from http://bmjopen.bmj.com/ on 23 May 2018.

[34] Mathieu K, Karmali M. Vector-borne diseases, climate change and healthy urban living: Next steps. Can Comm Dis Rep 2016;42:219-21. CCDR • October 6, 2016 • Volume 42-10 Page 220.

[35] For detail understanding please read Ogden NH. Vector-borne disease, climate change and urban design. Can Comm Dis Rep 2016;42:202.

in order to better understand their intricate relationship with potential emergence of VBDs in cities; and Analyze the costs and economic impacts of interventions versus no action[36].

8. Strategies at the global level: Implementing the United Nations Strategic Development Goals to address the problem of VBDs and other emerging infectious diseases; and continuing action against climate change.

CONCLUSION

"The global climate crisis threatens most people and their human rights," concluded Dr. Patz. "The adverse consequences of climate change will worsen. Addressing climate change is a health and human rights priority, and action cannot be delayed. Mitigation and adaptation measures must be equitable, respecting, protecting and promoting human rights."[37]

[36] Ibid 10

[37] Barry S. Levy, Jonathan A. Patz. **Climate Change, Human Rights, and Social Justice**. *Annals of Global Health*, 2015; 81(3): 310 DOI: 10.1016/j.aogh.2015.08.008

Indexed Journal
Refereed Journal
Peer Reviewed Journal

ISSN Online: 2349-4182
ISSN Print: 2349-5979
www.allsubjectjournal.com

Volume: 8 Issue: 9 Year: 2021

International Journal of Multidisciplinary Research and Development

Published By
Gupta Publications
Journal List : www.newresearchjournal.com

International Journal of Multidisciplinary Research and Development
www.allsubjectjournal.com
Online ISSN: 2349-4182, Print ISSN: 2349-5979
Received: 12-08-2021, Accepted: 27-08-2021, Published: 13-09-2021
Volume 8, Issue 9, 2021, Page No. 136-141

Intergenerational equity: A socio-legal framework for climate change

Sandhya Kalamdhad
Associate Professor, Department of Law, Dr Ambedkar College, Deeksha Bhoomi, Nagpur, Maharashtra, India

Abstract
Climate change is an issue of universal concern. Undoubtedly, human being is responsible to bring this disastrous changes to the environment. International and National efforts are warranted to check this disastrous effect way back in 1972. Yet till date desirous changes has not been seen in environmental upgradation. Therefore the author intends to critically analyze that who is responsible to protect the environment? The attempt of this article is to analyze that, how human actions that directly or indirectly degrade the environment in the present will affect future generations of humans and other living creatures. Government as a trustee of the natural resources should take rational and stringent steps for the protection of these for future generation. However, there is total callous attitude by the executive as well as legislature, as they are more interested in keeping this generation happy for their own personal gains. There are ample of examples which clearly gives us an idea about total failure on the part of government machinery to control pollution and protect the environment. In this context, this article seeks to focus on the individual duty to do the social justice to the future generations. The authors attempt is to bring the attention of every human being to the significance of the principle of intergenerational equity.

Keywords: climate change, environment protection, intergenerational equity, social justice

Introduction

"In 1972, 113 nations of the world gathered in Stockholm, Sweden. They were concerned. The much-vaunted goal of economic growth had brought prosperity and high standards of living. But it had also brought unwanted spillover effects. The land, air and waters of the world were being polluted to a dangerous level. The natural resources were being exploited unsustainably. The world's biological diversity was being diminished. Species were being culled at an exponential rate. It was time for a rethink."
-Justice Brian J. Preston

This was concern way back in 1972. Number of International and National efforts were warranted thereafter. Despite of that, in 2018 we are witnessing the momentous changes into the environment. Climate change is an issue of universal concern. This is no doubt a great testing period for the human species on this small planet. Who is responsible for this? Nobody will differ in the opinion. This is human being, who is responsible to bring disastrous changes into the environment. Undoubtedly "man is both creator and moulder of his environment, which gives him physical substance and affords him the opportunity for intellectual, moral, social and spiritual growth". History shows that - as one of nature's finest creations- man has proved itself and sustained and developed by full utilization of resources of the Earth. But as Gandhi underscored "Earth provides enough to satisfy every ones need but not anybody's greed". In fact defining and respecting the threshold of need is the principal source of humankind's dilemma. Because of the long and tortuous evolution of human race on this planet a man has transformed this environment at unprecedented scale. In the words of Dasmann, "Human race is likely on ape with hand granite. Nobody can say when he will pull the pin". In fact the man has caused irreversible harm to the environment, on which his own life and wellbeing is dependent. Nature has reciprocated to the action of human being. That compels human being to take measures for the restoration of natural balance of environment. The man, then united, took array of measures to prevent the frightening prospect of ecocide.

The efforts have warranted international environmental cooperation cutting across nation states. A set of principles and rules of international law have evolved in the process to provide a series for international environmental regulatory efforts. Accordingly national rules and regulations have been formulated to take efforts at national level. India is no exception to it. We have number of environmental legislations and policies to deal with the environmental problem. But will this be sufficient without co-operation from the basic root, i.e. individual human efforts? The attempt of this article is to analyze that, how human actions that directly or indirectly degrade the environment in the present will affect future generations of humans and other living creatures. In this context, it seeks to focus on the individual duty to do the social justice to the future generations.

Major Causes for Environmental Pollution

Man is the only rational animal on the earth. He is bound to think about his development. Development of the individual visa-vie state is impossible without Industrial development. Rather Industrial development is a part and parcel of state development. But at the same time we can not ignore the fact that industry is the main source of environmental pollution. According to central pollution control Board (CPCB) official's industrial effluents and wastes etc discharged into water is the biggest source of water pollution in India. As such 90% industrial wastes that reach the sea- a staggering 32,000 million metric tons is carried there by rivers and other inland water bottles. Heavy industrial sewage is expelled from the various industries such as jute mills, large distilleries textile mills, tanneries,

formidable pumps, paper mills having variable characteristics. Obviously this polluted water creates lot of health problem and also spoils the land. The soil pollution is an inevitable consequence of the water pollution. Besides water pollution air pollution resulting from industrial development is a major environmental concern today.

Some other sources also contribute greatly to the environmental pollution. There is a soil or land pollution because of unintended or incidental contamination of the soil with man made chemicals like pesticides garbage or polythene bags thrown in the water and soil. For instance River Yamuna, the main source of drinking water supply in Delhi is the free dumping place for untreated sewerage and industrial water. Likewise change in standard of living is also a major contributory factor for it, for instance, excessive use of motor vehicles, generators, gensets, and Air conditioners etc. Regular flow of persons from rural to urban area and deforestation also has made major contribution towards environmental degradation.

Absence of Working Plan by the Government

For the present scenario, one cannot deny the callous attitude shown by the authorities responsible for the pollution control in India. There are ample of examples which clearly gives us an idea about total failure in the part of government machinery to control pollution and protect the environment. Recent example is Adani Coal Plant at Tadoba, Chandrapur, which has been cancelled after the mass agitation. Thankfully the Indian judiciary rightly pointed out the lack of proper planning by the government and corrected the errors made by Govt., wherever required. Classic example of absence of a working plan by the Govt. despite of clear cut judicial order is the forest of Andaman and Nicobar Island, which is one of the global bio diversity hotspot. Calcutta High Court in Andaman & Nocobar islands forest plantation and development corporation and others V. Sushil Dhali, regarding the lease agreement between the F. D. and the A N E P D C, observed, "....we are at a loss to understand how under the law of contract or under any other law for the time being in force the Government could grant lease in 1987 with retrospective effect from 1977. The grant of lease with retrospective effect by the state authorities in favour of a corporation is not permissible under the law..." In spite of this observation of the court, the lease has continued to be operation till 2002. Means, in spite of clear order by the H. C. timber extraction in little Andaman, was continued for long time. In the meanwhile, there was one more judgment of the S. C. which said that, "the felling of trees is to remain suspended in accordance with the working plans of the state governments as approved by the central Government. Making the mockery of the law and the rights of the Onges (The Onges are a community of around a hundred individuals and the thickly forested Island of little Andaman is their only home. Ethno botanical knowledge of the Onge tribal community is staggering), there was a drastic decline of rare creatures like the monitor lizard, the dugong and the endemic Andaman wild pig".

Again the matter of violation of the tribal reserve in little Andaman and rights of the Onges tribal community were brought to notice of Calcutta High Court in 1999. The court directed the matter to the Supreme Court, as the related matter was pending before the Supreme Court.

Following the order of the High Court the petitioner approached to the Supreme Court in 1999 via an interlocutory application (IA) 502 in the Writ Petition (Civil) No. 202.T. N. Gondavamman Thirumulukpad V. Union of India and others. The court observed "In the mean time the cutting of naturally grown trees in any going projects or otherwise, except plantation wood, is prohibited". Then further directed that, "no sawmill plywood or veneer factory shall utilize any naturally grown trees without further order from this court." The court also appointed an expert commission to look after the state action.

Thus despite of various regulations for the protection of Andaman and Nikobar island judicial intervention was required for its protection because of lack of proper working plan to safe guard the natural gift from the god.

Another significant example could be poor Taj Mahal. Although Taj Mahal has always been one of the most talked about wonder of the world it has become the target of state irresponsibility's again and again. Taj Heritage Corridor project is the latest attempt to put in peril Shaha Jahan's dream as a "scam involving corrupt politicians and bureaucrats". Had the so called "Heritage corridor" come up, it would have also affected the ecology".

It is no doubt that, rapid industrial development, excessive use of transport vehicles, technical & scientific advancement, urbanization and deforestation, lack of proper town planning and layouts, modernization in standard of living have made major contribution towards environmental degradation but at the same time authorities entrusted with the work of pollution control can not be permitted to sit back with folded hands on one or the other pretext.

Pay Back Policy of the Environment

From the causes of the environmental pollution one could easily understand the irony of the situation that," more the economic development in the word, the more is danger to environment". Development no doubt is essential for human wellbeing but can it be at the cost of life of human being? The problem which present generation is suffering shall not be ignored at the sake of development. According to 1996 World Health Report 50000 people are dying every day form infectious diseases. In last 20 years at least 30 new infectious diseases have emerged, which are threatening the health of hundreds of million people. Many of these diseases have no treatment, cure or vaccine. We are standing on the bank of diseases. Apart from infectious diseases, there is a great threat of cholera, Malaria, tuberculosis, respiratory diseases.

Apart from the threat of spread of life killing diseases, the havoc created by nature through instances of natural calamities is also a warring to the human being that, no more interference with nature will be entertained! "Despite of all its intelligence and scientific power, humankind still remains primitive as far as its understanding of the earth is concerned".

What is Individual Role?

Today human society is facing a new risk and pressures in terms of polluted land, water and air. Human health is deteriorating because of direct or indirect effect from polluted environment. The poor and children are the most vulnerable section to the negative effect of climate change. This is result of ignorance on the individual part that, this is the earth which enabled life to come into existence. We do

require healthy environment for individual moral, spiritual, physical & intellectual development. But we have acted just like a shaikchilli and cut the branch of tree on which we are sitting. At least now we must wake up and try to understand our own duty towards environment. No doubt it is apparent that environmental problems cannot be resolved individually. Rather even individual states are not in a position to cope up with the problem without international co-operation. Undoubtedly there is note worthy contribution at international level through different international bodies. At international as well as national level there are plethora of legislations policies and programs, which have focus into environmental protection. Whenever there is lack of proper outlook by the Government, Indian Judiciary has played commendable role and has always proved its efficacy for the protection of ecological balance. In addition to this wide range of non-governmental organization are also concerned with environmental issue. Despite of all over efforts from all angles, where are we lacking? It is in designing the program or implementation of it? One may rightly think of it and very easily shift the responsibility on the shoulders of state but have we ever thought of our own responsibility? Have we ever asked a question to ourselves, what is my duty for the protection of environment on which my life and well being is depending? Very comfortably we have forgotten the fact of human evolution. We have started our journey from the very concept of nature only. That must be the reason why our scripture teaches us to respect nature.

In Hindu Philosophy, it is believed that the human body is composed of five elements (pancha tatva) vise, air, water, sky, earth and fire. In this way nature creates a body. Nature possesses an inherent quality of curing pollution by itself. "The protection and clearing up of environment was the essence of Vedic culture. In Hindu theology forests, trees and wildlife protection held a place of special reverence. These were worshipped as rituals". Vishnudharmasutra says that if you plant a tree it will be your son in the next generation. The plantation of trees were treated in Hindu culture not only a sacred ceremony or a religious activity but regular protection and patronage was also prescribed. Cutting green trees was prohibited and punishment was prescribed for such acts.

16-A of the Constitution of India also imposes an obligation on the individuals to protect and improve the natural environment (Art. 51 A [g]). There are several international conventions which also imposes a duty on individuals. Like under Stockholm Declaration – amongst other one principle says that "man bears a solemn responsibility to protect and improve the environment for present and future generation". India being the signatory to this have the same law. Sec. 4 of the Environmental Protection Act, 1986, imposes a duty on every person to take step to prevent or mitigate the environment pollution. Sec. 15 of the said Act contains provisions relating to the penalties that may be imposed for the contravention of any of the provisions of the said Act and directions issued there under.

If we would have realized duties of ours and would have acted through fuller knowledge and visor action, we would have achieved real prosperity & a better life.

Intergenerational Equity

The most widely accepted definition of 'intergenerational equity' is the one espoused by the World Commission on Environmental and Development in 1987, which held that "policy makers should seek to meet their own needs without compromising the ability of future generations to meet their own needs". The concept of intergenerational equity has the following three aspects, as enumerated by Professor Edith Brown Weiss in her seminal paper 'Intergenerational equity: a legal framework for global environmental change' published in 1992 and reinforced by Justice Brian J. Preston in his paper 'The Role of the Judiciary in Promoting Sustainable Development: The Experience of Asia and the Pacific':

1. Each generation should be required to conserve the diversity of the natural and cultural resource base, so that it does not unduly restrict the options available to future generations in solving their problems and satisfying their own values, and should also be entitled to diversity comparable to that enjoyed by previous generations. This principle is called "conservation of options".
2. Each generation should be required to maintain the quality of the planet so that it is passed on in no worse condition than that in which it was received, and should also be entitled to planetary quality comparable to that enjoyed by previous generations. This is the principle of "conservation of quality."
3. Each generation should provide its members with equitable rights of access to the legacy of past generations and should conserve this access for future generations. This is the principle of "conservation of access."

The essence of the concept is summarized by Edith Brown Weiss in the following terms:

"The proposed theory of intergenerational equity postulates that all countries have an intergenerational obligation to future generations as a class, regardless of nationality… There is increasing recognition that while we may be able to maximise the welfare of a few immediate successors, we will be able to do so only at the expense of our more remote descendants who will inherit a despoiled nature and environment. Our planet is finite, and we are becoming increasingly interdependent in using it. Our rapid technological growth ensures that this dependence will increase. Thus our concern for our own country must, as we extend our concerns into longer time horizons and broader geographical scales, focus on protecting the planetary quality of our natural and cultural environment. This means that, even to protect our own future nationals, we must cooperate in the conservation of natural and cultural resources for all future generations".

The concepts of intergenerational and intragenerational equity are an integral element of ecologically sustainable development, and have been incorporated into international law as such. The 1975 Charter of Economic Rights and Duties of States declared that:

"The protection, preservation and enhancement of the environment for the present and future generations is the responsibility of all States. All States shall endeavour to establish their own environmental and developmental policies in conformity with such responsibility. The environmental policies of all States shall enhance and not adversely affect the present and future development potential of developing countries" [1].

Similarly, the concepts of intergenerational and intragenerational equity are enshrined in Principle 3 of the

1992 Rio Declaration which provides that:
"the right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations".

Can Intergenerational Equity be the Answer?

Life is precious. it has to be preserve. Life definitely does not mean mere animal existence. To lead a meaningful & dignified life clean environment is required. This is possible only if holistic approach towards environment is adopted at the world level through individual efforts. because primarily it is the individual who pollute the environment most.

The concept of intergenerational equity and responsibility may be the probable answer to get clean environment. As discussed earlier world level effort are been required to achieve environmental protection. But this will really be fructified. if human being individually decides to contribute some thing for this. The concept of intergeneration equity talks on the same line. This is the responsibility of present generation to think about the well being of future generation. Indeed intergenerational equity is a value concept which focuses on the right of future generations. It is a notion i.e. implicit in ecological sustainability. It emphasizes the need for thinking about how human actions that directly or indirectly degrade the environment in the present will affect future generations of human and other life creatures. Intergenerational equity is a notion that views the human community, a partnership among all generations. Each generation has the right to access to the same diversity in natural and cultural resources enjoyed by previous generations and to equitable access to the use and benefit of these resources. At the same time the present generation is a custodian of planate for future generation, obliged to conserve this legacy so that future generations may also enjoy these same rights. In this way Intergenerational equity extends the scope of social justice in to the future. Intergenerational equity refers to relationship that a particular family has on resources. As every individual member inclusive of future member has right over the family property. each member from future generation has right over the natural and clean environment. Therefore individual has to think on the same line and shall make positive efforts to protect the environment. We may better realize this if be imagine the situation from individual point of view. We must think about our own child. what am I going to give to my child? Is it money with no body to enjoy that? What will he inherit from me? Is it diseases and unpredictable climate? Obviously, nobody wish to handover this kind of situation to ones child. Therefore more than international and national policies what we need is change in the attitude of human being. Change mind set to do some thing for the future generation (my own child) will definitely achieve required social justice.

Intergenerational equity is not only a social concept but has been greatly appreciated by legal fraternity. This concept is being applied by courts to settle disputes involving questions relating to environmental pollution and development. The Supreme Court in *K.M. Chinnappa V. Union of India* very aptly described the importance of the principle of intergenerational equity and held that "sustainable development is essential policy and strategy for continued economic and social development without detriment to the environment and natural resources on the quality of which continued activity and further development depend. Therefore. while thinking of the development natures the need of the present and the ability of the future to meet its own needs and the requirement have to be kept in view. While thinking of the present. the future should not be forgotten. We owe a duty to future generation and for a bright today, bleak tomorrow can not be countenanced. We must learn from our experiences. mistakes from the past. so that they can be rectified for a better present and the future. It can not be lost sight of that while today is yesterdays tomorrow, it is tomorrow's yesterday".

Role of the Judiciary

The Executive Director of the United Nations Environment Programme (UNEP), stated in his message to the UNEP Global Judges Programme:

"Success in tackling environmental degradation relies on the full participation of everyone in society. It is essential. therefore. to forge a global partnership among all relevant stakeholders for the protection of the environment based on the affirmation of the human values set out in the United Nations Millennium Declaration: freedom. equality. solidarity. tolerance. respect for nature and shared responsibility. The judiciary plays a key role in weaving these values into the fabric of our societies.

The judiciary is also a crucial partner in promoting environmental governance. upholding the rule of law and in ensuring a fair balance between environmental. social and developmental consideration through its judgements and declarations".

Befitting to the responsibility. in number of judicial decisions the judiciary played a very pivotal role in promoting the intergenerational equity.

In *State of Himachal Pradesh v Ganesh Wood Products*. a writ petition was filed seeking issuance of a writ restraining the government of the State of Himachal Pradesh from permitting the establishment of any factory units for the manufacture of Katha in the State. Katha is derived from the Khair tree which are found in considerable numbers in the State. Only the central portion of the trunk of the Khair tree is used for the manufacture of Katha. Hence. the manufacture of Katha requires the cutting of the Khair trees. The Supreme Court of India (B.P Jeevan Reddy J and M.K. Mukherjee J) in a Judgement delivered by BP Jeevan Reddy J upheld the appeal and stated that:

"The considerations of environment and ecology and preservation of forest wealth are absolutely relevant considerations which the Government must keep in mind while devising its policies and programmes".

The Supreme Court then emphasised the significance of the concepts of sustainable development and intergenerational equity. As to the latter. the Supreme Court said:

"Intergenerational equity means the concern for the generations to come. The present generation has no right to impede the safety and well being of the next generation or the generation sot come thereafter".

In *Rural Litigation and Entitlement Kendra v State of Uttar Pradesh*. the petitioners were rural villagers concerned about the unauthorized and illegal mining of limestone in the Mussorie-Dehradun belt in the State of Uttar Pradesh which adversely affected the ecology of the area and led to environmental disorder. The mining also adversely affect the villagers.

The Supreme Court described the environmental consequences caused by the excessive exploitation and

clearing of the forests and considered the mines that were operating in reserved forests: The Supreme Court held that:

"To these areas the Forest Conservation Act applies and to the allow mining in these areas even under strictest control as a permanent feature would not only be violative of the provision of Forest (Conservation) Act but would be detrimental to restoration of the forest growth in a natural way in this area. Once the importance of forests is realised and as a matter of national policy and in the interests of the community, preservation of forests is accepted as the goal, nothing which would detract from that end should be permitted. In such circumstances we reiterate our conclusion that mining in this area has to be totally stopped".

The Supreme Court's decision, therefore, addressed both intergenerational equity and intragenerational equity for the affected villagers in the valley.

In *M.C. Mehta v. Union of India*. The Supreme Court stayed all mining operations in the entire Aravalli Hill range within the State of Haryana in which mining operations were being carried out by upholding the principle of intergenerational equity. The Supreme Court held that: "Environment and ecology are national assets. They are subject to inter-generational equity…."

In *T.N. Godavarman Thirumulpad v. Union of India*. The Supreme Court, while considering Measures to be taken to compensate for loss of forest land and effect on ecology when forest land is used for non-forest purposes including payment of Net Present Value based on Total Economic Value, held that:

"The damage to environment is a damage to the country's assets as a whole. Ecology knows no boundaries. It can have impact on the climate. The principles and parameters for valuation of the damage have to be evolved also keeping in view the likely impact of activities on future generation."

Recently in Goa Mining Case. The Hon'ble SC of India once again compelled everyone to think about the significance of principle of intergenerational equity. In this case the SC was determined to implement intergenerational equity and formed an Expert Committee to examine the issue. In this case. Goa Foundation. the petitioner in the Goa mining case. raised the issue of Intergenerational Equity in its petition. In the course of the hearings. Adv. Prashant Bhushan. representing Goa Foundation submitted a detailed note on the legal aspects of intergenerational equity.

This judgement of the SC on 21st April. 2014 had a number of significant elements. amongst other. the Hon'ble SC held that all minings after 22 Nov. 2007 was illegal and finally stopped mining on 11 Sep. 2012. And the Goa Iron Ore Permanent Fund was established on grounds of intergenerational equity and sustainable development.

There are few different aspects that need to be assessed as to what happened aftermath this judgment. however. that is not a subject matter of present study. However. the important point which author intend to appreciate is the judicial activism or interference is always required to protect the environment as government i.e. executive as well as legislature are only concerned with the present generation and we individual also do not find enough time till today to rethink about our actions.

Conclusion

The frequent disastrous attack by the nature on human communities through different ways are indeed lessons for the human being. This is high time that we must learn a lesson that is to respect nature and to think in terms of living in harmony with the environment that surrounds us. Our mother earth is teaching us a lesson in universal responsibility. But are we ready to take the responsibility? We always wish to shift this responsibility on the shoulders of others. some time on nation and some time on international bodies. What these international and national bodies will do without the co-operation of common individual. Perhaps it is individual initiative which will definitely help to bring ecological balance. Individually. one need to think what little bit contribution he / she might make for the protection of environment.

We must act as a prudent human being and shape our action for the protection of our own mother. We must reciprocate to the love and care shown to us by this mother. Let take a pledge of not changing the word but to change our own mindset for small but meaning contribution for the protection of environment. So that I can allow my own child. my next generation to take a breath in healthy environment. This changed attitude of each individual on the earth will definitely make a big difference and this nature again bestowed the love and happiness on us for our peaceful and meaningful co-existence which in turn will definitely lead to the development.

References

1. Justice Brian J. Preston. Chief Judge of the Land and Environment Court of New South Wales. Australia "The Role of the Judiciary in Promoting Sustainable Development: The Experience of Asia and the Pacific". January. 2006.
2. Proclamation made by the UN's Conference on Human Environment Stockholm. 1972. 5(16).
3. Bharat H. Desai. "Revitalizing International Environmental Institutions: The UN Task Force Report and Beyond." IJLI. 2000. 40.
4. Dasmann. RF. Environmental Conservation. New York. 1976.
5. Smruti Koppikar. The Feat of Life. India Today. 1997. 84.
6. Lal's Commentary on Water and Air Pollution Laws. 1992. 749.
7. Almitra H Patel V. Union of India. AIR 2000 SC 1256. Kinkri Devi V. State of Himachal Pradesh. AIR 1988 HP 4 (Limestone quarrying in the Shivalik Hills). General Public of Saproon Valley V. State of Himachal Pradesh. AIR 1993 HP 52 (mining in a mountain ecosystem) Tariun Bharat Sangh V. Union of India. AIR 1993 SC 293 (mining in a tiger reserve).
8. Calcutta HC., Circuit Bench at Port Blair in the case FMAT No. 3353 of 1995 order dated May. 1996.
9. "The colonization of Little Andaman Island. Its Impact on the Onge Tribal Community". Combat Law. 2002. 1.
10. Kalpavriksh. Society for Andaman and Nicobar Ecology (SANE) a Port Blair based NGO and the Bombay Natural History Society. BNHS V. Union Territory of Andaman and Nikobar Islands and others. 1999.
11. TN Gondavamman Thirumulukpad V. Union of India and others. Interim order dated. 2001. 10.
12. Mehata MC. Supreme Court Advocate. Reported in. "Poor Taj Mahal!". Jyotika Yog. Lawyers Collective. 2003. 18.
13. UNEP. In Defence of the Earth. UN Environment

Programme. Nairobi. 1981. 3.
14. Indian Express. 1996.
15. Norma Alvares. "The Government Fails while the Judiciary Scores". Lawyers Collective. 2005. 20.
16. Tiwari BN. "Hindu Culture and Ecology. Environment. Man & Nature". 2000.
17. Yajnavalkya Smriti. https://nivedita2015.wordpress.com/ksou-ma-sanskrit/smrti-yajnavalkya-smrti/.
18. E Brown Weiss. In Fairness to Future Generations. UN University Press. 1989. 26-27.
19. State of Tamil Nadu V. Hind Stone AIR 1981 SC 711. Consumer Education and Research Society V. Union of India 2 SC 599 (605). 2002.
20. AIR SC 724 (737). 2003.
21. Goa Foundation V. Union of India. 6 SCC 590. 2014.
22. A Note of Adv. Prashant Bhushan on behalf of Goa Foundation in Goa mining case is available as-intergenerational Equity.docx-The Goenchimati Movement at goenchimati.org/.../Note-on-legal aspects-of-Intergenerational Equity.dox.2013:I:10.
23. 'Intergenerational Equity documents'. available at goenchimati.org/intergenerational-equity-documents/.

Volume-7, 2021 ISSN 2394-6903

RAINBOW

Multidisciplinary Peer Reviewed Annual Journal

Shri Nagpur Gujarati Mandal's

V. M. VASANT COMMERCE, J. M. THAKAR ARTS & J. J. PATEL SCIENCE COLLEGE

Wardhaman Nagar, Nagpur-8

Scanned with CamScanner

Volume-7, 2021

ISSN 2394-6903

RAINBOW

Multidisciplinary Peer Reviewed Annual Journal

Shri Nagpur Gujarati Mandal's

VMV Commerce, JMT Arts and JJP Science College

WARDHAMAN NAGAR, NAGPUR-440008.

Ph.: 2764391, 2733941, 6508158

E-mail: vmvnagpur@gmail.com, rainbowvmv@gmail.com

Website : www.vmvnagpur.org

Scanned with CamScanner

Publisher

VMV Commerce, JMT Arts & JJP Science College
Wardhaman Nagar, Nagpur

Printer

R. R. Offset Works
H.B.Town, Old Pardi Naka,
Bhandara Road, Nagpur.

Rainbow Vol.-7, March 2021. All rights reserved. No part of this publication may be reproduced in any form or by any means or used by any information storage and retrieval system without written permission from the copyright owner.

Opinions expressed in the articles, research papers are those of contributors and do not necessarily reflect the views of the publisher. The publisher is not responsible (as a matter of product liability, negligence or otherwise) for any consequences resulting from any information contained therein.

Scanned with CamScanner

ADVISORY BOARD

1. **Prof. Sachin C. Ketkar**
   Department of English,
   Faculty of Arts, Maharaja Sayajirao University of Baroda,
   Vadodara, Gujarat E-mail : sachinketkar@gmail.com

2. **Dr. Krishna Kumar Goswami**
   Director (Ex-Professor & Advisor C- Dac)
   Vishwa Nagri Vigyan Sansthan, Delhi
   E-mail : kkgoswami1942@gmail.com

3. **Dr. H. R. Kulkarni**
   Principal (Ex-Chairman Physics Board, Savatribai Phule Pune University)
   JSPM's Jayawantrao Sawant College of Commerce & Science,
   Hadapsar, Pune E-mail : hrkulkarni@rediffmail.com

4. **Dr. Dhanyakumar P. Jain**
   Director,
   AJMVPS, HKCCSM Institute of Management Research and
   Rural Development, Lal Taki Road, Ahmednagar
   E-mail : dp_jain@yahoo.com

Chief Editor : - Principal Dr. K. P. Kariya

Editor : Dr. M. J. Kolhatkar

Co-Editor :- Dr. Savita Devgirkar

Editorial Board

Dr. S. R. Mishra
Dr. S. K. Karhade
Dr. D. N. Padole
Dr. A. K. Bondre
Dr. P. G. Pandya
Dr. Jay Tanna

Scanned with CamScanner

29	डॉ. बाबासाहेब आंबेडकरांचे शेतीविषयक विचार	प्रा. शिवचरण धांडे	192
30	Dr. Babasaheb Ambedkar Views on the Empowerment of Dalit Education	Dr. Sujata H. Gaurkhede	196
31	सावित्रीबाई फुले-प्रभावी व्यक्तिमत्व एक विवेचन	डॉ. उज्जवला गोंडाणे	201
32	लक्ष्मीमुक्ती अभियान	प्रा. अविनाश अवचट	205
33	Special Libraries: a study	Ms. Jyotsna N. Wakude	208
34	पुस्तकालय तथा सुचना विद्यान शिक्षा में ई-लर्निंग के साधनों की उपयोगिता	मोहन रतकंठीवार	213
35	महाविद्यालयीन ग्रंथालयात मनुष्यबळ विकास	डॉ. मुरलीधर हेडावू	221
36	सतत् विकास और स्मार्ट शहरःवर्तमान चुनौतियाँ और भविष्य की संभावनायें	डॉ.श्रध्दा गावंडे	225
37	कृषी अर्थशास्त्र आणि भारतातील अल्पभुधारक शेतकरी	प्रा. विलास बी. कांबळे	230
38	हिंदी साहित्य के विकास मे लोक, जनता और संस्कृति की भूमिका	निर्भयकुमार त्रिगुण	235
39	Higher Education in 21st century & Sustainable Human Development	Dr. Sheela S. Khedikar	239
40	New Consumer Protection Act, 2019 – A Positive Step Towards Reformation of Consumer Laws And Rights In India	Dr. Pratima Lokhande	244

Hindi

41	हिंदी आलोचना का स्वरुप एवं विकास	डॉ. सुधा जांगिड डॉ. सोनू जेसवानी	248

Scanned with CamScanner

ISSN 2394-6903

New Consumer Protection Act, 2019 – A Positive Step Towards Reformation of Consumer Laws And Rights In India

Dr. Pratima Lokhande
LLM, NET, Ph.D , Diploma In Cyber Law Assistant Professor,
Department of Law,Dr. Ambedkar College, Deekshabhoomi, Nagpur

In the present time, demands and expectations of the consumer have changed due to globalization and growing awareness. A consumer is the person who buys or hires goods or services from the seller which helps to generate employment in the country. A consumer will now mean any person who "buys any goods" and "hires any services" which shall include **both online and offline transactions** through electronic means, teleshopping, direct selling or multi-level marketing. Consumer is an important factor in the economy. Protection of rights of the consumers is thus important as no economy can flourish without the rights of the consumer being protected. Consumer Rights are strengthened in India with the Parliament passing the Consumer Protection Act, 2019 and repealing the Consumer Protection Act, 1986 making consumers more powerful than before. The new law brings structural and procedural changes and an attempt has been made to extinguish the shortcomings of the 1986 Act. In this article author deals with the major concepts and new provisions of Consumer Protection Act, 2019. A humble attempt has been made to discuss and evaluate certain significant changes which have been made under this Act.

MAJOR CHANGES UNDER THE CONSUMER PROTECTION ACT, 2019

1. PRODUCT LIABILITY:

A significant addition to the 2019 Act is the introduction of "Product Liability" whereby manufacturers and sellers of products or services have been made responsible to compensate for any harm caused to a consumer by defective products, manufactured or sold, or for deficiency in services. The term product liabilityis defined as "the responsibility of a product manufacturer or product seller, of any product or service, to compensate for any harm caused to a consumer by such defective product manufactured or sold or by deficiency in services relating thereto." The impact is that it is not only the manufacturer who will be liable to compensate a consumer but also the seller if it fulfills the conditions mentioned in the New Act. According to the product liability, the sellers will be liable to refund the consumer if the services rendered or goods sold turns out to be defective and violates the right of the consumer. This will increase the liability of the sellers and it will work as a restraint on the sellers from selling goods with deficiencies.

Scanned with CamScanner

2. MISLEADING ADVERTISEMENTS MADE BY ENDORSERS AND CELEBRITY ENDORSEMENTS:

The Consumer Protection Act, 2019 now provides for penalties for misleading advertisements made by endorsers. Large companies and brands often promote their products through celebrities when it comes to targeting consumers. Thus Celebrity endorsers have often become synonymous with the brands that they endorse and are the great influencers. They add value to the brands, and play an integral role in influencing consumer choices. Consumers often select and eventually purchase the products and services endorsed by their preferred celebrity. Therefore, it is important for such celebrities to ensure that the claims made in their endorsements are not misleading or unsubstantiated in order to safeguard the interests of consumers at large. The Central Authority under the Act may order discontinuation/modification of a misleading/false advertisement which is prejudicial to the interest of the consumer or in contravention with the consumer rights. The Central Authority may also impose a penalty on the endorser of the false or misleading advertisement which may extend to ten lakh rupees and up to fifty lakh rupees for every subsequent contravention. The Central Authority may further prohibit the endorser of a false or misleading advertisement from making endorsement of any product or service for a period which may extend to one year and up to three years for every subsequent contravention. However, the only defense available to the endorsers is that they need to exercise due diligence to verify the veracity of the claims made in the advertisement regarding the product or service being endorsed by them.

3. CENTRAL CONSUMER PROTECTION AUTHORITY:

It establishes a Central Consumer Protection Authority which acts as a regulatory body to "promote, protect, enforce consumer rights as a class." A clear shift from Caveat emptor (let the buyer be aware) to Caveat venditor (let the seller be aware) can be seen in the new provisions Central Consumer Protection Authority (CCPA) is established to regulate matters relating to violation of rights of consumers, unfair trade practices and false or misleading advertisements which are prejudicial to the interests of public and consumers and to promote, protect and enforce the rights of consumers as a class. Central Authority shall consist of a Chief Commissioner and such number of other Commissioners as may be prescribed, to be appointed by the Central Government to exercise the powers and discharge the functions under this Act. It will consist of an investigation wing headed by a Director-General for the purpose of conducting inquiry or investigation under this Act as may be directed by the Central Authority. An appeal to an order passed by the CCPA on this issue can be filed before the National Commission within a period of 30 days from the date of the receipt of such order. Violation of rights of consumers as a class and complaints against misleading advertisements can only be reported to the Central Consumer Protection Authority. A consumer can also file a

Scanned with CamScanner

ISSN 2394-6903

complaint with the Central Consumer Protection Authority against any advertisement which gives or conveys false description of a product or service or contains a representation constituting an unfair trade practice etc.

4. RECOGNITION OF ALTERNATIVE DISPUTE REDRESSAL MECHANISM:

Delay in procedure of settlement is the main problem of Indian Judicial system. Keeping in mind the current scenario of the Courts in India where people have to wait for several years for the decision of the court, the new Act proposes the establishment of Mediation cells along with the Central Consumer Protection Authority. These mediation Cells attached to the Commissions will fasten the process of settling consumer complaints as the parties can approach the mediation cells any time between the arguments. Mediation as an alternate dispute resolution mechanism is introduced in order to resolve the consumer dispute in a faster way without having to approach the Commissions. Thus, in the events where the mediation is successful in whole, the terms of such agreement shall be reduced into writing accordingly. Where the dispute is settled only in part, the Commission shall record the statement of the issues which have been settled, and shall continue to hear the remaining issues involved in the dispute. In case of unsuccessful mediation the respective Commission shall within seven days of the receipt of the settlement report, pass a suitable order and dispose of the matter accordingly.

5. E-COMMERCE TRANSACTIONS:

India is one of the largest e-Commerce markets. With the increase in the volume and consumer base for the E-commerce markets there should be a corresponding development of a legal framework which should able to efficiently regulate its functioning and offer remedial measures for the grievances of the consumers. The central authority with a view to protect the interest of the consumers from the e-commerce entities who make direct sales to the consumers will provide for measures in the future which will protect the consumer from unfair trade practices in e-commerce. All the online transactions of buying or selling of goods or services including digital products over digital or electronic network has been brought under the ambit of E-Commerce. As per the provisions of the 2019 Act, a person who purchases any goods or avail any services through any of the online platforms will be treated as a consumer for the purpose of the Act and will be able to claim protection and seek remedies under the Act. Entities which allow a seller to engage to advertise, market or sell their goods or services to a consumer through their platform have been brought under the definition of electronic service provider. The online market places and the online auction sites have been expressly brought under the ambit of this definition. Such electronic service providers will have the same duties, responsibilities and liabilities as that of a Product Seller under the 2019 Act.

Scanned with CamScanner

6. UNFAIR CONTRACTS:

Another newly introduced concept is that of "unfair contracts" aimed to protect consumers from unreasonable contracts which lean in favour of manufacturers or service providers. A contract between a manufacturer or trader and consumer will be deemed to be unfair under the Consumer Protection Act, 2019, if it causes a significant change in rights of a consumer. Contractual terms which specify excessive security deposits, provide for unilateral termination or assignment without consent of other party are among the several grounds which render a contract unfair. Insertion of unfair contract provided the consumers a relief against the standard form contracts which they were force to execute without any option to negotiate.

7. THE POWER OF JUDICIAL REVIEW:

It will allow Consumer Commissions to review their orders, thereby reducing the burden faced on account of appeals being preferred to rectify errors apparent on the face of the record. Appeals from the State Commission to the National Commission may now only be made where they involve substantial questions of law. Appeals from the National Commission to the Supreme Court can only be made against complaints which originated in the National Commission.

CONCLUSION:

In the light of dynamically changing socio-economic developments, introduction of new concepts in Consumer Protection act 2019 has brought in several commendable changes in the existing framework so as to protect the interests of the consumers. Ensuring good quality products and services for the consumers is a welcoming and positive change. Also, the definition of unfair trade practices has been widened to include the term unfair trade contract as well within its ambit. The definition of Consumer is also expanded. There is a increase in the pecuniary jurisdiction of the Commissions. New act empowers consumers by imposing responsibilities not only on the sellers, manufacturers, service providers, but also the endorsers of such products. It also attempts to address the issues that were not comprehensively touched upon by CPA 1986, such interests of consumers as a class, E-commerce, Product liability, Mediation as an alternative dispute resolution mechanism etc. But at the same time there is a need for a self-regulatory mechanism and to put in place a system to effectively monitor the implementation of the consumer laws.

Scanned with CamScanner

Cover Page

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :7.816(2022); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:11, ISSUE:4(1), April: 2022
Online Copy of Article Publication Available (2022 Issues): www.ijmer.in
Digital Certificate of Publication: http://ijmer.in/pdf/e-Certificate%20of%20Publication-IJMER.pdf
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd April 2022
Publication Date:10th May 2022
Publisher: Sucharitha Publication, India

DOI: http://ijmer.in.doi./2022/11.04.09

STUDY OF GEOGRAPHICAL INDICATION PROTECTION TO TIRUPATI LADDU IN THE LIGHT OF OBJECTIVE OF GI LAW IN INDIA

MS Shilpa Rathod
Assistant Professor
Dr. Ambedkar College
Deeksha Bhoomi, Nagpur, Maharashtra, India

ABSTRACT

After the accord of Geographical Indication (GI) tag to the 'Tirupati Laddus' prepared by the world's richest religious trust, poses significant impact on the producers who used to prepare the laddu's just outside the temple precincts. This began the unended debate on the ground that how could Registry of GI granted the protection to the private entity by derogating the very foundation objective behind GI Act in protecting community interest. Analysis of the decision of Supreme Court wherein the grant of GI was challenge on the ground of inconsistency with the provision of GI Act proves futile. This may result in opening the channel for the commercialisation of faith. In this article researcher seeks to critically examine the latest manifestation of bare commercialization of sacred divine abode as an asset by grating the Intellectual Property protection. It seeks to explore that grant of GI to private entity, takes us to the understanding that the geographical name is used as a trademark under the name of Geographical Indication. This tends to bring down the replacement of producer centric approach by trader centric approach as against the very objective of Geographical Indication Act.

Keywords: Geographical Indication, Intellectual Property, Commercialisation, Producer, Trademark, Tirupati Laddu.

INTRODUCTION

In general, Geographical Indication is a name, sign or symbol for any goods which has an origin from specific place, region, or locality and possesses assured quality or the reputation attributed to their origin. Additionally, it protects the exclusive rights of the producers of a geographical region to use the same name, sign or symbol for differentiating their products from competing goods in the commercial market.[1] For instance, the signs or symbol like Nashik Grapes, Puneri Pagdi, Kashmir Pashmina or Darjeeling Tea depicts explicitly regarding quality and reputations of products attributed to the area, locality or place. After the prolonged struggled of many countries seen in Paris convention, Madrid agreement and Lisbon Agreement at international level, finally it was agreement on The Trade Related Aspects of Intellectual Property Rights (TRIPS) which has provided the detailed provision for the protection of Geographical Indication. TRIPS for the first time used the term "Geographical Indication" and has defined the 'geographical indications as any indication that identifies a good as originating from a particular place, where a given quality, reputation or other characteristics of the good are essentially attributable to its geographical origin[2].

In order to comply with an obligation laid down in TRIPS, Indian Parliament passed the Geographical Indications of Goods (Registration and Protection) Act (hereinafter the GI Act) in December, 1999 and The Geographical Indications of Goods (Registration and Protection) Rules, (hereinafter GI Rules) 2002, with an object to accord legal protection to goods or product associate with the geographical area in India. It has laid down process for seeking on the registration. However, it does not mandate all GI to undergo through the registration for protecting the rights; even an unregistered GI can avail the legal remedy by filing the suit of passing off on the occasion of its unauthorised use[3].But it is always recommended to opt for the registration, because if you have a registered GI, you can file the suit of infringement which is not available for the unregistered GI[4].

After the GI tag accorded to the Tirupati Laddu owned by Tirumala Tirupati Devastanam (TTD), raises many eyebrows, and unended debate posing the serious threat on the very principal objective of GI act. These will be discussed under following heads.

Geographical Indication is considered as an important intellectual asset like other intellectual properties. In the Intellectual Property regime, the laws of trademark, Copyright, Designs, and Patents aims at providing protection to the individual interest by granting the exclusive rights to the owner. In addition to individual interest, it also enables to know the general consumers regarding the

[1]Felix Addor, Alexandra Grazioli, Geographical Indications beyond Wines and Spirits: A Roadmap for a better protection for Geographical Indications in the WTO TRIPS Agreement, 5 J.W.I.P. 6 website https://www.ige.ch/e/jurinfo/documents/PDFdoku3.pdf. (Last visited on Oct 7, 2020).
[2]Article 22 of TRIPS
[3]Section 20 (2) "Nothing in this Act shall be deemed to affect rights of action against any person for passing off goods as the goods of another person or the remedies in respect thereof".
[4]Section 20 (1) "No person shall be entitled to institute any proceeding to prevent, or to recover damages for, the infringement of an unregistered geographical indication"

Cover Page

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :7.816(2022); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:11, ISSUE:4(1), April: 2022
Online Copy of Article Publication Available (2022 Issues): www.ijmer.in
Digital Certificate of Publication: http://ijmer.in/pdf/e-Certificate%20of%20Publication-IJMER.pdf
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd April 2022
Publication Date:10th May 2022
Publisher: Sucharitha Publication, India

DOI: http://ijmer.in.doi./2022/11.04.09

origin or ownership of the product. On the other hand, we have the Geographical Indication laws, whose primary objective is to provide the protection to the community at large whose livelihood is dependent on the goods prepared or produced in the specific geographical area. So, by granting the GI tag to Basmati rice from Himalayan region, Pashmina from Kashmir, Grapes of Nashik from Maharashtra, Pochampally Ikat from Telangana, and many more accords and protect the common interest of all the marginalized, poor, and indigenous community.

Being a collective right, it can effectively protect the livelihood of the artisans or other local communities who specialize in items unique to particular geographic locations[5].

As per the current notification issued by the GI registry, there are total 370 products all across the different parts of India have got the GI tag after going through due process of registration and more than 300 are still pending[6]. This proves that GI has an immense potential through which the interest of poor and indigenous community can serve. This helps in uplifting the marginalized sections of the society whose livelihood is depend on products coming from the specific geographical location. Therefore, proper protection of such intellectual asset is very important to prevent unauthorised user from free riding on the reputation built up by an indigenous community[7]. The present GI act came up with the primary object to protect the interest of indigenous community by providing the collective rights as against the private individual or entity. In the light of this it is worth to examine the long-term ramifications of this phenomenon. There are some occasions wherein, the government is just registering several GIs but not doing anything to secure the commercial benefits to the artisans of those areas[8]. After the GI tag accorded to the Tirupati Laddu owned by Tirumala Tirupati Devastanam (TTD), raises many eyebrows, and unended debate posing the serious threat on the very principal objective of GI act. These will be discussed through this research article.

RESEARCH METHODOLOGY

The Research Methodology of the proposed study shall be Doctrinal. The research will base on existing literature, Books, articles, journals, Acts etc. It will be explanatory as it explains the importance and role of geographical indication in protecting the interest of the community in the back drop of TRIPS. The research involves critical analysis of GI Protection to Tirupatti Laddu in the light of Objectives of GI Act 1999.

DISCUSSION

It is worth to mention the statement by an author Galileo Galilee that "I do not feel obliged to believe that the same God who has endowed us with sense, reason, and intellect has intended us to forgo their use[9]".

This means, when God who blessed human being with all senses of learning, thinking, creativity which proves useful for progress and overall development never intended the same to get misused at any occasion. Hence, in order to preserve the essence of one's intellect, it needs the blanket protection in order to curtail any occasion of misuse.

I. GRANTING GI TAG TO TIRUPATI LADDU

The world's famous richest Tirupati temple of Lord Balaji (Venkateshwara) managed by Tirumala Tirupati Devastanam situated at Tirumala in Andhra Pradesh always enthralled with millions of pilgrims every year. In the year 2008, the Trust applied for seeking GI registration before the GI Registry in Chennai for the Prasadam (Pious food) prepared in bulk in the Kitchen of Devastanam (temple trust)[10]. The Trust contended that the reason behind application for GI is to curb black market in and around Tirupati where the entire venders of the sweet shops are in practice of selling their laddu under the name "Tirupati Laddu" (pious food) despite all the surveillance and vigilance on the part of trust authorities[11]. The authorities had mentioned that the Prasadam has been prepared from boondi (small

[5] Madabhushi Sridhar (2009) GI for the Tirupati Laddu: Whose Interests Protected website: http://indiacurrentaffairs.org/gi-for-tirupathi-laddu-whose-interests-protectedprofessor-madabhushi-sridhar/. (Last visited on Feb 11, 2022)
[6]Government of India, Controller General of Patent, Design and Trademark website: http://www.ipindia.nic.in/writereaddata/Portal/Images/pdf/GI_Application_Register_10-09-2019.pdf,[Last visited on Feb, 11, 2022],
[7] Kasturi Das, Protection of Geographical Indications, An Overview of Select Issues with particular reference to India, (Centad Working Paper No. 8, 2007), website http://www.centad.org/cwp_10.asp. (Last visited on Feb 11, 2022)
[8] BananaIP Reporter (2019) on GI For Tirupathi Laddu: Whose Interests Are Protected available at https://www.bananaip.com/ip-news-center/gi-for-tirupathi-laddu-whose-interests/ (Last visited on Feb 11, 2022)
[9] Galilee An overview of Geographical indication website: http://www.legalserviceindia.com/article/l267-Geographical-Indications.html [last visited on Oct 7, 2020], Page. 1
[10] Tirupati Laddus get GI status, THE DECCANHERALD, (Hydrabad), Feb 28, 2014, website https://www.deccanherald.com/national/tirupati-laddu-gets-gi-tag-378561.html. (Last visited on Feb 13, 2022).
[11] Id

Cover Page

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :7.816(2022); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:11, ISSUE:4(1), April: 2022
Online Copy of Article Publication Available (2022 Issues): www.ijmer.in
Digital Certificate of Publication: http://ijmer.in/pdf/e-Certificate%20of%20Publication-IJMER.pdf
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd April 2022
Publication Date:10th May 2022
Publisher: Sucharitha Publication, India

DOI: http://ijmer.in.doi./2022/11.04.09

Balls made from gram flour) mixed with sugar syrup and pure cow ghee and contains a variety of other ingredients such as cashewnuts, cardamom, diamond sugar candies, raisins and almonds[12]. Further the authorities contended that the Pasadam is the result of the painstaking process of the skilled cook who uses appropriate quantity of the above ingredients to bring the unique flavour, which is different from those vendors who prepare the same outside the vicinity of temple. In addition to this, it further explained the prasadam not only gets its reputation and quality from its unique taste alone but from its sacred sanctity because it first offered to lord Balaji in small amount and the same has mixed with the bulk to make it more sacred as it involves god's blessing[13]. After examining the application filed by TTD, the Registry of Chennai finally accorded GI Tag to Tirupati Laddu on 15th September, 2009. This enables the TTD to use the exclusive rights as against all the producers of the same region from use of name Tirupati Laddu for their sweet products prepared outside the vicinity of Temple. This opens the avenue for the criticisms and debates on the various issues like whether the said grant is in consonance with the objective of GI law in protecting community interest. Tirupati Laddu indeed possesses unique features primarily on account of its association with the temple; this uniqueness may not be a sufficient criterion for granting GI status[14]. The grant brought the pious food (Prasadam) under the category of "goods" like other GI products for instance, Nagpur Orange, Darjeeling Tea and Goa fene which have commercial value in the market, Grant of GI tag results in brazen commercialization of divine abode[15]. The various issues pertaining to grant of GI status to Tirupati Laddu has explored on the below mentioned grounds-

a. **PROTECTING INTEREST OF PRIVATE ENTITY UNDER THE NAME OF GI.**

The major issue of utter cry emerged after the accord of GI tag to Tirupati Laddu, is whether the GI in derogation with its main object can protect the interest of the private entity in contrast with serving common interest of community at large? This is because unlike the other IP, GI law has frame only to serve the common interest of the community who produces the same goods by sharing the common topography. For example: All people from Darjeeling who produces tea in that region collectively get the protection after the grant. But in case of Tirupati laddu, only TTD is exercising monopoly rights to use name Tirupati laddu by restricting all those who are living in the same region. This would mean that everyone from Tirupati can have the right to use GI on "Tirupati Laddu", as long as their laddu geographically originates in Tirupati and has the same delicacy and features attributable to the laddu that is prepared by the temple trust[16]. This takes us to the understanding that now just like trademark, the protection is accorded to the private entity under the name of GI, which has lost the essence in complying the basic objective of GI in protecting community interest. While applying the GI grant to Tirupathi Laddu, the trust contended that the laddu's got the uniqueness because the same has been prepared by the skilled cook but when it comes to benefit sharing then it came to notice that the makers of the laddu's are regular workers of the TTD, who never get any share in profits out of selling Laddus[17].

In Geographical Indication Act 1999, it has specifically provided the eligibility of the applicant for filing GI application for their respective goods. It provides under section 11(1) that the application can file by any association, organisation or authorised entity that represents the interest of the producers in relation to the respective goods or product[18]. But in case of Tirupati Laddu, TTD as an applicant does not represent the interest of the producers preparing the same sweet outside temple, by sharing same locality. This proves that the laddus gets the reputation and uniqueness not because it has prepared by the skilled cooks of temple but because of the sanctity achieved by offering the same to Lord Balaji at the time of recitation of mantras along with the tune of chanting bells. But this is not the justified ground that it deserves the GI protection. This opens the claim from the indigenous producers who produces the laddus outside the temple, who could have got the same blessing and sanctity by offering their sweets to Lord Balaji by entering in the temple, as there is no restriction on the entry of the person within the temple. It is imperative that God could never be biased in accepting the offering and according the blessings to the sweets produced by the Temple trust as that of the producers from outside the temple. Providing GI protection to Tirupati laddu proved that, trademark is been granted to private trust under the nomenclature of Geographical Indication. This gives the wrong impact on all other private producers that GI is also available for them as well on the similar note that of Tirupati

[12] G.I Application Number 121, Geographical Indications Journal (Vol 28), website: http://ipindiaservices.gov.in/GIRPublic/Application/Details/121 (Last Visited on Feb 13, 2022).
[13] Supra Note 9
[14] Meghna Banerjee & Susanah Nausahd (2017) Grant of Geographical Indication Designation to Tirupati Laddu: Commercialization of Faith? Website: http://docs.manupatra.in/newsline/articles/Upload/691B89AA-4C96-4C9E-912B-AAE42E89B6FC.pdf (Last Visited on Feb 23, 2022)
[15] Supra Note
[16] Supra note 14
[17] Ibid
[18] Section 11 (1) of The Geographical Indications of Goods (Registration and Protection) Act, 1999 the application for GI designation has to be made to the Registrar by "any association of persons or any organization or authority established by or under any law for the time being in force representing the interest of the producers of the concerned goods, who are desirous of registering a geographical indication in relation to such goods."

Cover Page

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :7.816(2022); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:11, ISSUE:4(1), April: 2022
Online Copy of Article Publication Available (2022 Issues): www.ijmer.in
Digital Certificate of Publication: http://ijmer.in/pdf/e-Certificate%20of%20Publication-IJMER.pdf
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd April 2022
Publication Date:10th May 2022
Publisher: Sucharitha Publication, India

DOI: http://ijmer.in.doi./2022/11.04.09

Laddu[19]. For instance- Bambino vermicelli being the registered Trademark of solo enterprise applied for the GI but same has not allowed, if could have been treated casually like Laddu, would prove fatal in achieving the purpose of the GI Act, 1999.

b. AGAINST ECONOMIC PROSPERITY OF THE COMMON PRODUCER.

In addition to provide protection to common indigenous community, GI law also aims at prospecting and enhancing the economic prosperity of producers of goods sharing the common geographical area. Granting the GI status to 'Tirupati Laddus', protected the monopolistic rights enjoyed by the private trust by providing the protection in derogation to the objective of GI Act, 1999. Temple trust is considered as the world's richest religious institutions as millions of the devotees give hefty donations. It has been practicing of the temple to sell the Prasad in consideration of the money. The accumulated amount on the sale of Prasadam entirely becomes the property of the Trust, which makes them alone richer and prosperous. This brought the big reason of worries for the common producers living in the precinct of the temple premise and producing the same sweets, but not allowed to sale under the name of Tirupati Laddu. The essence of distribution of benefit sharing is absolutely absent in this case, because the entire amount accumulated in the hands of trust, neither distributed with the skilled cook who prepares the food nor amongst the workers who provides services to the temple. They are rather the paid labour appointed by the authorities of the temple trust.

It is worth to mention here that the cost of laddu's varies at Rs 25 to 100 depending on its size. Around 70,000 pilgrims visit Tirumala every day and almost every one purchases laddu, leading to a turnover of Rs. 17 to 70 lakh a day which is used by the single entity[20]. Recently, as per the temple source, the administration of Trust has incurred an annual loss of over Rs 140 crore for the last three years owing to its subsidised price and free distribution of the pious prasadam to some devotees[21]. This proves that Trust is more concerns about its own gain and losses incurred annually by forgetting the economic prosperity of the common producer due to the loss incurred to them after the grant of GI tag to Tirupati laddu. Till present date, there is no proper justification provided by the Trust as well as GI registry on this issue.

c. RELIGIOUS FOOD USED AS GOODS OF COMMERCE.

Geographical indication means an indication which identifies such goods as agricultural goods, natural goods or manufactured goods as originating, or manufactured in the territory of a country, or a region or locality in that territory[22]. Further, goods mean agricultural, natural or manufactured goods or any goods of handicraft or of industry and include food stuff[23] .This explicitly not includes any religious food as akin to manufactured food produced industries. When it comes to the case of Tirupati laddu, the pious food prepared in the potus of the temple's kitchen explicitly implies that the pious food is neither natural goods nor agricultural goods and the same is not manufactured one because, temple is not an industry wherein they are manufacturing the food. Rather it is a religious institution which never intent to use in commerce. As per Wikipedia report, the temple trust received 10 million dollars in 2007 out of sale of Laddus, this implies that Prasadam is just a commercial food article[24]. As per the source of the temple, there are various schemes used in the temple for the sale of Laddu[25].

1. Selling the laddu at Rs 10 per piece as against subsidised rate to devotees who opt for free darshan and wait for several hours in long queues.
2. The introduction of scheme in Oct 2013 in which one free laddu given to each devotee who walks 11 km.
3. The devotees who avail Rs 300 special entry darshan pass and Rs 500 VIP darshan tickets were also getting two laddus free.

In providing these schemes, as per the source from the temple, TTD incurs a huge lose at the tune of Rs 140 Crore till date. This proves that the Trust authorities are more concerned about the annual loss or gain as a whole by forgetting the great spiritual

[19] Sumathi Chandrashekharan,(2009) Guest Post: Tirupati Laddu or the Lord?, website: http://spicyipindia.blogspot.com/2009/09/guest-post-tirupati-laddu-orlord.htm (Last visited on Feb 23, 2022).
[20] TTD's application published in Geographical Indication Journal No. 28 at page 38, published on 17/11/2008 available at http://www.ipindia.nic.in/writereaddata/Portal/Images/pdf/Journal_28.pdf (Last Visited Feb 14 2022)
[21] 'Tirupati Laddu truns bitter for TTdD, causes Rs 140 crore lose' **(Feb 19, 2017)** *The Economic Times* **available at** https://economictimes.indiatimes.com/news/politics-and-nation/tirupati-laddu-turns-bitter-for-ttd-causes-rs-140-crore-loss/articleshow/57237627.cms?from=mdr **(**(Last Visited Feb 14 2022**)**
[22] Section 2 (1)(e) of The Geographical Indications of Goods (Registration and Protection) Act, 1999
"Geographical Indication", in relation to goods, means an indication which identifies such goods as agricultural goods, natural goods or manufactured goods as originating, or manufactured in the territory of a country, or a region or locality in that territory, where a given quality, reputation or other characteristic of such goods is essentially attributable to its geographical origin and in case where such goods are manufactured goods one of the activities of either the production or of processing or preparation of the goods concerned takes place in such territory, region or locality, as the case may be.
[23] Section 2(f) of The Geographical Indications of Goods (Registration and Protection) Act, 1999
[24] Supra note 9
[25] Supra note 21

Cover Page

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :7.816(2022); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:11, ISSUE:4(1), April: 2022
Online Copy of Article Publication Available (2022 Issues): www.ijmer.in
Digital Certificate of Publication: http://ijmer.in/pdf/e-Certificate%20of%20Publication-IJMER.pdf
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd April 2022
Publication Date:10th May 2022
Publisher: Sucharitha Publication, India

DOI: http://ijmer.in.doi./2022/11.04.09

significance attached to the Prasadam by reducing it in the categories of the goods for commercial gain. It is pertinent to mention here that, the GI to Tirupathi Laddu opens an avenue for others to use the religious Prasad as goods which can use as a tool of commerce.

d. QUESTIONS ON DISTINCTIVENESS.

For getting the GI protection one must comply with distinctive requirement. While filing the application at Chennai registry the trust Tirumala Tirupati Devastanam mentioned that the Laddus are only prepared by the skilled cook who uses specific ingredients in the kitchen of temple and possess distinctiveness in terms of quality, reputation and other characteristics[26].It has further mentioned that, in addition to the skill used only within the temple kitchen , few quantity of Laddus are offered before the idol in sanctum sanctorum during Puja and then it is taken to the pottu where they are mixed with the bulk[27]. This gives the sacred sanctity to the laddu's which makes it distinctive. Then the Registrar of Geographical Indications has appointed a panel of experts for examination of the merits of the application and opined that the Laddu is worthy to get a GI tag and finally accorded GI status to same[28].

In the light of this it is worth to decide whether preparing food in the temple premise and mixing of small amount of laddu offered during pooja with the bulk would be sufficient to acquire distinctiveness?

This brought the agitation in the indigenous producer who produces the laddus outside the temple, who could have got the same blessing and sanctity by offering their sweets to Lord Balaji by entering in the temple, as there is no restriction on the entry of the person within the temple. It is imperative that God could never be biased in accepting the offering and according the blessings to the sweets produced outside the Temple. So, if the general vendors who are preparing the laddu in their shop equally shares the same climate of the Tirumala hills and are very close to the temple. By offering their food (as Naivedayam) to Idol by entering into temple equally gets the same sanctity and sacredness as that of accorded to the pious food of temple trust and hence can equally get the distinctiveness.

e. UNJUSTIFIED REASON ON GRANTING GI STATUS TO TIRUPTI LADDU

At various occasions, it has proved that no appropriate justification has been provided behind granting GI status to Tirupati Laddu. During the stage of registration, the registrar has appointed the expert panel for examining the application field by TTD, wherein they have easily convinced that TTD has possesses the distinctiveness and suggested to accord protection to same, which finally became one of the registered GI of India.

In the famous case filed by Mr. R. S. Praveen Raj, a scientist at NIIST against Tirumala Tirupati Devasthanams has raised many questions on the very rational behind granting GI status to Tirupati Laddu. In this case it has argued that the Grant of GI to Tirupati Laddu ensures the monopoly to a single producer would defeat the primary objective of GI law in serving community interest[29]. In addition to this he highlighted that the protection is accorded in contraventions of the provisions of G.I Act 1999[30]. Being mark which would be likely to deceive or becoming the reason to cause confusion to people[31]. Further the mark which likely to hurt the religious susceptibilities of the common masses of India is also not registrable[32]. But unfortunately, despite all endeavour the GI Registry, Chennai rejects the contention by Mr. Praveen Raj demanding the removal of the GI tag accorded to Tirupati Laddu only on the ground that he failed to prove the locus Standi. Thereafter, the status of GI has been challenged in Madras High Court on the ground of violating Article 25 of the Indian Constitution and the Provisions of GI act 1999 and brings into question the entire registration process[33]. But unfortunately, the court has provided the judgement in favour of the Temple Trust that considered as a black day for the indigenous producers whose interest is diluted beyond any cost.

II. POSSIBLE THREATS AFTERMATH OF COURT'S DECISION.

The efforts taken by Praveen Raj for challenging the GI stated accorded to Tirupati laddu proved futile not on any legal ground but for the want of locus standi, it opens the channels for all religious trust like Shirdi Devasthan, Shanishingnapur, Murgan Temple,

[26] G.I Application Number 121, Geographical Indications Journal (Vol 28), website: http://ipindiaservices.gov.in/GIRPublic/Application/Details/121 (Last Visited on March 23, 2022).
[27] Id
[28]Geographical Indications Journal (Vol. 30), website: http://ipindiaservices.gov.in/GIRPublic/Application/ViewDocument (Last visited on Mar 23, 2022).
[29] Section 11(1) of The Geographical Indications of Goods (Registration and Protection) Act, 1999
[30] R.S. Praveen Raj, (2009,21 Sept) Collective Community Rights or Private Monopoly Rights? website: http://www.articlesbase.com/advertising-articles/collectivecommunity-rights-or-private-monopoly-rights-gi-tag-on-tirupathi-laddu-oppugns-thelegislative-intent-of-the-statute-1254579.html (Last visited on Oct 14, 2020).
[31] Section 9 (a) of The Geographical Indications of Goods (Registration and Protection) Act, 1999
[32] Section 9 (d) of The Geographical Indications of Goods (Registration and Protection) Act, 1999
[33] Tirupati Laddus: Caught in a controversy Rediff.Com 21 Oct 2009 website: https://www.rediff.com/money/slide-show/slide-show-1-tirupati-laddus-caught-in-a-controversy/20091021.htm (March 27 2022)

Cover Page

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :7.816(2022); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:11, ISSUE:4(1), April: 2022
Online Copy of Article Publication Available (2022 Issues): www.ijmer.in
Digital Certificate of Publication: http://ijmer.in/pdf/e-Certificate%20of%20Publication-IJMER.pdf
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd April 2022
Publication Date:10th May 2022
Publisher: Sucharitha Publication, India

DOI: http://ijmer.in.doi./2022/11.04.09

Kedarnath, and many more throughout the India, for applying GI on the same note as that of Tirupati Religious Trust. Mixing IPR with religion will have serious consequences in the future and it hurts the religious sentiments[34]. Recent past has evident that there are many instances of inappropriate GI applications filed for seeking protection. One of such instances is application for Bambino vermicelli filed by the single entity. A similar attempt by the giant and renowned Reliance Industries Ltd (RIL), filed an application for registering the gas pumped from its Krishna-Godavari fields and its various petroleum products manufactured in the refinery situated in Jamnagar, regrettably reaches at the stage of advertisement where it has received the opposition[35]. Though the same was not successful in getting the registration but it is a matter of great concern that how registry could allow the said applications reaches till the stage of advertisement[36]. In case of other IPs like trademark and patents the efforts of many applicants proved futile at the stage of examination only in proving that how their IP is unique and worthy of getting protection. Therefore, hefty applications of Trademarks and Patents are still pending with the IP office. On the other hand, GI protects the community interest of the indigenous people but the above discussed instances of Reliance Company, case of Tirupati laddu proved that GI office is very lenient in accepting and examining the applications for GI protection. This may result in grave implications and matter of much concern for the future of GI governance in India. This may pose the serious threat on the very foundation objectives of the India's GI Act.

CONCLUSION

GI is considered as an important intellectual asset not only for the producer stakeholders and the Consumers but it has a great significance for the entire country in promoting the economic development. Granting GI status to Tirupati ladu proved the utter disguised on the part of GI registry that, in handling the case of the world's richest & prosperous temple very leniently without going into the merits and credentials of it. This brought the absolute unrest in the indigenous community whose interest has been crushed in derogation with the cardinal objective behind enacting the GI act, 1999. On the other hand, if the religious entities are getting the GI tag for their food, articles or ornaments only on the ground that the distinctiveness is acquired out of pious blessing and sanctity from God, then the GI registry would be flooding with the application for protecting the individual interest under the name of Geographical region. Though the proper protection of GI, we can encourage all the indigenous, marginalized and poor people who don't have any other means and source of income. Although the GI Act enacted with the ultimate aim to provide a effective and efficient regulatory mechanism but it is evident that the GI Registry while entertaining the GI application for Tirupati Laddu failed to comply with the minimum requirements laid down under the Act[37].

India is secular country, wherein the religious aspect and sentiments of the people are protected as a matter of fundamental right by the Constitution. Therefore, it is the foremost responsibility of the Government to enforce the strict action against any instance which hurts the religious sentiments of the common people.

The ultimate purpose of GI is to serve the common interest of the community as against promoting the monopoly right of single entity. Vanquishing and replacing the very essence of enacted laws to monopoly practices would be more dangerous for future[38]. Government authorities must show due diligence and extreme caution in governing IPR laws. Letting IPRs to take the form of monopoly is detrimental to the interests of a democratic nation. Judiciary should be vigilant in entertaining the GI cases as it is very sensitive for the interest of common producers who are the sole bread earner for their family. So, it is expected that the judiciary should intervene Suo motto in the cases of GIs wherein the issue goes beyond the objectives behind framing laws of land. Great autonomy and vigilance should be maintained by the authorities in ensuring that the cardinal objective of serving common interest will be preserved effectively in future. It is absolutely unacceptable fact that allows the religious institutions to play with the sentiments of the common public by using their assets for the commercial purpose. If that happen then on one day one can claim the trademark and other IP on God too, which brings the place of worship in the category of industry.

[34] R.S Praveen raj (2015) Inside view: India: Poor man's Intellectual Property if Hacked website: https://www.ip-watch.org/2015/09/28/india-poor-mans-intellectual-property-is-hijacked/ (Last Visited on Oct 17 2020)
[35] Id
[36] id
[37] Arun S, GI Protection in India: A time to Introspect? FINANCIAL EXPRESS, (2008, August 31) website: http:// www.financialexpress.com/news/GI-protection-in-India-A-time-to-introspect/355400/2 (Last visited on Mar 27, 2022).
[38] Sumathi Chandrashekharan, Payyanur Ring (2010, February 7,) GI: religious sentiments no bar to registration, website: http://spicyipindia.blogspot.com/2010/02/payyanur-ringgi-religious-sentiment-no.html (Last visited on Mar 27, 2022).

Cover Page

DOI: http://ijmer.in.doi./2022/11.04.09

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY EDUCATIONAL RESEARCH
ISSN:2277-7881; IMPACT FACTOR :7.816(2022); IC VALUE:5.16; ISI VALUE:2.286
Peer Reviewed and Refereed Journal: VOLUME:11, ISSUE:4(1), April: 2022
Online Copy of Article Publication Available (2022 Issues): www.ijmer.in
Digital Certificate of Publication: http://ijmer.in/pdf/e-Certificate%20of%20Publication-IJMER.pdf
Scopus Review ID: A2B96D3ACF3FEA2A
Article Received: 2nd April 2022
Publication Date:10th May 2022
Publisher: Sucharitha Publication, India

REFERENCES

Books

1. Dr. Sreenivasulu N.S. "Impact of TRIPS on IP laws in India- a post TRIPS scenario", ed.2017, Regal publication, New Delhi, p-247
2. Nair.L.R "Geographical Indication- A search for Identity", Lexus nexus, ed. 2004 New Delhi, pp.23-46
3. Carlos.M Correa on "Trade Related Aspect on Intellectual Property Rights" Oxford University Press, ed. 2018 p.p 223-235

Journal Articles

1. J Adithya Reddy and Siladitya Chatterjee "Critique of the Indian Law and Approach towards Protection of Geographical Indications with Specific Reference to Genericide" Journal of Intellectual Property Rights, vol. 12, November 2007.
2. N. Krishna Kumar "Geographical Indications Laws in India: Issues and Challenges" Journal of Intellectual Property Rights Law, vol. 3, Issue1, 2020
3. Felix Addor, Alexandra Grazioli, Geographical Indications beyond Wines and Spirits: A Roadmap for a better protection for Geographical Indications in the WTO TRIPS Agreement, Journal of World Intellectual Property, vol.5, Issue 6, 2005
4. Geographical Indications Journal (Vol. 30), website http://ipindiaservices.gov.in/GIRPublic/Application/ViewDocument
5. Arun S, GI Protection in India: A time to Introspect?,FINANCIAL EXPRESS, August 31, 2008website http:// www.financialexpress.com/news/GI-protection-in-India-A-time-to-introspect/355400/2
6. Sumathi Chandrashekharan, Payyanur Ring GI: religious sentiments no bar to registration, February 7, 2010, available at http://spicyipindia.blogspot.com/2010/02/payyanur-ringgi-religious-sentiment-no.html
7. R.S Praveen raj "Inside view: India: Poor man's Intellectual Property if Hacked" 2015 available at https://www.ip-watch.org/2015/09/28/india-poor-mans-intellectual-property-is-hijacked/
8. Madabhushi Sridhar, "GI for the Tirupati Laddu: Whose Interests Protected", (2009), available at http://indiacurrentaffairs.org/gi-for-tirupathi-laddu-whose-interests-protectedprofessor-madabhushi-sridhar/.
9. Kasturi Das, "Protection of Geographical Indications, An Overview of Select Issues with particular reference to India, 2007, available at http://www.centad.org/cwp_10.asp.
10. Oskari R on "Monopolising names? The Protection of Geographical Indications in the European Community", 2006 www.thesis.helsinki.fi/julkaisut/oik/julki/pg/rovamo/abstract.htmlpage. 2-5
11. Dr. Ganguly on "Geographical indication – its Evolving contours", 2009 available at http://www.iips.ac.inmain_book.pdf.
12. Almida. Alberto "Key difference between trade mark and geographical indication" 2009 available at http://citizenseminars.blogactiv.eu/files/2009/03/trade-marks-in-pdf.pdf

REPORTS, MAGAZINE AND NEWS PAPER

1. Banana IP reporter "GI For Tirupathi Laddu: Whose Interests Are Protected" https://www.bananaip.com/ip-news-center/gi-for-tirupathi-laddu-whose-interests/, 2019
2. International Food & Agricultural Trade Policy Council (IFATPC) Report, 2003 P.p. 342-349 available at http://www.agritrade.org/Publications/DiscussionPapers/GI.pdf
3. WTO Document No.IP/C/W/278/Rev. http://docsonli ne.wto.org/DDFDocument s/t/ IP/C/W308R1.doc), pp.1-4
4. WIPO magazine (2007) "Geographical indication: From Darjeeling to Doha" available http://www.wipo.int/wipo_magazine/en/2007/04/article_0003.html
5. IFATPC "Geographical Indication" http://www.agritrade.org/Publications/DiscussionPapers/GI.pdf, pp.2-4
6. SCT Report (2002) on "Definition of Geographical Indication", Ninth Session, Geneva, November 11 to 15, 2002 available at http://www.wipo.int/edocs/mdocs/sct/en/sct_9/sct_9_4.pdf
7. Tirupati Laddus: Caught in a controversy Rediff.Com 21 Oct 2009 available at https://www.rediff.com/money/slide-show/slide-show-1-tirupati-laddus-caught-in-a-controversy/20091021.htm
8. 'Tirupati Laddu truns bitter for TTdD, causes Rs 140 crore lose' The Economic Times, (Feb 19, 2017), available at https://economictimes.indiatimes.com/news/politics-and-nation/tirupati-laddu-turns-bitter-for-ttd-causes-rs-140-crore-loss/articleshow/57237627.cms?from=mdr

CRITICAL EVALUATION OF - MAINTENANCE AND WELFARE OF PARENTS AND SENIOR CITIZENS ACT, 2007

Professor Dr. Hema V. Menon, Professor and Head, Department of Law, Dr. Ambedkar College, Nagpur

&

Dr. Swati R. Chiney, Associate Professor, Head-Dept. of Business Laws. Symbiosis College of Arts & Commerce, Pune

ABSTRACT

In India; with the rise in - life expectancy, senior citizens' population, cost of living, migration of young people, number of nuclear families, withering away of joint family system and covid pandemic effect - there would be certainly a rising issue of financial and social insecurity of elderly population in near future. The Maintenance and Welfare of Parents and Senior Citizens Act, 2007 has been enacted in India to protect the right to maintenance and welfare of parents and senior citizens. According to the researcher, the efficacy of any law needs to be evaluated and tested. So, the researcher has felt the necessity to study and critically evaluate the said Act through this research paper. The object is to initiate discussions and more research on the contemporary issue of maintenance and welfare of parents and senior citizens of India. The researcher here has studied and evaluated the said Act by reviewing both, its appreciable provisions and criticism.

Key words – maintenance, welfare, senior citizens, parents, said Act.

Introduction:

"*Matru Devo Bhava; Pitru Devo Bhava*".

This Sanskrit quote reflects the Indian ideology of worshiping the parents as gods and goddesses and to pay respect to them. This is the underlying principle of Indian tradition and culture. All religions in India expect the adult children to take care of their parents and senior citizens in the family. But if the children fail in this 'duty' then it gives rise to a corresponding 'right' to the parents and senior citizens to demand assistance for their livelihood from their children. This is nothing but the 'right to maintenance' of parents.

There are no universal definitions of 'maintenance,' 'welfare', 'parent' and 'senior citizen'. So, the researcher has interpreted these words as defined by 'The Maintenance and Welfare of Parents and Senior Citizens Act, 2007' (herein after referred to as 'the said Act'). Section 2(*b*) of the said Act defines the word 'maintenance' as; '*Maintenance includes provision for food, clothing, residence and medical attendance and treatment*'.[1] These are the basic necessities of livelihood. One can stay alive only if one has these bare essentials.

According to section 2(*k*) of the said Act '*Welfare means provision for food, health care, recreation centres and other amenities necessary for the senior citizens*.' [2] Besides the basic necessities of life, what one requires in old age are welfare facilities for their well-being.

According to section 2(*d*) of the said Act, a '*Parent means father or mother whether biological, adoptive or step father or step mother, as the case may be, whether or not the father or the mother is a senior citizen.'* [3] This interpretation of the word 'parent' is the widest one than in the earlier maintenance laws in India, and it includes not only biological but even adoptive parents and step-parents whether they are senior citizens or not.

[1] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 2(*b*), pg. 2
[2] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 2(*k*), pg. 2
[3] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 2(*d*), pg. 2

According to section 2(*h*) of the said Act, a '*senior citizen means any person being a citizen of India, who has attained the age of sixty years and above'*.[4] So the definition includes any citizen of India who is sixty years and above, staying in India or staying abroad as well.

Changing demography of Senior citizens in India:

The average life expectancy in India has more than doubled since independence till today.[5] In 1947, the average life expectancy in India was 31 years.[6] India's life expectancy in 2021 is 69 years.[7] Increase in life expectancy due to family planning, improved medical facilities, healthy food and health awareness etc. has increased the senior citizens population.[8] Population ageing is the most noteworthy result of the process known as demographic transition. Population aging is a worldwide phenomenon, and India is no exception.[9] As per 2011 Census in India, 8.56 % of the total population were aged 60 years and above.[10] According to UN by 2050 the population of 60+ in India would likely to go up-to 20% of the total population.[11] Presently, 1/8th of the Worlds Elderly Population lives in India.[12] This rings an alarming bell for the increasing issue of maintenance and welfare of senior citizens of India in the coming years.

Research problem:

With the changing lifestyle in the Indian families, the joint family system is withering away into a nuclear family system leaving behind many elderly people to take care of themselves. If they are unable to maintain themselves or their children are unable to look after their parents or senior citizens at home, then ultimately 'personal responsibility' will become a 'public responsibility' shouldered upon society at large.

[4] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 2(*h*), pg. 2
[5] Awate, Subhash. "Human Rights of Aging People." *Human Rights of Vulnerable Group.* (Ed.) Vijay Chitnis. Pune: Digital Publications, 1999. Pg. 193.
[6] https://timesofindia.indiatimes.com/sa-aiyar/swaminomics/our-greatest-achievement-longer-lives/articleshow/2291641.cms
[7] https://www.drishtiias.com/daily-updates/daily-news-analysis/india-s-life-expectancy-on-world-health-day-2021
[8] www.sjsa.maharashtra.gov.in/seniorcitizens
[9] Agewell Foundation Research Report. *Human Rights of Older People in India A Reality Check.* New Delhi: Agewell Foundation, 2014. pg.5.
[10] Ministry of Social Justice & Empowerment, *Annual Report*, 2015-16.
[11] Kataria, R.P. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Allahabad: Orient Publishing Company, 2012, First Edition. pg 3.
[12] *National Policy for Senior Citizens, 2011*. pg.2

The first question arises is whose responsibility is it to provide these basic provisions of livelihood to parents and senior citizens? The obvious answer is that one should be self-sufficient and one should save enough to take care of oneself. But the problem arises when parents and/or senior citizens are not self-sufficient or they do not have enough savings or resources to maintain themselves. So, the next question arises as to who should maintain such destitute and neglected parents and/or senior citizens who are unable to maintain themselves? The researcher tried to search for the answers to these questions in the various policies, schemes, laws relating to maintenance, welfare and social security in India.

Conceptually, all religions in India show unanimity in the area of maintenance of parents. All Family laws in India recognise the moral duty of children to maintain their parents especially in their old age. However, the scope and extent of such liability varies from community to community.[13]

Section 125(1)(d) of Criminal Procedure Code 1973, (hereinafter referred to as Cr. P.C.) is the first secular law in India for recognising the 'right to maintenance of parents' who are unable to maintain themselves. Section 125 Cr. P.C. provision is unique and un-parallel in Indian legislation. It shows a blending of the characteristics of criminal law, civil law and family law. Though it provided for 'right to maintenance of parents', but still it was silent about the 'right to maintenance of senior citizens' in general. So, the Maintenance and Welfare of Parents and Senior Citizens Act 2007 was enacted to provide 'maintenance to parents and senior citizens' as well. However, the efficacy of this law needs to be evaluated and tested. So, the researcher has felt the necessity to study and critically evaluate the said Act through this research paper.

Objectives:

The researcher's study is based on literature review and the interpretation of the said Act. The aim of this research paper is:

1. To study and evaluate 'The Maintenance and Welfare of Parents and Senior Citizens Act, 2007' by reviewing its appreciable provisions and criticism.
2. To initiate discussions and research on the contemporary issue of maintenance and welfare of parents and senior citizens of India.

[13] www.dadadadi.org/advocacy

3. To draw conclusion as to whether the said Act is really a ray of hope for parents and senior citizens of India.

Purpose of the said Act:

The Preamble states that this Act has been passed '*to provide for more effective provisions for the maintenance and welfare of parents and senior citizens guaranteed and recognised under the Constitution and for matters connected therewith or incidental thereto*.'[14] The objectives of the Act are appreciable and are summarised by the researcher as follows:

a) To provide for appropriate mechanism to be set-up to provide need-based maintenance to the parents and senior citizens from their children, grandchildren or relatives as the case may be,
b) To provide for adequate medical facilities to senior citizens,
c) To provide for a suitable mechanism for protection of life and property of senior citizens,
d) To provide for penal provision for abandonment of senior citizens,
e) To provide facilities for poor and destitute senior citizens,
f) To provide for setting up of old age homes in every district.

Uniqueness of the said Act:

Till 2007, there was no special or separate legislation exclusively for maintenance of senior citizens of India. The Government of India, through its Ministry of Social Justice and Empowerment, introduced the Bill titled as "The Maintenance and Welfare of Parents and Senior Citizens Bill 2007" (L.No.40) in Lok Sabha which was passed in the Parliament with a swiping majority.[15] This Act passed by the Central Government of India has to be implemented by individual State Governments and Union Territories in their own jurisdiction by due notification.[16]

Earlier laws of maintenance such as the Hindu Adoption and Maintenance Act 1956, other Family Laws governing Hindus, Muslims, Christians and Parsis, Section 125 of Cr.P.C.1973,

[14] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Preamble. Pg. 1.
[15] Dr. Chavate, Prafull, *Law for Senior Citizens and Elder People in India.* Pune: Hind Law Publications, 2014. Pg. 137.
[16] National Human Rights Commission, India. *Know Your Rights: Elderly People.* New Delhi: NHRC, 2011, pg.15.

the Himachal Pradesh Maintenance of Parents and Dependents Act 2001, provided for maintenance to PARENTS only. As a result, senior citizens who were not parents were not covered by the scope of earlier maintenance laws. But the said Act has overcome this problem; thereby recognising the right to maintenance of all SENIOR CITIZENS and PARENTS OF ALL AGES.

The Act has made several appreciable provisions like providing for separate Maintenance Tribunals, Maintenance Officers, Old Age Homes, medical care of senior citizens, protection of life and property of senior citizens, orientation of police and judiciary, penalty for abandonment of parents and senior citizens, penalty for any non-compliance of orders and many more which are discussed at length herein below.

Appreciable provisions of the said Act:

The Maintenance and Welfare of Parents and Senior Citizens Act 2007 **is** certainly a milestone in the history of laws of maintenance for parents and senior citizens. The researcher appreciates the good provisions of it which are summarised as follows –

1. *The Act applies to citizens of India staying abroad as well*.[17] This is indeed a welcome provision for senior citizens of India who stay in India or abroad.
2. The Act lays down a right to maintenance of parents and/or senior citizens who are unable to maintain themselves. Parents here include biological, adoptive, step mothers and step fathers whether senior citizens or not.[18] And senior citizens include irrespective of married or not; or having children or not.
3. '*Maintenance' includes provision for food, clothing, residence and medical attendance and treatment*.[19] These are the bare essentials for livelihood. However, as per section 4(2) and (3) of the Act, maintenance also extends to the 'needs' of the parent / senior citizen so that he may 'lead a normal life'. The 'needs of a person' is a relative term and changes from person to person. This means the Act takes into account the 'standard of living' and the requirements of the claimant parent or senior citizen, which is indeed an appreciable

[17] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 1(2). Pg.1.
[18] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 2(d). pg. 2.
[19] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 2(b). pg. 2.

provision. Thus, a wider interpretation is given to the word 'maintenance' beyond just bare essentials.

4. Parent of any age and/or senior citizen is entitled to claim maintenance from his children / relatives provided
    - he is unable to maintain himself from his own earnings or own property and
    - if his children / relatives have refused or neglected to maintain him.[20]
5. Such a parent or senior citizen can be entitled to a monthly maintenance allowance up-to Rs. 10,000/- from his children or relatives, as the case may be after filing a claim against them with the Maintenance Tribunal.[21]
6. The Act allows not only parents but also grandparents to claim maintenance from their grandchildren, which is a first of its kind provision in maintenance laws of India.
7. Childless senior citizen or an unmarried senior citizen who do not have children can claim maintenance from his legal heirs to his property, who are defined as his 'relative' by the Act.[22] Such a provision has been made for the first time in any Indian legislation.
8. Provision for interim maintenance has been made during the pendency of the proceedings.[23]
9. The Rule of *locus standi* has been relaxed under this Act for the benefit of the needy parents and senior citizens. Section 5 of the Act allows the claim application for maintenance to be filed by either the parent or senior citizen himself or if they are incapable then any person or organisation authorised by them. The Maintenance Tribunal is also allowed to take the cognisance *suo motu*.
10. The Act directs the State Government to set up one or more Maintenance Tribunals in every sub-division and an Appellate Tribunal in every district, to hear applications of maintenance and appeals respectively, and gives details about their constitution, procedure, rights and duties.[24]
11. The Maintenance Tribunals shall be presided over by an officer not below the rank of a Sub-Divisional Officer of a State and the Appellate Tribunal shall be presided over by an

[20] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 4(1). Pg. 2.
[21] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 9. Pg. 5.
[22] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 4(1). Pg. 2.
[23] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 5(2). Pg. 3.
[24] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 7,15. Pg. 5, 7.

officer not below the rank of a District Magistrate.[25] This shows that the Revenue and Administrative Officers have been made the Competent Authority under this Act instead of any Officials from the Judiciary. According to the researcher, this has been purposely done with an intention to provide a quick and simple legal remedy.

12. Tribunals on receiving applications are supposed to hold an inquiry and after being satisfied that children or relatives have neglected or refused to take care of applicant parent /senior citizen, have to pass an order of maintenance.[26] According to the researcher this procedure is very much simplified and assures quick justice to the applicant.
13. The Tribunals enjoy dual powers. For the purpose of conducting the proceedings it shall be deemed to be a Civil Court and also enjoys powers of a Criminal Court.[27] For securing the attendance of children or relatives, the Tribunals therefore can issue a warrant against them if required.
14. Speedy remedy is the objective of this Act, which lays down a time limit of 90 days for disposal of applications before Maintenance Tribunal and 1 month before the Appellate Tribunal.[28]
15. Since no stamp duty is required to be paid by the applicant, the objective of inexpensive remedy has been assured by this Act. Lawyers by default are not allowed to represent the parties in the Tribunals, which saves the expenses of the needy parents and senior citizens.
16. The State Government is under a duty to designate an Officer not below the rank of a District Social Welfare Officer to be appointed as a Maintenance Officer who shall represent a parent before the Tribunals under this Act.[29] Since the parents are not allowed to be represented by any lawyer before the Tribunals, the provision for appointment of Maintenance Officers is highly appreciated by the researcher.
17. Jurisdiction issue has been simplified by allowing parents or senior citizens to file applications in any district where they reside or where the children or relative resides or lastly resided.[30]

---

[25] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 7,15. Pg. 5, 7

[26] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 9. Pg. 5

[27] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 8. Pg. 5

[28] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 5(4); 16(6). Pg. 3, 8

[29] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 18. Pg. 8

[30] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 6(1). Pg. 4

18. Conciliation proceedings are also suggested if required for an amicable settlement between the parties.[31] The Maintenance Tribunal if required is empowered to recommend the matter to the Conciliation Officer.
19. This Act also lays down a duty on State Governments to establish Old Age Homes in every district for accommodating minimum 150 indigent senior citizens and to prescribe a scheme for the management of such homes.[32] For the purpose of this section, "indigent" has been explained as – '*any senior citizen who is not having sufficient means, as determined by the State Government, from time to time, to maintain himself*.' This type of a provision of establishing at least one old age home in each district, has been made for the first time through any Indian legislation.
20. This Act throws responsibility on State Government who is to ensure that Government hospitals and hospitals funded by the Government provide adequate beds for all senior citizens and such other provisions as required for ensuring medical care of senior citizens.[33] A gerontological perspective in taking medical care of senior citizens is thus tried to be achieved through this provision.
21. The State Governments are to be responsible for wide publicity of the provisions of this Act through public media like television, radio and print media at regular intervals.[34]
22. The State Governments are to ensure that the Government Officers, including police officers, members of judicial service are given periodic sensitization and awareness training on issues relating to the Act.[35]
23. The State Governments are to confer such powers and impose such duties on District Magistrate to ensure that the provisions of this Act are executed properly. The State Governments are also given a duty to prescribe a comprehensive action plan for providing 'protection of life and property' of senior citizens.[36]
24. The provision for 'protection of property' of senior citizens is ensured by giving an authority to the Maintenance Tribunal to declare a transfer of property by way of gift or

[31] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 6(6). Pg. 4
[32] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 19. Pg. 8
[33] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 20. Pg. 9.
[34] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 21. Pg. 9.
[35] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 21. Pg. 9.
[36] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 22. Pg. 9.

otherwise from a senior citizen to a transferee as void, if the transfer was made under the condition providing maintenance to the senior citizen and the transferee neglects to maintain such senior citizen.[37] According to the researcher, this provision is indeed a big leap taken by the legislature in protecting the transfer of property of a senior citizen made by way of coercion, undue influence, fraud or with any other malicious intention.

25. Any person who is having care or protection of any senior citizen intentionally abandons him, shall be liable for punishment of imprisonment up to 3 months and/or fine up to Rs. 5000.[38] Such provision gives a security for the 'protection of life' of senior citizens and has defined a new offence of '*abandoning a senior citizen intentionally*'.
26. Every offence under this Act is cognisable and bailable and shall be tried summarily by a Magistrate.[39] Punishment for non-compliance of orders includes both fines as well as imprisonment.
27. Every officer or staff appointed to exercise functions under this Act shall be deemed to be a *public servant* as per section 21 of the Indian Penal Code.[40]
28. A total immunity from prosecution has been granted to the government and public servants who are associated with the provisions of this Act, provided their actions are done '*in good faith*'.[41]
29. Civil Court does not have any jurisdiction with respect to any provision of this Act and no injunction orders can be passed by any Civil Court in respect of anything done under this Act.[42] This provision shows the extensive ambit of the Act, which keeps away judiciary from certain jurisdiction.
30. The Central Government is empowered to give directions to the State Governments and to make periodic review and monitor the progress of the implementation of this Act done by the State Governments.[43]

[37] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 23. Pg. 10.
[38] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 24. Pg. 10.
[39] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 25. Pg. 10.
[40] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 26. Pg. 11.
[41] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 28. Pg. 11.
[42] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 27. Pg. 11.
[43] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007.* Delhi: Professional Book Publishers, 2021. Section 30, 31. Pg. 11.

31. The State Governments are empowered to make rules for carrying out the purposes of this Act with respect to the procedures, management and execution of the various provisions of this Act.[44] Accordingly the State of Maharashtra has passed 'The Maharashtra Maintenance and Welfare of Parents and Senior Citizens Rules, 2010'. Accordingly, the said Act is to be read along with these Rules of 2010, for the purpose of State of Maharashtra.

Issues of concern about the said Act:

Howsoever good and appreciable the above said provisions are, they have some *grey areas*. This Act has been criticised by Experts with respect to various issues. The problem areas of this Act have been summarised below by the researcher:

1. There is no procedural uniformity amongst the States in implementation of the Act.
2. The procedural implementation of the Act is burdened on State Governments which causes a bureaucratic delay in implementation of such a good Act.
3. Since the presiding officers of Tribunals, Conciliation Officers and Maintenance Officers appointed under this Act are not from judiciary or any legal background, there is a possibility of miscarriage of justice happening, because of want of legal expertise.
4. The Act recognises the right of childless senior citizens to claim maintenance from their relatives who will inherit their property. This means, the relatives are obliged to provide maintenance to childless senior citizens. This looks like only a 'feel good factor' on paper but in reality, is difficult to be implemented.
5. But the Act is silent upon similar problems of the childless persons who are not yet senior citizens, because they are neither senior citizens nor parents.
6. The Act throws responsibility on State Governments to establish old age homes in every district. However, there are a number of provisions where the procedural implementation is required; such as prescribing a scheme for management of old age homes, laying down the standards and types of services to be provided by them etc. which are difficult to be followed up and will certainly cause a delay in implementation of such good provisions of the Act.
7. Further, the duty of giving publicity to this Act, sensitising and training the public servants, co-ordination between various Ministries and departments of Government etc. is burdened on the State Governments, which will ultimately cause bureaucratic delay.

[44] Professional's Bare Act. *The Maintenance and Welfare of Parents and Senior Citizens Act, 2007*. Delhi: Professional Book Publishers, 2021. Section 32. Pg. 11.

8. Section 29 of the Maintenance Act provides that if any difficulty arises in giving effect to the provisions of the Act, then within two years from the commencement of this Act, the State Government may make such provisions as appear to it to be necessary or expedient for removing the difficulty. The issue of concern is that this provision restricts the State Governments to overcome the difficulty after expiry of 2 years from the commencement of the Act.

Major findings and observations:

1. Gerontology, a new branch of knowledge requiring investigation into the study of aged population, is gaining importance.
2. Withering away of joint family system in India and increased life expectancy has surfaced a new problem of maintenance, social security and sustainability of senior citizens in India. So, the legal provisions related to these issues are of utmost importance.
3. The 'Maintenance and Welfare of Parents and Senior Citizens Act, 2007' is the first secular law in India providing maintenance and welfare for 'senior citizens' including 'childless and unmarried senior citizens.' Earlier laws provided for maintenance to 'parents' only.
4. The earlier legal provisions related to maintenance of parents were time consuming and expensive. This Act provides for a simple, inexpensive and speedy provision to claim maintenance for parents and senior citizens of India.
5. Besides the legal framework provided by the Government, there is a need for sensitizing the society in general about the special needs of the elderly.
6. Besides the Government, there is a wide scope for involvement of the voluntary or private sector in addressing the needs of the elderly.
7. Policy makers should realise that caring for the aged will no more be a sympathetic consideration but a hard-nosed strategy for they already comprise a sizeable population with a voice and a vote.[45]

[45] Agarwal, R. (2017, July-September Issue, p.6). Editorial – *Care for the Aged, so that we leave no one behind*. Local Government Quarterly. Mumbai: All India Institute of Local Self-Government. [Online]. Available: http://www.aiilsg.org/wp-content/uploads/2018/01/03-LGQ-July-Sep-2017.pdf (Retrieved Nov. 22, 2018)

8. The Act tries to minimise the pains and sufferings of destitute parents and senior citizens who are one of the vulnerable sections of the society. This Act is a progressive step towards ensuring better human rights status for parents and senior citizens.[46]

Suggestions for improvisation of the said Act:

1. 'Unmarried senior citizens' have not been expressly mentioned in the legislation, though they are indirectly covered by the phrase "childless senior citizens". This is a legislative gap according to the researcher. As a result, the provision under section 4(1)(ii) of the said Act for 'maintenance of childless senior citizen' is assumed to apply even to 'unmarried senior citizens who do not have children'. This ambiguity should be overcome by an amendment to that effect.
2. As per section 16 of the Act, 'senior citizen or parent who are aggrieved by the order' of a Tribunal may appeal to the Appellate Tribunal. This means the 'children or relatives who may have been aggrieved by the order' of the Tribunal have not been permitted to appeal. Only aggrieved parents and senior citizens have been given the right to appeal. Children are not allowed to appeal even if aggrieved. This indeed is an issue of ambiguity and a Legislative gap in the enactment which should be done away with by the Legislature. According to the researcher any aggrieved party should be given a fair chance of filing an appeal.
3. The term 'relative' as defined by this Act is linked with the 'property' of a senior citizen. What happens if a senior citizen does not have any property to be inherited by anyone? Is he not covered by the Act? This indeed is one more ambiguity in the Act which needs to be rectified.
4. A childless senior citizen can make a 'will' of his property. So, it is unclear how one can determine who would inherit the property after death. This means, the definition of the term 'relative' is left open for interpretation and there is a legislative gap to be looked into.
5. Section 20 of the Act provides that the State Government shall ensure that the government funded hospitals should provide beds for all senior citizens as far as possible. This phrase "as far as possible" leaves a gap for interpretation. This lacuna should be removed by an amendment to the Act.

[46] National Human Rights Commission, India. *Know Your Rights: Elderly People.* New Delhi: NHRC, 2011, pg.15.

6. Section 29 of the Maintenance Act provides that if any difficulty arises in giving effect to the provisions of the Act, then within two years from the commencement of this Act, the State Government may make such provisions as appear to it to be necessary or expedient for removing the difficulty. According to the researcher, the issue of concern is that this provision restricts the State Government from making any provision after expiry of 2 years from the commencement of the Act. This legislative gap in the section limiting the period up-to 2 years only, should either be amended or removed from the Act.

Conclusion and Take-Home Message from the researcher:

The Union Ministry of Social Justice and Empowerment needs to be appreciated for passing of the Maintenance and Welfare of Parents and Senior Citizens Act, 2007 as a stand-alone statute to promote the protection, maintenance, welfare and care of parents and senior citizens, in the country. This Act emphasises on the 'duty of maintenance' of children and relatives, rather than the 'right of maintenance' of parents and senior citizens. The Act is therefore a welcome step and was a must because of multiple reasons of concern such as - rise in life expectancy, rise in senior citizens population, rise in cost of living, rise in social insecurity of elderly, rise in nuclear families due to withering away of joint family system - to name a few. However, the Act needs to be effectively implemented by the State Governments. In spite of some criticism, this Act is surely a step forward in safeguarding and upholding the human rights of parents and senior citizens to live with dignity.

(SJIF) Impact Factor-8.575 ISSN-2278-9308

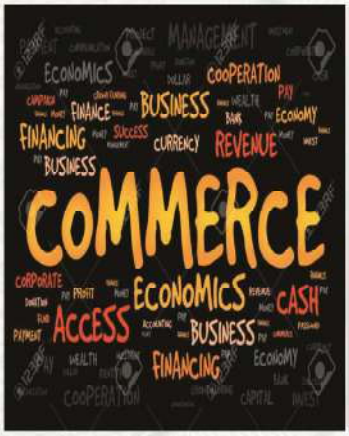
B.Aadhar

Peer-Reviewed & Refereed Indexed

Multidisciplinary International Research Journal

May -2022

ISSUE No- 349 (CCCXLIX)



Chief Editor
Prof. Virag S. Gawande
Director
Aadhar Social
Research & Development
Training Institute Amravati

Editor
Dr.Dinesh W.Nichit
Principal
Sant Gadge Maharaj
Art's Comm,Sci Collage,
Walgaon.Dist. Amravati.

Executive Editor
Dr.Sanjay J. Kothari
Head, Deptt. of Economics,
G.S.Tompe ArtsComm,Sci Collage
Chandur Bazar Dist. Amravati

The Journal is indexed in:

Scientific Journal Impact Factor (SJIF)

Cosmos Impact Factor (CIF)

International Impact Factor Services (IIFS)

Impact Factor – 8.575 **ISSN – 2278-9308**

B.Aadhar

Peer-Reviewed & Refereed Indexed

Multidisciplinary International Research Journal

May -2022

ISSUE No- (CCCXLIX) 349-A

Sciences, Social Sciences, Commerce, Education, Language & Law

Prof. Virag.S.Gawande
Chief Editor
Director
Aadhar Social Research &, Development Training Institute, Amravati.

Dr.Dinesh W.Nichit
Editor
Principal,
Sant Gadge Maharaj Art's Comm,Sci Collage, Walgaon.Dist. Amravati.

Dr.Sanjay J. Kothari
Head, Deptt. of Economics, G.S.Tompe Arts Comm,Sci Collage
Chandur Bazar Dist. Amravati

Aadhar International Publication

For Details Visit To : **www.aadharsocial.com**

© **All rights reserved with the authors & publisher**

Editorial Board

Chief Editor -
Prof.Virag S.Gawande,
Director,
Aadhar Social Research &,
Development Training Institute, Amravati. **[M.S.] INDIA**

Executive-Editors -

- **Dr.Dinesh W.Nichit** - Principal, Sant Gadge Maharaj Art's Comm,Sci Collage, **Walgaon.Dist. Amravati.**
- **Dr.Sanjay J. Kothari** - Head, Deptt. of Economics, G.S.Tompe Arts Comm,Sci Collage Chandur Bazar Dist. Amravati

Advisory Board -

- **Dr. Dhnyaneshwar Yawale** - Principal, Sarswati Kala Mahavidyalaya , Dahihanda, Tq-Akola.
- **Prof.Dr. Shabab Rizvi ,**Pillai's College of Arts, Comm. & Sci., New Panvel, Navi Mumbai
- **Dr. Udaysinh R. Manepatil** ,Smt. A. R. Patil Kanya Mahavidyalaya, Ichalkaranji,
- **Dr. Sou. Parvati Bhagwan Patil** , Principal, C.S. Shindure College Hupri, Dist Kolhapur
- **Dr.Usha Sinha** , Principal ,G.D.M. Mahavidyalay,Patna Magadh University.Bodhgay Bihar

Review Committee -

- **Dr. D. R. Panzade,** Assistant Pro. Yeshwantrao Chavan College, Sillod. Dist. Aurangabad (MS)
- **Dr.Suhas R.Patil** ,Principal ,Government College Of Education, Bhandara, Maharashtra
- Dr. **Kundan Ajabrao Alone** ,Ramkrushna Mahavidyalaya, Darapur Tal-Daryapur, Dist-Amravati.
- **DR. Gajanan P. Wader** Principal , Pillai College of Arts, Commerce & Science, Panvel
- **Dr. Bhagyashree A. Deshpande**, Professor Dr. P. D. College of Law, Amravati]
- **Dr. Sandip B. Kale,** Head, Dept. of Pol. Sci., Yeshwant Mahavidyalaya, Seloo, Dist. Wardha.
- **Dr. Hrushikesh Dalai** , Asstt. Professor K.K. Sanskrit University, Ramtek

Our Editors have reviewed paper with experts' committee, and they have checked the papers on their level best to stop furtive literature. Except it, the respective authors of the papers are responicible for originality of the papers and intensive thoughts in the papers.

- Executive Editor

Published by -
Prof.Virag Gawande
Aadhar Publication ,Aadhar Social Research & Development Training Institute, New Hanuman Nagar, In Front Of Pathyapustak Mandal, Behind V.M.V. College,Amravati
(M.S) India _Pin- 444604 **Email :** aadharpublication@gmail.com
Website : www.aadharsocial.com **Mobile :** 9595560278 /

INDEX

No.	Title of the Paper — Authors' Name	Page No.
1	Contribution Of Panchala To Indian Culture — **Dr. Meenu Mishra**	1
2	Various aspect of Human Development Index (HDI) — **Prof. Ganesh Shivaji Kiroche**	4
3	To Study Cultural Continuity through Analysing Architecture of Hindu Temples in India — **Gauri S. Anasane , Prof.Ar .Snehal Vidhale**	6
4	Approach To Sustainable Architecturein construction Practice — **Prajwal Sune , Prof.Sarang Holey**	14
5	Application Of Bionic Archtecture In Building Made Using Mordern Material — **Bhavesh G. Sabalkar , Ar. Sarang Holey**	18
6	Religion, Politics and society Dhamma and Din-i-ilahi: Religion and Social Reforms — **Dalia Varghese**	23
7	Indian Consciousness & Humanism in Jayant Mahapatra's Poetry — **Dr. G. O. Jondhalekar**	27
8	Discuss the Problem of Huck's Growth in Huckleberry Finn — **Dr. Laxman Gajanan Kolte**	30
9	The Role of E-Commerce in Emerging Markets — **Dr. Rajesh M. Deshmukh**	32
10	Contribitution Of Rashtrakutas Dynasty In Today's Architecture — **Komal Ahuja , Ar. Pratiksha Langote**	35
11	Where Are The Women In Ipr? An Endeavour In Bridging The Gender Gap In Intellectual Property Rights — **MS. Shilpa Ram Rathod**	39
12	Role of Banking Sector for financing in Entrepreneurship Development in India and the Problems Therewith — **Ms. Tejashwini K C**	43
13	Comparative Study Of Selected Physiological And Psychological Variables Among Vegetarian And Non-Vegetarian Runner. — **Dr. Omprakash Aneja**	46
14	Importantce Of Life Skill Education For Youth — **Dr. Tikshya Shyamkul**	49
15	जागतिकीकरण व ग्रामीण कादंबरी — **गणेश दिगंबर सावजी**	52
16	माध्यमिक शाळेतील नियमित पुरुष शिक्षक व पुरुष शिक्षण सेवक यांचे व्यावसायिक समाधान आणि समायोजन यांचा तुलनात्मक अभ्यास — **डॉ. महेंद्र म. श्यामकुल**	56

Where Are The Women In Ipr? An Endeavour In Bridging The Gender Gap In Intellectual Property Rights

MS. Shilpa Ram Rathod

Assistant Professor Dr. Ambedkar College, Deeksha Bhoomi Nagpur- 440010

Email id: shilparathod777@gmail.com ,Mb: 9112233045,9325230736

ABSTRACT:

In the recent arena, at every social, political, economic and technological front, women have contributed themselves on the equal footing just like a man. On some fronts women are placed a head of men, either when it is come to contribute for their families or when it comes to contributes for their works. The women have taken a giant step when they have secured the position from becoming driver of bus to the pilot on the cockpit. Today, women reach to the moon as well. Various laws have been framed for the protection and upliftment of women in the society. We have various constitutional provisions for women, penal laws are there for their protection and safety. Various schemes have been introduced by the governments for the upliftment of women which enables them to participate in all social, cultural, political and economic fields.But, still there are few areas they are always under represented. One of the grey areas is Intellectual Property right laws (IPR) where we find the huge gender gap ratio between men and women. In the contemporary era, with increase in these fields of science and technology the intellectual property laws has been of immense importance. In this paper the researcher seeks to analyze the position and contribution of women in all the intellectual property rights, and study the endeavor taken at the national and international level to fill the gender gap.

KEYWORDS: Intellectual Property Right (IPR), Woman, Gender, Technology, World Intellectual Property Organization

INTRODUCTION:

It is being increasingly realized that women play an important role in variety of the fields of science, creativity, technology and modernization. The women have taken a giant step by reaching to moon. In the contemporary era with increase in these fields of science and technology the intellectual property laws has been of immense importance. Intellectual property (IP) laws ensure the recognition for the artistic and creative contribution of the people by providing the exclusive right to the use and exploit peoples work. To simplify this is the reward given to the individuals for their creative work which they have done by using their own intellect. Different subject matter has specifically got the protection under different IP legislations namely Patent, Trademark, Copyrights, Designs, Geographical Indications, Traditional Knowledge etc.

James Watt invented steam engines, Alexander Graham Bell invented the telephone, the Wright Brothers invented airplane; whereas Thomas Edison got worldwide recognition forhismultiple inventions namely electric light bulb to the phonograph to the motion picture camera. It is worth to mention that he filed more than 1000 patents for his inventions. We all know these scientists who have made our lives better and easier. But if it is asked you to name a female inventor, most of us will take a lot of time to name even one. Some of us may even think that we don't have any female inventors; but that is completely untrue!

The place of women in different intellectual properties has been mentioned as under-

WOMEN AND PATENTS:

Like the popular male scientist here is the list of female inventors-

1) A Female inventor -Margaret E. Knight who has invented a well-known machine which folded and glued paper to create flat bottom paper bags. She was known as the female inventor of 19th century.Her invention was so popular that one man had stolenher idea and applied for getting patent for himself. When the Ms. Knight encountered this, she sued that man in the court for patent infringement. During the trial he argued that women cannot understand a mechanical complicity. Knight won her case by providing all the proofs and evidences that she is the real inventor of that a machine by providing all the design procedure of that machine an also earning herself to right to patent her machine.

2) Joyce Chena Chinese chefinvented stir fry pan for Chinese food consisting of flat bottom wok with handle.

3) Patricia Bath invented a distinguished Probe, which is useful in laser technology to treat cataracts.
4) Ann Makosinskias one of the younger inventors on this list, Makosinski created the "Hollow Flashlight," which uses a thermoelectric effect to convert body heat into electricity to power LED bulbs.
5) Dame Pratibha Gai invented the "atomic resolution environmental transmission electron microscope (ETEM)," This invention enables the scientist to visualize and analyze gas-catalyst reactions at an atomic scale, which helps in getting better understanding of how catalysts work. She has received awards such as the 2013 L'Oreal-UNESCO for Women in Science Awards Laureate for Europe, and the 2014 Fellow of the Royal Academy of Engineering among others.

If we refer the aforesaid instances wherein the female inventor has secured a place for their unique contribution in Patent filed of IP. Despite this fact, there is huge gender bias latently encountered in the world, specifically when we take a glance in modern patent filing. Statistically, it has cleared that there is substantial disparity existed in filing the patent applications between male and female applicants. Very rare applications have been filed in the name of Female as an applicant and Inventor.

"*This gap varies somewhat by jurisdiction; patent applications include a female inventor only about 4 percent of the time in German-speaking nations, only 10 percent of the time in the United States, and around 20 percent in a number of Spanish-speaking nations. In no case does the number of patent filings by women approach anything near population parity. Perhaps not surprisingly, studies of patent law practitioners also show the number of female attorneys and agents to be dramatically lower than that of male practitioners*".

From the aforesaid explanation it is clear that the female contribution as an applicant or inventor is rare in patents as compare to male.

WOMEN AND COPYRIGHTS:

The artistic skills, dramatic skills, musical skills are equally gifted by God to the individuals irrespective of any gender bias. But the history is evident that the work of artist, writer, photographer, choreographer and musician are mostly male dominated. On the other hand, when any female came up with any creative work outside their household chores were subject to strong criticism and any sort of reward or recognition was considered taboo. In some liberal society the creative work of women were circulated by hiding their identity under the nomenclature of pseudonymous work.

It is also worth to mentioned here that IP law is also not free to be followed such social prohibitions. This is clear from the work of Professor Shelly Wright who has noted as under-

"Copyright historically encompassed the "fine arts" such as sculpture, painting, literature and music – fields that were male dominated if not exclusively masculine, with "crafts" such as needlework, knitting, quilting and other "domestic" fiber arts until relatively recently excluded from the canon of copyrightable subject matter"

Similarly, Female creative and artistic work receives less attention, reward and recognition than the creative works of men. Female received less compensation when they collectively work with the male counterparts.

WOMEN AND TRADITIONAL KNOWLEDGE:

As per the World intellectual Property Organization there is no world accepted definition of Traditional Knowledge, in general terms-

"Traditional knowledge refers to the knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity".

For example, turmeric has been used as an antiseptic since the ages,Tulsi and neem has a medicinal value.

If we compare both men and women, men can exert physically by doing the job involves laborious work like mining, digging, stone cutting, cutting timbers, whereas females are mostly occupied with household chores and fodder. On this comparative note women possess more knowledge about natural and forest resources like herbs, plants, fruits, seeds, flora, dried roots etc. which are for the beneficial utility of the mankind. In most of the families the traditional way of curing any ailment by using homemade remedies popularly known in the name of 'Dadijikenuske'. Therefore, women should deserve the place in international IP Protection. Women should not be dependent on the male dominated paradigm for their recognition of knowledge they possess, so that

we could avoid the undue exploitation of their knowledge by the commercial exploiters in national and international market by keeping feminist values of equality and dignity.

WIPO: WOMEN AND INTELLECTUAL PROPERTY

World Intellectual Property Organization (WIPO) is endeavoring in promoting gender equality and women's empowerment. They have framed various policies for promoting the women both within the Organization and in the globe for the protection of intellectual property (IP). These haves been enumerated as under-

1) WIPO introduced a Policy on Gender Equality which aims atproviding a general framework for integrating a gender perspective while framing different policies and programs. This includes gender equality not only within its own workplace comprising of the staff members but also provides the program at different national and international level in protecting IP rightsin close cooperation with the Gender Focal Points. They have developed the following regulations

a) To promote gender equality within WIPO's workplace, with the paramount consideration in the recruitment and appointment of staff members being the need to secure the highest standards of efficiency, competence and integrity as per the Staff Regulations and Rules, the Organization strives to achieve gender balance in staffing at all levels by 2020.

b) All advisory bodies to the Director General 2 will include members of both genders.

c) An enabling work environment is essential to promoting gender equality in the workplace. Measures will be taken to foster an enabling environment, including the support of work-life balance initiatives, career development, and prevention of discrimination and harassment for men and women.

2) In order to achieve the gender equality, they have developed their program which is experimental based. The flaws encountered in one program can be built upon and rectified in another area of program. A key objective underlying these practicesis recording the knowledge and experience ensures what would be a good practice for mainstreaming gender perspectives.

3) "WIPO in order to mainstream the Gender perspectives, uses the gender analysis and gender-sensitive performance indicators. In order to work on this, note they have developed the strategic planning, biennial planning and annual work planning processes, as well as implementation and monitoring, performance assessment and evaluation mechanisms. Member States' input will be systematically sought in this process during discussions in the Program and Budget Committee and the Assemblies on the Program and Budgets and the Program Performance Reports".

WOMEN IPR PROGRAM BY GOVERNMENT OF INDIA

Government of India, Patent Facilitating Centre (PFC) of Technology Information has introduced various schemes like Women Scientist Scholarship Scheme (WOS-C) in the year 2014 under the agies of Knowledge Involvement in Research Advancement through Nurturing (KIRAN) by Department of Science and Technology through which the one-year training is being given to the women scientist who are having Scientific, medicinal, technical and other respected areas with the Intellectual Property Rights. Through these schemes woman got trained and it helps in developing pool to promote the creativity and innovation. In order to avail the benefit of these schemes there is an eligibility criterion for selection and training program.

CONCLUSION:

In order to conclude on the gender, dimension the aforesaid points make it clear that women have crucial role to contribute and participate in every fields. When it specifically comes to Intellectual Property, we can not forget their intellectual contribution in creativity, art, scientifical and technological areas. It is clear that women are the backbone to preserve and protect IP. Therefore, there is an untiring need to take the meticulous effort for motivating and facilitating the intellectual capabilities of women in various fields. It is a high time for the development partners, concerned authorities and Government to go beyond the gender issues present in the contemporary time and encourage and aid the women in all their intellectual contribution by providing the favorable environment of recognition and protection. This must involvethecommitment from the concerned authorities and government to direct specific research on Woman's IP-

1. To identify the woman IP specifically.
2. Documenting the IP by woman.
3. Dissemination of the Women IP to the entire globe.
4. Strengthening the woman knowledge in any specialized field.
5. To provide the platform for exchange of their knowledge.

Furthermore, the woman who has a traditional knowledge of herbs, shrubs, flora, seeds, dried roots, ribosomes etc.should get the recognition as traditional women practitioners so that they should get the fiscal recognition of their right over IP by withering away all the past and present practices which deprive them to practice their expertise.

Due to the scarcity of the data showing the contribution of women in others forms of Intellectual property other than the heads mentioned above namely Copyright and trademark. However, it is evident form the online database managed and maintained by the IP Registry office the quantum of applications filed in woman name are comparative less than those field in the name of Male applicant. More work is needed to ensure that both women and men can equally access and use the IP system and profit fully from their creative and innovative assets for economic, social, and cultural development.

REFERENCES:

1. Ann Bartow (2006)"Fair Use and the Fairer Sex: Gender, Feminism, and Copyright Law" (2006) Journal of Gender, Social Policy & the Law Volume 14 Issue 3 pp. 137-144
2. **Dan L. Burk (2018) Bridging the gender gap in intellectual property" WIPO magazine Nbr 2-2018** Available online at https://www.wipo.int/wipo_magazine/en/2018/02/article_0001.html (last visited on 15 May 2022)
3. Terra L. Gearhart-Sema (2015) Women's Work, Women's Knowing: Intellectual Property and the Recognition of Women's Traditional Knowledge" Yale Journal of Law and Feminism Vol. 21:372 Available online at https://openyls.law.yale.edu/bitstream/handle/20.500.13051/7020/16_21YaleJL_Feminism372_2009_2010_.pdf?sequence=2&isAllowed=y
4. Wikipedia Available online at https://en.wikipedia.org/wiki/Margaret_E._Knight
5. Wikipedia Available online at https://www.findagrave.com/memorial/124096525/joyce-chen
6. Wikipedia Available online https://www.iipta.com/women-role-ipr/
7. WIPO official website: https://www.wipo.int/tk/en/tk/
8. https://www.wipo.int/export/sites/www/women-and-ip/docs/en/wipo_policy_gender_equality_en.pdf

Journal of Magnetism and Magnetic Materials 551 (2022) 169162

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

journal homepage: www.elsevier.com/locate/jmmm

Influence of Bi^{3+} ions substitution on structural, magnetic, and electrical properties of lead hexaferrite

Y.D. Choudhari *, K.G. Rewatkar

Department of Physics, Dr. Ambedkar College, DeekshaBhoomi, Nagpur 10, India

ARTICLE INFO

Keywords:
Hexaferrite
XRD
SEM
VSM
Electrical conductivity

ABSTRACT

The Microwave induced sol-gel auto-combustion process was used to make lead hexaferrite, $PbFe_{12-x}Bi_xO_{19}$ ($x = 0.2$ to 0.8), with Bi^{3+} as a replacement. X-ray powder diffractometer (XRD), scanning electron microscopy (SEM), vibrating sample Magnetometry (VSM), Fourier transform infrared spectroscopy (FT-IR), and Impedance analysis was used to test the impact of added Bi^{3+} ions on the structure, morphology, magnetic, and dielectric properties of lead hexaferrite. Single-phase hexagonal ferrite nanoparticles with average crystalline sizes of 43 to 59 nm were achieved with the space group of P63/mmc. The magnetic analysis revealed that when the Bi^{3+} ion is supplemented in the Pb ferrite, the coercive and saturation magnetization of the material was amplified. The substance's dielectric constant, electric conductivity, and loss tangent were calculated for frequencies of 20 Hz to 10 MHz, indicating that it is appropriate for wide applications like permanent magnets, high-density magnetic recording media.

1. Introduction

Ferrite materials offer unique electrical and magnetic properties, with a substantial link between spin, charge, and degrees of freedom. All these materials reveal a link between magneto-electric features and have been universally referred to as potential materials for usage in various memory gadgets [1]. More than 80% of permanent magnetic materials used globally are made from this chemically inert and cost-effective substances. A study has spotted that hexaferrite, particularly Sr, Ca and Ba is capable of significant attenuation of electromagnetic waves due to its lower magnetic loss and wider frequency range. Hexaferrite materials with uniaxial magneto-plumbites structure have reasonably large saturation magnetization (Ms), tunable coercive force (Hc), high electrical resistivity(ρ), and low eddy current [2].

M-type hexaferrite has the most significant form of hexaferrite that has a lot of value in the electronics industry. Because of their high magnetization, magnetic anisotropy, and outstanding stability, those are preferable over other ferrites [3]. An M-type hexaferrite contains a set of Pb-M molecular units, units subdivided into layers of cubic S and hexagonal R, with the frame of SRS*R*, have further separated each of the molecular units, in the unit cell, there are $38O^{2-}$ ions, $2Pb^{2+}$ ions, while $24Fe^{3+}$ ions in 5 crystallographic sites (1 trigonal-bi-pyramidal site, 1 tetrahedral site, and 3 octahedral sites). The exchange of Fe^{3+} ions with alternative ions can modify the magnetic characteristic depending on the dopant's magnetic moment, concentration, and proclivity to occupy Fe^{3+} ion sites [4]. Numerous writers have replaced divalent ions for Fe^{3+} and Ba^{2+}, Sr^{2+}, ions, or a mixture of both to change the characteristics of M-type hexagonal ferrite.

Researchers led by Fatima Sehar used the powder metallurgy route to synthesize Bi^{3+} substituted barium ferrite. When the substitution concentration rises in the Ba ferrite, the coercivity and net magnetic moment increase from 1844 to 2466 Oe and 45.39 to 79.12 emu/g. The optical band gap of Ba ferrite also altered at room temperature [5]. T. Osotochan prepared Bi^{3+} ion substituted Ba^{2+} ferrite, coercivity, and net magnetic moment decreases. Bi^{3+} ions would take the place of Fe ions in either the 4e or $4f_n$ sites. By substituting non-magnetic ions at sites such as 4e, a spin-up layer, Ms should be reduced, while at sites such as $4f_n$, a spin-down layer, an increase in Ms should be observed [6]. Deepak Basandrai synthesized Bi^{3+} ion substituted Sr ferrite, the squareness ratio, coercivity, and net magnetic moment improve in the material when the Bi^{3+} concentration increase, making it the optimal material for magnetic applications [7].

An almost large number of hexaferrite research has concentrated on barium and strontium, with minimal research on lead hexaferrite. And there is no research on the effect of Bi^{3+} doping on the structural and magnetic properties of M-type lead hexaferrite. The temperature at

* Corresponding author.
E-mail address: yograjchoudhari476@gmail.com (Y.D. Choudhari).

https://doi.org/10.1016/j.jmmm.2022.169162
Received 5 November 2021; Received in revised form 31 January 2022; Accepted 9 February 2022
Available online 12 February 2022
0304-8853/© 2022 Elsevier B.V. All rights reserved.

which Pb–M hexaferrite forms is relatively low than the temperature at which Ba and Sr hexaferrite forms. As a result, this investigation has been carried out to determine the specific impact of Bi^{3+} on the magnetic, structural, and electrical properties of lead hexaferrite via microwave-induced sol-gel auto combustion processes.

2. Experimental procedure

The Microwave induced sol-gel auto combustion path is used to synthesize Bi^{3+} substituted M-type lead hexaferrite ($PbBi_xFe_{12-x}O_{19}$) (x = 0.2 to 0.8) powders, because of its many advantages, such as ease of use, low anneal or calcine temperature, energy efficiency, and fast reaction rate, produces ultrafine nanoparticle powder with a greater specimen size distribution excellent chemical uniformity, and a more prominent chance of acquiring a single domain structure, using AR grade chemicals like $Pb(NO_3)_3.6H_2O$ (99.99 percent purity), $Fe(NO_3)_3{\cdot}.9H_2O$ (99.99 percent purity), $Bi(NO_3)_3$ (99.99 percent purity), and urea (99.99 percent purity) [8]. Fig. 1 illustrates the synthesis step, in stoichiometric amounts, iron, and metal salts are dissolved in distilled water, then a mixture is made at ambient temperature with continuous stirring. The fuel was urea, which was dissolved into the solution at a 1:1 M ratio of metal ions to urea [9]. The solvent was then evaporated more on a magnetic heating plate at 70–90 °C till it formed a viscous gel. The gel was placed in a specially built microwave oven, this gel is then ignited, producing a homogeneous nanocrystalline powder, resulting in the creation of a large volume of gas. To obtain lead nano-hexaferrite, the resulting precursor powder was sintered at 800 °C for 4 hr. X-ray diffraction was utilized tons examine the structural features of the samples [10]. Fourier Transform Infrared Spectroscopy (FTIR) revealed the occurrence of chemical bonds in the optimum crystal phase. Vibrational sample Magnetometry is also used to investigate the magnetic properties and characteristics of the samples like Saturation magnetization, coercivity, remnant magnetization, and other essential parameters [11], [1,2,4–54]

3. Results and discussion

3.1. XRD data and analysis

Using a Bruker AXS, D8 Advance X-ray diffractometer (STIC Kochi) [λ = 1.5406 Å] for Cu-Kα, structural analysis, and phase identification has performed for the Pb-Bi ferrites', XRD pattern has illustrated in Fig. 2, this pattern consists of a predominantly pure hexagonal phase diffraction pattern (JCPDS No.: 017-0660) with spacing core group P63/mmc [12]. The sample has been found to contain a doped lead hexaferrite phase. Ferrite's peak appears in the same location, but with a different intensity. Reorganized in hexagonal form throughout doped ferrite with various concentrations of Bi^{3+} (x = 0.2, to 0.8). The angle range of scattering (2θ) was preferred from 15° to 65° [13].

The X-ray line's broadening aided in determining crystalline size D. the Debye Scherer's formula is used to calculate the D

$$D = \frac{K\lambda}{\beta \cos\theta} \tag{1.1}$$

In Equation (1.1),

θ is the Bragg angle.
β is the full width at half-maximum expressed in units of 2θ
λ is the X-ray wavelength,
K is the Scherer constant (k = 0.9).

The materials to be amorphous when not calcined, but crystallinity is

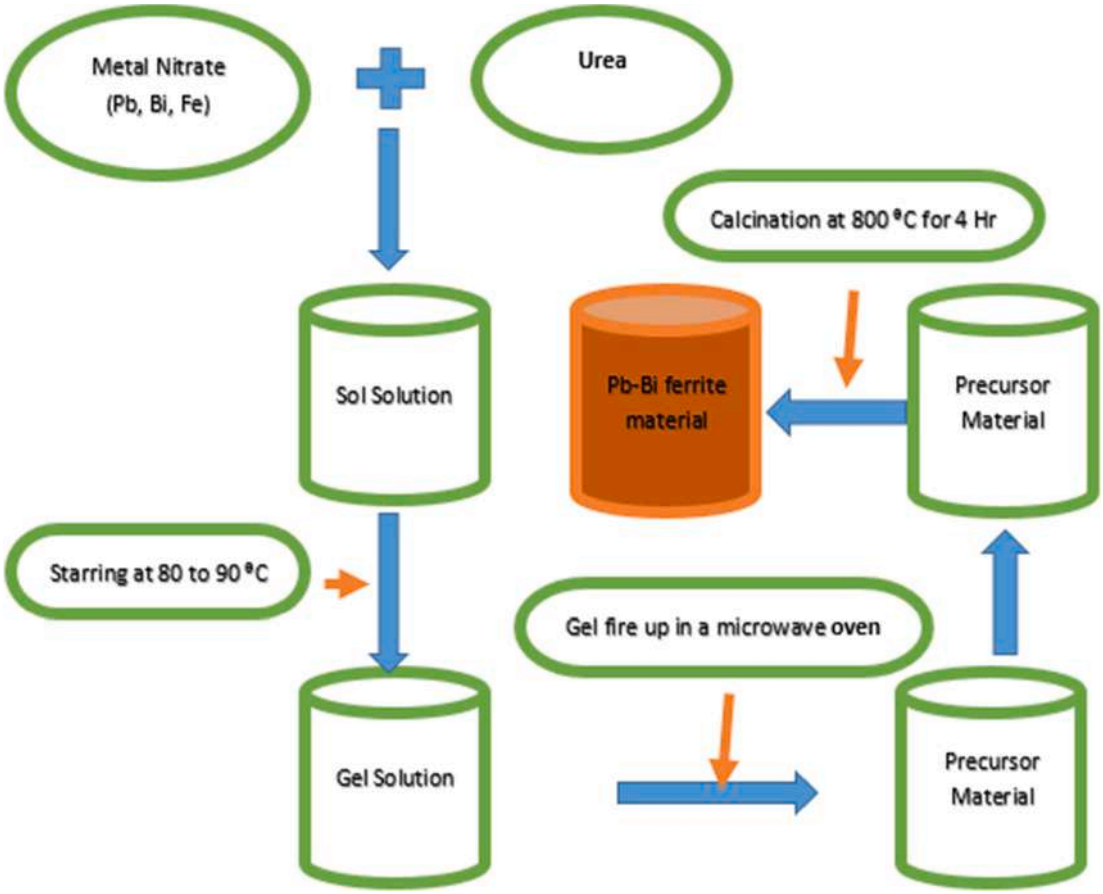


Fig. 1. Flowchart for synthesis of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

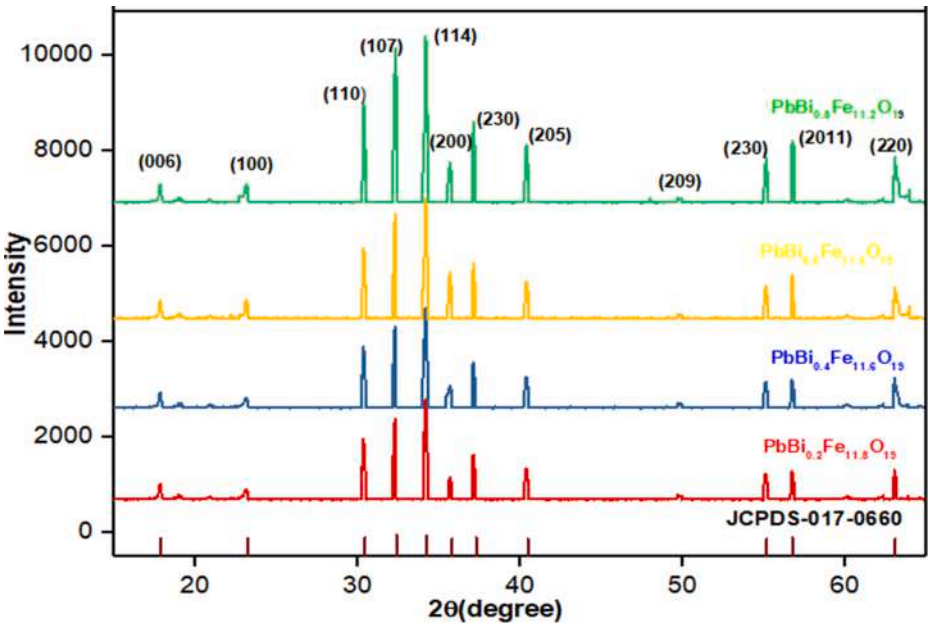


Fig. 2. XRD pattern of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

obtained after calcination, as can be seen in results. While supplementing various concentrations of bismuth in a lead hexaferrite sample, the pattern shows peak formation and broadening. The existence of reflection planes with hkl values of (110), (107), (114), (200), (203), (205), and (2011) for the Pb-Bi hexaferrite proves the formation of hexaferrite as a product and the disappearance of any impurities [14]. According to the Scherer Equation (1.1), the crystalline size for peak intensities is between 43 and 59 nm. The analysis indicates that as the dopant content Bi^{3+} rises, the crystallite size of the extracted ferrite increases. The value of the lattice parameters (a) of the samples decreased, but that of (c) heightened as shown in Fig. 3. This may be due to massive Bi^{3+} (1.03 Å) ions replacing Fe (0.64 Å) cations inside hexagonal block R [15]. It has been reported that hexaferrite with grain sizes less than 60 nm are suitable for a low signal-to-noise ratio and thus be useful for magnetic recording media.

The bulk density (B) was calculated using the Archimedes theorem, and X-ray (Xd) density is determined by the formula

$$X_d = \frac{ZM}{NV}$$

where M is the molecular weight, N is Avogadro's number, Z is the number of molecules for an M-type hexagonal crystal structure, and V is the unit cell's volume, all these outcomes are calculated with the help of various equations and are shown in Table 1 [16]. As the X-ray density has a direct relation with the molecular weight. With an increased amount of substituted Bi^{3+} ions, the value of X-ray density raises this due to the higher molecular weight of substituted samples than that of $PbFe_{12}O_{19}$. The porosity 'P' of all specimens was determined using the formula $P = 1 - \frac{B}{X_d}$ percent. As Bi^{3+} substitution is increased to its full value, the porosity data leads to an increase [17]. The majority of Bismuth atoms enter the hexagonal crystal structure if they are tinier than a value (1.06 Å), and their porosity is improved.

$$S = 6000/D^{*}x_d \tag{1.2}$$

The range of values for porosity and surface area (S) were between 45 and 47 % and 16–23 cm^2/g. The surface area is, as according to equation (1.2), closely correlated with the sample size of crystallites (D), and it was found to vary inversely in S and D: that is to say, the smaller

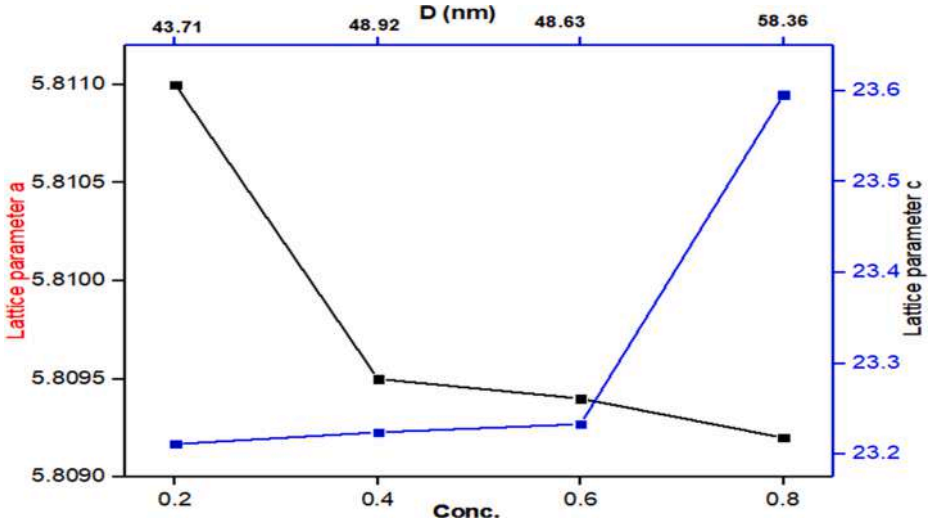


Fig. 3. Concentration vs Lattice parameter and Crystalline size (D) of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Table 1
Lattice parameter, x-ray density bulk density, and particle size of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Compound Name		$PbBi_{0.2}Fe_{11.8}O_{19}$	$PbBi_{0.4}Fe_{11.6}O_{19}$	$PbBi_{0.6}Fe_{11.4}O_{19}$	$PbBi_{0.8}Fe_{11.2}O_{19}$
Lattice parameter	a (Å)	5.8110	5.8095	5.8094	5.8092
	c (Å)	23.2112	23.2242	23.2331	23.5956
Crystalline Size (nm)		43.71	48.92	48.63	58.36
c/a		3.994	3.998	3.999	4.062
Molecular Weight (gm/mol)		1211.967	1242.594	1273.221	1303.848
Volume $(Å)^3$		678.060	678.75	679.771	689.566
X-ray density (gm/mol^3)		5.925	6.078	6.238	6.278
Bulk Density (gm/mol^3)		3.248	3.271	3.327	3.422
Porosity (%)		45.18	46.18	46.66	47.01
Surface area $(*10^7\ cm^2/g)$		23.17	20.18	19.78	16.37

the crystallite size, the larger the surface area and the more atoms at the surface, the higher [18].

3.2. FTIR analysis

Infrared scanning is also used to look into the composition of the hexagonal structure in Bi^{3+} mixed lead ferrite. Fig. 4, shows the typical FTIR spectrum of Pb-Bi Ferrite. The IR spectrum of all samples confirms the residence of absorption bands within the 400–600 cm^{-1} range, which is a typical feature of hexaferrite [19]. Fe-O bending vibration in the octahedral site is assigned to the lower frequency absorption band B_1, which lies between 400 and 490 cm^{-1}, and Fe-O stretching vibration in the tetrahedral site is assigned to the higher frequency absorption band B_2, which lies between 500 and 600 $cm^{-1.}$ The B_1 and B_2 bands are constantly increasing, indicating a high degree of crystallinity [14]. There are very few bands visible, implying that a single $PbFe_{12}O_{19}$ phase was obtained, which is consistent with XRD analysis. The impressive maximum absorbance at 545–565 cm^{-1} in pure hexaferrite is tied to the Pb-O stretching vibration band. Since it overlaps with the absorption band (B_1 and B_2) of hexaferrite, this point is less visible in substituted ferrites. Metal-Oxygen-Metal groups are linked with bands in the region of 900–1800 cm^{-1}, while the opaque band about 3400–3500 cm^{-1} is referring to hydroxyl groups [20]. Since the absorbance of the B_1 and B_2 bands are comparable, there is a uniform accumulation of metal ions in the two sites. For substituted hexaferrite, this trend shifts. When Bismuth is substituted, the absorbance of symmetric stretching in the tetrahedral site B_2 is higher than either bending vibrations in the octahedral site; however, for PBM ferrite, the absorbance of B_2 is greater than that of B_1. This efficacy can be explained by the mass of the particles: dense atoms pulsate quicker than smaller ones, so the Me-O bond can jiggle at a lower intensity, resulting in lower sprawling absorption for bismuth as compared to other hexaferrite [21]. However, based on its IR spectrum, it appears to prefer the tetrahedral spot. According to lattice parameters calculated from an XRD analysis, Bi^{3+} with its broad ionic radius tends to populate the octahedral region. As a result, increasing the bismuth, the nodding vibration of this site improved its dimension and thus its absorbance [22].

3.3. SEM analysis

Fig. 5, displays the surface morphology of the specimens taken using a scanning electron microscope (Jeol-6390LA), revealing a nanostructure of Bi^{3+} substituted $PbFe_{12}O_{19}$ sample with sharp grain boundaries. A close examination of SEM may reveal the hexagonal pattern of the grains, which is a feature of the hexagonal crystal formation of $PbFe_{12}O_{19}$ with Bi^{3+} substitutions at Fe sites [18]. The good grain sizes and analogous diversity in the targeted region indicate that the sample is made up of single-phase ferrite. Ferrite structural and magnetic qualities are largely determined by the form and compatibility of their grains. Ferrite platelet-like hexagonal texture has been scrutinized as a possible nominee to a variety of applications, including storage media and microwave absorption coating [23].

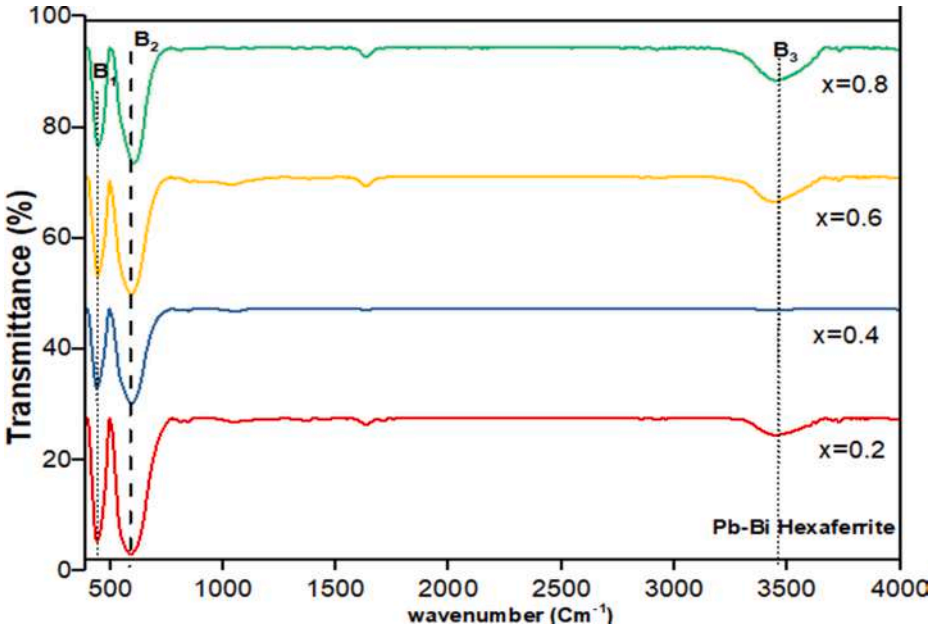


Fig. 4. FTIR image of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

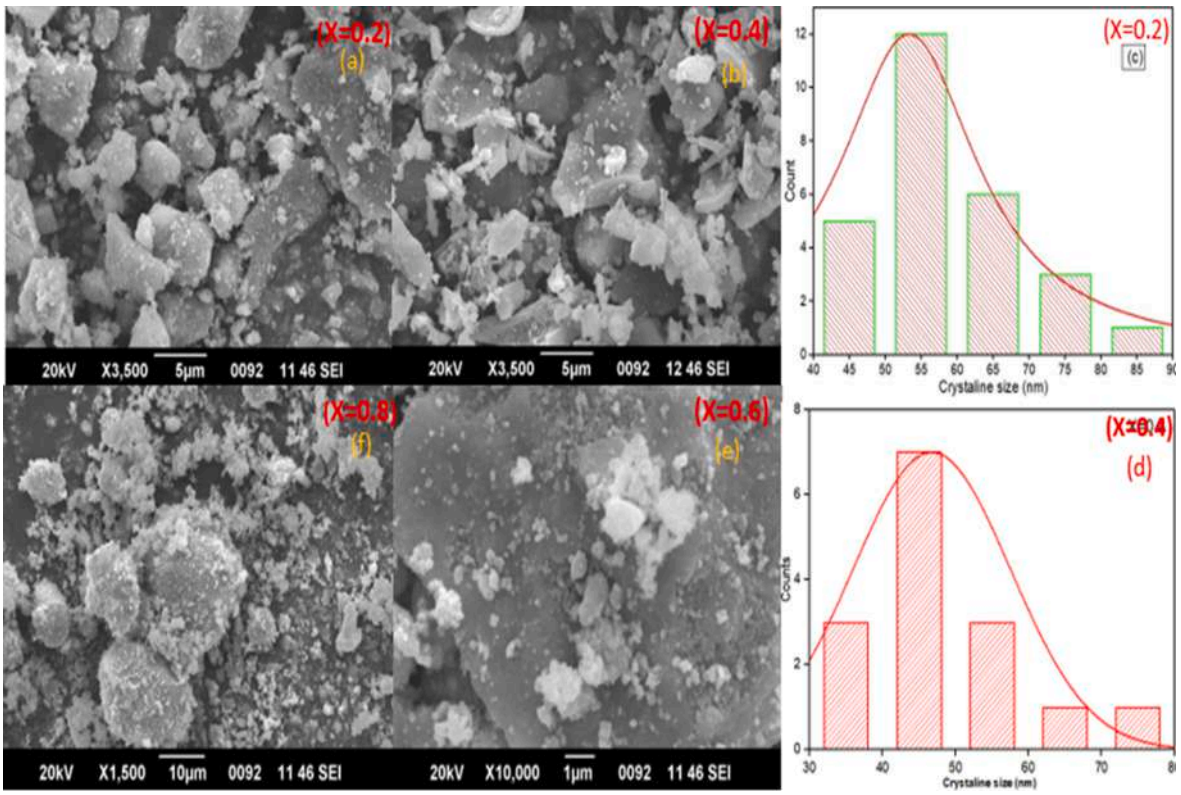


Fig. 5. SEM images of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) and (c), (d) histogram image of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2 and 0.4) hexaferrite.

3.4. HR-TEM analysis

HR-TEM microscopy (**Jeol/JEM 2100**) was used to quantitatively evaluate the particle shape and size of the synthesized nanocomposite. HR-TEM images and a selected area electron diffraction pattern (SAED) for Pb-Bi hexaferrite has shown in Fig. 6 (a) and (b). The $PbBi_xFe_{12-x}O_{19}$ nanoparticles have an approximated average particle size of 40–65 nm based on HR-TEM images [24]. The crystalline particle size obtained from the XRD analysis and SEM pictures has closely paired with the projected average particle size from the HR-TEM images. Furthermore, HR-TEM investigates validated the synthesized nanoparticles non - uniform shape and agglomerated nature [25]. The SAED pattern displayed in Fig. 6 (c) indicates that **$PbBi_xFe_{12-x}O_{19}$ (x = 0.2).** Hexaferrite is polycrystalline, as it has the required number of diffraction rings. The estimated structure from the SAED pattern was also a hexa structure, which was confirmed by the results. Thus, Pb-Bi Hexaferrite nanoparticles possess an M-type hexagonal structure [26].

3.5. VSM analysis

The magnetic theory states that the magnetic behavior in ferrites is caused by the spin-up and down orientation. The distribution of iron ions in the lattice sites is largely responsible for the magnetic properties of ferrites. Lead hexaferrite has a hexagonal structure with 64 ions in varied places in each unit cell [27]. These iron ions have unpaired electrons, and they are all in a unique group. There are five locations, three of which are on 12K, 2a, $4f_2$ (octahedral site), $4f_1$ (tetrahedral site), and 2b (bi-pyramidal site). The overall magnetic moment of lead hexaferrite has been determined by the summation of the magnetic moments of iron ions.

$$\mathbf{M} = \mathbf{M}(2\mathbf{a} + 2\mathbf{b} + 12\mathbf{k}) - \mathbf{M}(4\mathbf{f}_2 + 4\mathbf{f}_1)$$

The total magnetic moment per unit formula for un-doped lead hexaferrite has been calculated to be approximately 20 μ_B due to Fe^{3+} containing a magnetic moment of 5 μ_B. Thus, the unit cell's magnetic moment is 40 μ_B. The magnetic characteristics of $PbFe_{12}O_{19}$ can be altered by replacing other cations [9]. The magnetic characteristics of $PbBi_xFe_{12-x}O_{19}$ hexaferrite were determined and analyzed using a Vibrating Sample Magnetometer (Lakeshore 7410 model, CIF-IITG) with an applied field of 15 KOe. The VSM hysteresis loop reveals the relationship between magnetization (B) and applied field (H) at room temperature [28]. The loop's retrieved parameters include Coercivity (Hc), Saturation Magnetization (Ms), and Remanence (Mr).

The magnetization vs applied magnetic field (B vs H) curve for Pb-Bi hexaferrite samples has shown in Fig. 7. The hysteresis loops are ferromagnetic in Pb-Bi ferrites nanostructures. Increasing the Bi^{3+} content at the A-site and B-site of Fe substantially alters the magnetic properties of the produced nanoparticles. Table 2 displays the values of the Bohr magnetron and another magnetic paramters [29].Fig. 8.

3.5.1. Effect on coercivity, saturation magnetization and retentivity

The material crystallinity, size, topology, porosity, anisotropy constant (K), and other factors play a significant role in the coercivity of nano ferrite material. The coercivity of produced lead hexaferrite has been reported to enhance from 2756.3 to 4386.4 Oe as Bi^{3+} content increased. In this case, the observed rise in coercivity was caused by the crystalline size and anisotropy constant [18]. The relationship between coercivity and crystallite size has simply been explained by the critical diameter of crystallite size and domain structure. SEM and TEM examinations revealed that increasing the Bi^{3+} content boosted coercivity because of the homogeneous shape and minimal crystallite size that were formed. Coercivity was enhanced with smaller crystalline sizes because the single domain crystallite has high magnetic energy, but when it is not split into several domains, the magnetization energy boosts [30]. Table 2 shows the values of anisotropy constants, which were computed using the equation below.

$$\mathbf{K} = \frac{\mathbf{M_s}^{*}\mathbf{H_c}}{\mathbf{0.96}}$$

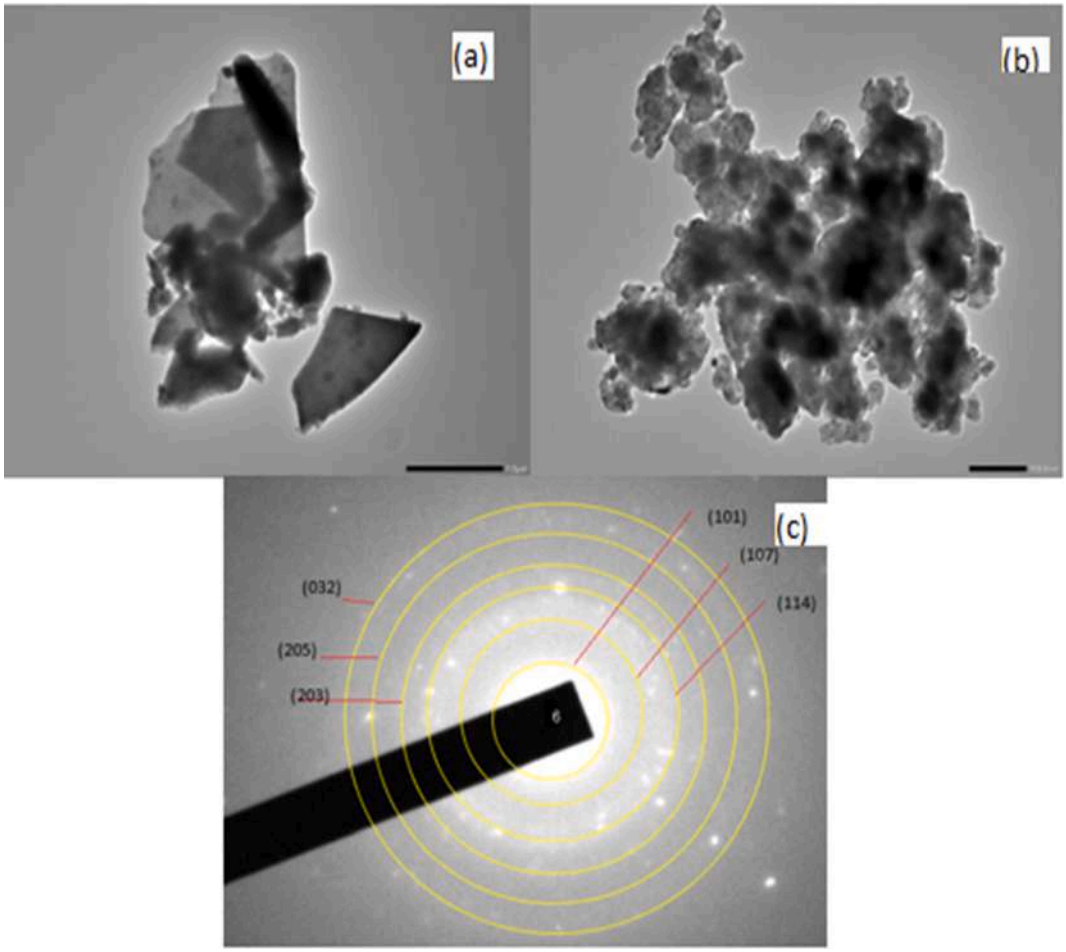


Fig. 6. (a) and (b) HR-TEM micrograph, (c) SAED micrograph of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2) hexaferrite.

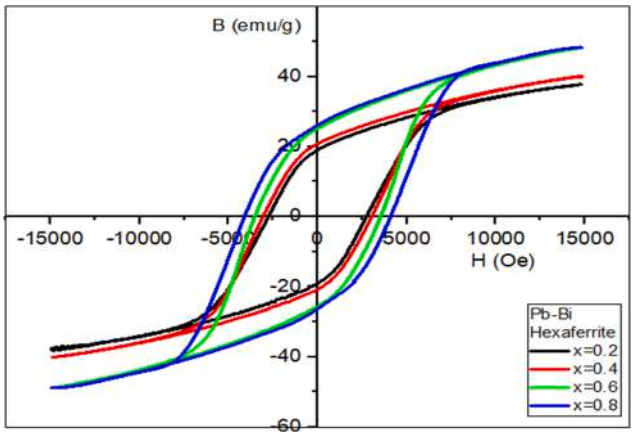


Fig. 7. VSM image of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

The total anisotropy constant for Bi^{3+} substituted lead hexaferrite is the sum of the anisotropy constants of Bi^{3+} and Pb^{2+}. As the concentration of Bi^{3+} increases, the total magnetic anisotropy constant gets

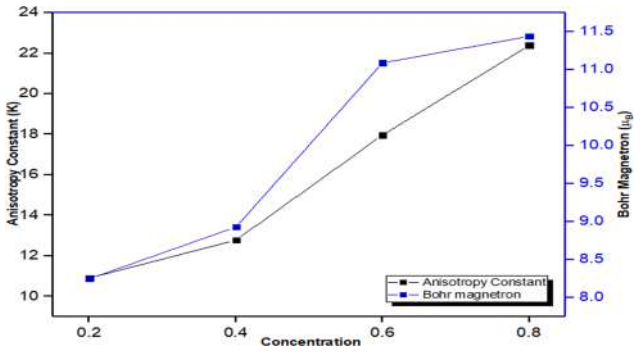


Fig. 8. Concentration vs Bohr magnetron and Anisotropy constant of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Table 2
Ms, Mr, Hc of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Sr no	Conc. x	Saturation Magnetization Ms (emu/g)	Retentivity Mr (emu/g)	Coercivity Hc (Oe)	Bohr magneton μ_B	SQR Ratio (Mr/Ms)	Anisotropy constant (K)*10^4 (HA^2/kg)
1	0.2	38.003	19.037	2756.3	8.25	0.5009	10.91
2	0.4	40.126	20.796	3058.4	8.93	0.5183	12.78
3	0.6	48.661	25.478	3544.6	11.09	0.5235	17.96
4	0.8	49.016	26.590	4386.4	11.44	0.5423	22.39

increases due to a large K value, which in turn increases coercivity. The remanent magnetization Mr, like coercivity, increased as Bi^{3+} content increased. Due to the single domain nature of the nano-sized crystallite [31]. Ms and Mr values in ferrite samples ramped up from 38.003 to 49.016 emu/g and 19.037 to 26.590 emu/g

For the Bohr's magneton, the following equation was used to determine

$$\mu_B = \frac{M_s * M_w}{5585}$$

M_w has the sample's molecular weight, When Bi^{3+} ions are processed, the values of the Bohr magnetron improve, which is related to the enhanced magnetization of the material. Cation distribution was used to explain the overall increase in μ_B. In this scenario, Bi^{3+} ions occupied octahedral sites where they replaced ferromagnetic Fe ions, resulting in an increase in magnetic dipole moments at octahedral sites [22]. However, the presence of a single magnetic domain is indicated by a squareness ratio (Mr/Ms) higher than 0.5, a ratio enhanced from 0.50 to 0.54 in the study as shown in Fig. 9. The crystalline structure has been identified as having a crucial role in influencing the material's magnetic activity. Pb hexaferrite has five non-equivalent sublattices with three octahedral (2a, 12 k, and 4f), one tetrahedral ($4f_1$), and one trigonal bipyramidal (2b) site in its crystal structure. Three of these sites (2a, 12 k, and 2b) have upward spin, while the other two ($4f_1$ and $4f_2$) have downward spin [18]. As a consequence of the upward spins, there is a net magnetic moment, as Bi^{3+} is replaced for any of the iron ions, the net saturation magnetization rises, and it continues to grow as the Bi^{3+} content is increased up to x = 0.8 [22]. Since the supplemented ions tend to favor to populate the octahedral 12k site, which has upswing spin, preceded by 2a and $4f_2$, this increase in Ms value could be due to accession in superexchange interactions between certain Fe A 3+-O-Fe B3+.

3.6. Impedance analysis

Impedance spectroscopy may be used to detect the electronic properties of micron-sized compounds, such as their electronics, dielectrics, and the effects of nearly any doping as a pattern and distribution. The impedance of submicron-sized particles extracted with grain boundaries has been further examined using spectrographic analysis [32]. In this approach, the dielectric characteristics were determined using a two-probe method over a frequency spectrum of 20 Hz to 1 MHz at room temperature around 303 K. Each sample mounting was calibrated to operate as an asymmetric platform to evaluate the dielectric constant and loss tangent of doped ferrite, as shown in Fig. 10 and Fig. 11. The substance to be investigated is sandwiched between two circular plates to produce a twin-plate capacitor-like module in this step [33]. In this arrangement, the load value was calculated using an LCR unit. Which is

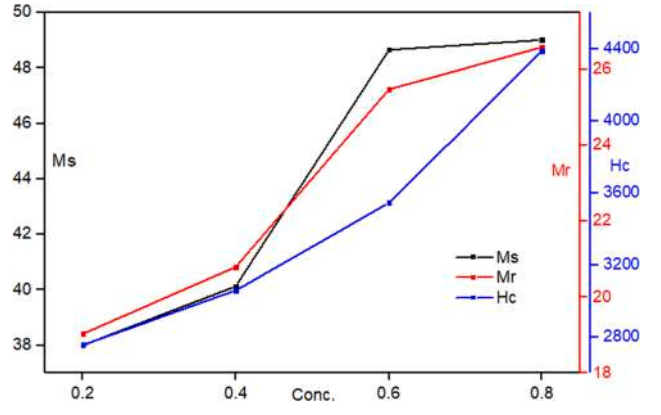


Fig. 9. Concentration vs Ms, Mr and Hc of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

stated mathematically as follows.

$$\tan\ \delta = \varepsilon'' / \varepsilon' \quad (2.1)$$

$$\varepsilon' = C^*d/A^*\varepsilon_0$$

The capacitance of the cell is denoted by C, the cross-sectional area of the pellet's flat surface is A, and its thickness is d of the pallet. The plots inside this figure are based on the theoretical hypothesis that any dielectric material introduced to an electric field experiences a latency as well as a reduction in dielectric reaction with the field [19]. ε′ denotes the amount of energy retained in the dielectric material as a result of the applied field, while ε″ denotes the decline to the ac electric field. As a result, the loss tangent (**tanδ**) is the proportion of the complex relative permittivity's imaginary to real parts shown in Eq. (2.1). The value of loss tangent and dielectric loss for all Bi^{3+} substituted lead hexaferrite ceramics reduces at high frequency [34]. There are fewer total dipoles that may aggregate and polarise themselves in the trajectory of the applied electric field with increasing frequency, so this leads to a plunge in a dielectric loss at high frequencies. The existence of many kinds of polarization, including interfacial, dipolar, atomic, ionic, and electronic, leads to larger dielectric values at lower frequencies [35]. At the increased frequency range, the above polarizations make less influence, which means the value of dielectric goes down. The high dielectric value at low frequencies (less than 100 KHz) can be explained by Maxwell-Wagner polarization, also known as interfacial polarization. The high value of the dielectric is due to heterogeneous conduction in the grain and grain boundary, as well as grain separation by more insulating intergrain barriers [36]. The loss tangent for lead ferrite is almost zero, indicating that it is a non-dielectric absorbing component. In comparing the results to pure Pb ferrite, the loss tangent of Bi^{3+} doped lead ferrite reduces. This validates reports of enhanced dielectric properties based on the concentration of a dopant [23].

With the insertion of dopants, the loss tangent of bismuth drugged lead ferrite strengthened dielectric properties. By hopping through the grain boundary, the electrons enter the grain boundary [33]. If somehow the resistance of the grain boundary seems to be intense, the electrons stay heaped up there, resulting in polarization. A charge carrier must travel in the path of the imposed ac field for a set amount of period. The carrier must match their orientation to the applied ac field more consistently as the frequency of the Pb-Bi hexaferrite material increases. As a result, their chances of reaching the grain boundary are decreased, resulting in declining polarization [37]. The doped lead hexaferrite structure uniformity is also verified by the low dielectric loss tangent value. With the addition of a dopant, the electrical conductivity appears almost consistent. Its linearity proves that polarized form conduction exists [38].

In the range of temperatures 323–650 K, electrical conductance was calculated as a function of temperature. Fig. 12 shows a plot of ln of σ as a function of 1000/T. As the temperature rises, the dc electrical resistivity rises as well. This is based on the possibility that as the heat increases, the kinetic energy of the electrons reduces [10]. The movement of electron skipping from one octahedral site over the next, fall's drift mobility reduces, and thus resistivity rises. The porous structure, grain size, and cation distribution on octahedral all play a significant role in ferrites' electrical resistivity. Increased electrical resistivity is caused by increased porosity and smaller particle size [39]. The electrical resistivity is heavily influenced by the Fe^{2+} ion concentration on the octahedral site. The charge carriers available for conduction would increase as the concentration increased, and the resistivity would decrease. The graph also shows that as the concentration of Bi rises, the resistivity gradually increases as well. The difference in Fe^{2+} concentration on the octahedral 12k site is the reason for this [27].

The dielectric constant of Pb ferrite varies with temperature at the constant frequency of 100 Hz, as shown in Fig. 13. This constant was spotted to be temperature independent up to 300 K, then grows after

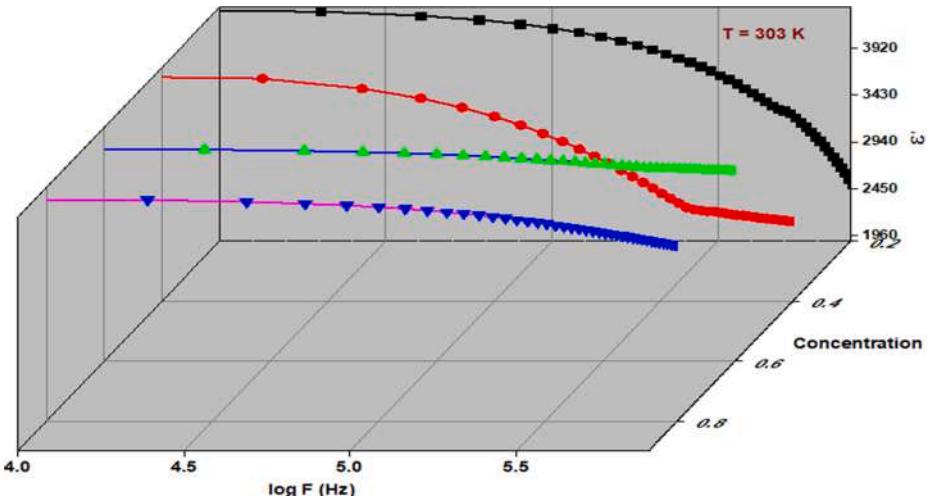


Fig. 10. Frequency Vs Dielectric loss of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

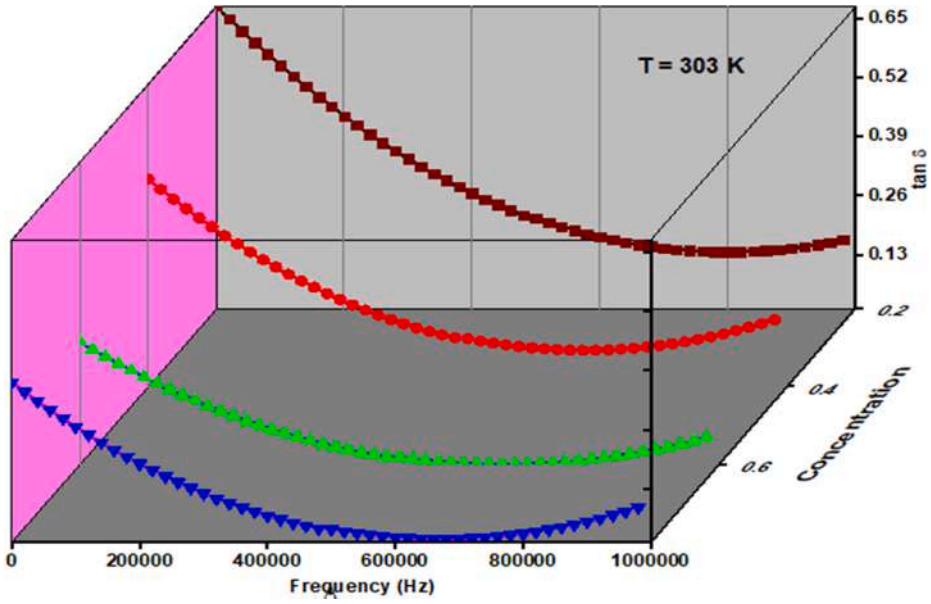


Fig. 11. Frequency Vs Tangential loss of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

that [40]. As can be observed, the dielectric constant increases gradually as the temperature increases and reaches a maximum at 602 K for the composition x = 0.2, 549 K for the composition x = 0.4, 496 K for the composition x = 0.6, and 448 K for the composition x = 0.8. The dielectric constant peak values for lead hexaferrites declined from >10112 at x = 0.2 to >2751 at x = 0.8. Lead hexaferrite compounds have a wide peak, which has considered a diffusive phase transition, and a strong frequency-dependent dielectric constant [41]. On an atomic basis, lead hexaferrite composition has thought to be chemically disordered, meaning that various metal ions are dispersed equally or even randomly across comparable lattice positions [42]. This gives rise to randomly directed polarization, even in the macroscopical phase, these local dipoles and fields exist. Koop's model can be used to describe the polarization of composites. Koop demonstrated the dielectric dispersion by thinking of the ferrite compressed as a multilayer capacitor with specific features [43]. Respectively two identical grains, the grains serve as an insulating medium. Many researchers have looked at how the dielectric constant in ferrites changes with temperature. The conduction mechanisms are based on electron hopping among Fe^{2+} and Fe^{3+} ions, as well as a hole hopping in Bi^{3+} and Pb^{2+} on the octahedral sites in the present ferrite. The electron jumping is triggered by heat. Target deflections in the direction of the externally applied field result from electron hopping [44]. Dielectric polarization in ferrite nanoparticles is an example of this. As the temperature rises, the dielectric polarization and dielectric constant rise with it. Ferrites have an intrinsic ionic polarization due to their existence as ionic solids, in addition to the polarization caused by charge carrier hoping [45]. The dielectric constant started to decline off at a certain higher temperature (T_C) due to non - uniform inclination of dipoles, indicating a phase change through ferromagnetic to the paramagnetic condition. As shown in Fig. 14, T_C also showed a downward tendency with rising Bi^{3+} substrate, which is nearly identical to the other research. In terms of the temperature coefficient of dielectric constant, the present Bi substituted lead hexaferrite material (x = 0.2 to 0.8) displays good thermal stability. Each compound's dielectric properties have been highly influenced by the structural and morphological aspects of its crystalline system [33]. The order-disorder effects, which are caused by reasons like particle size, surface morphology, and lattice defects, are thought to be the most critical aspects. This combination of parameters linked with the results describes the behavior of the Bi^{3+} substituted lead hexaferrite sample

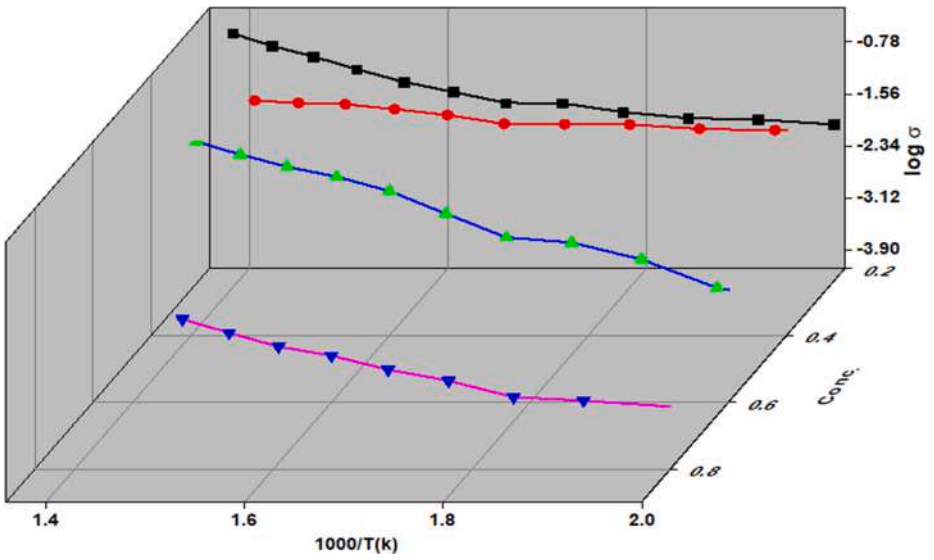


Fig. 12. Conductance vs Temperature of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

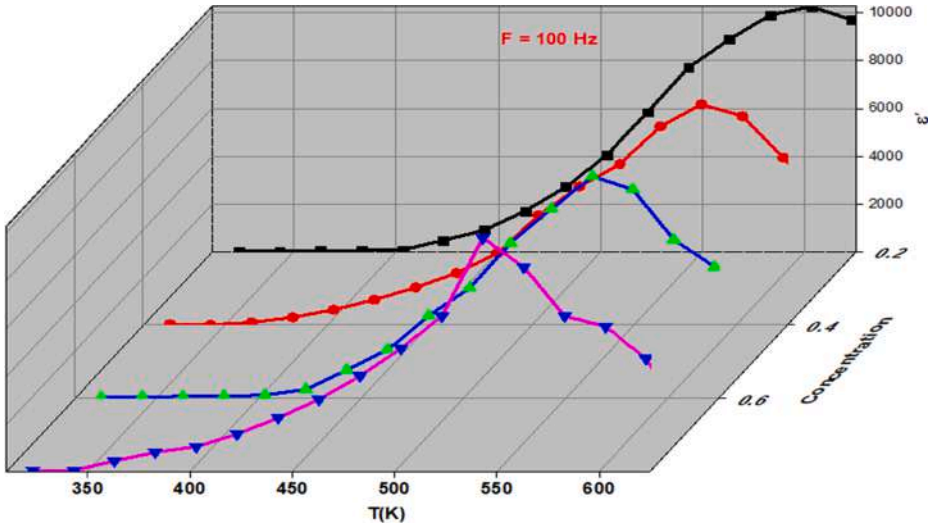


Fig. 13. Dielectric constant vs Temperature of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

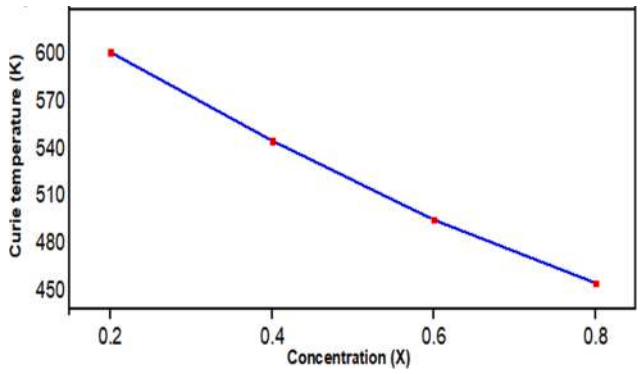


Fig. 14. Curie Temperature Vs Concentration of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

with x = 0.2 to 0.8. The minimal dielectric constant at higher temperatures and frequencies in this investigation implies that the materials are thermally stable at specific frequencies [46].

Using the impedance spectroscopy technique, the role of the grain boundary and grain of ferrites in the electrical resistance process was investigated. The real part of the impedance (Z′) of Bi^{3+} substituted lead hexaferrite nanoparticles is shown in Fig. 15. At lower frequencies, the scattering of the real part with frequency is minimal, whereas it increases with frequency [38]. It could be related to the polarization effect in the samples. This refers to the normal negative temperature coefficient of resistance behavior of ceramics, which is commonly seen in semiconductors [47]. All of the curves intersect at a very minimal value in the high-frequency region, and Z′ appears to be frequency independent. It denotes the possibility of a space charge release [48]. Fig. 16 shows the imaginary part (-Z″) varies with the frequency of lead hexaferrite nanoparticles. The effect of grain boundary has shown as a high-intensity relaxation peak in the lower frequency region [49].

The grains' influence is visible at high frequencies, with a low relaxation peak. Modulus peaks shift to the higher frequency side, indicating a link between the motions of mobile charge carriers [50]. The asymmetry in peak broadening means that relaxation times with different time constants are scattered apart, indicating that the relaxation is not of the Debye type. Low-frequency peaks indicate that ions can go to large regions, but high-frequency peaks indicate that ions have

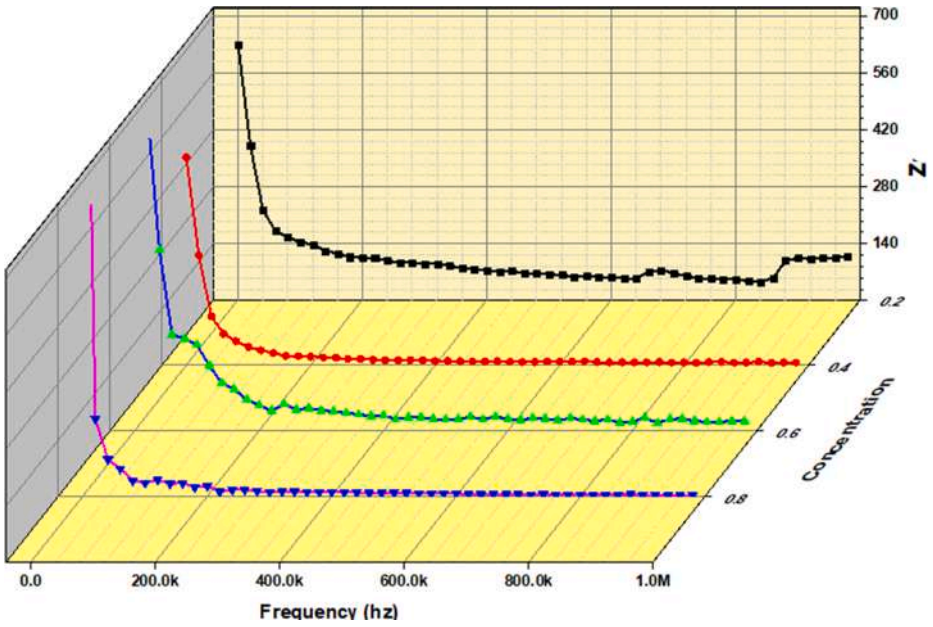


Fig. 15. Variation of real part vs frequency of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

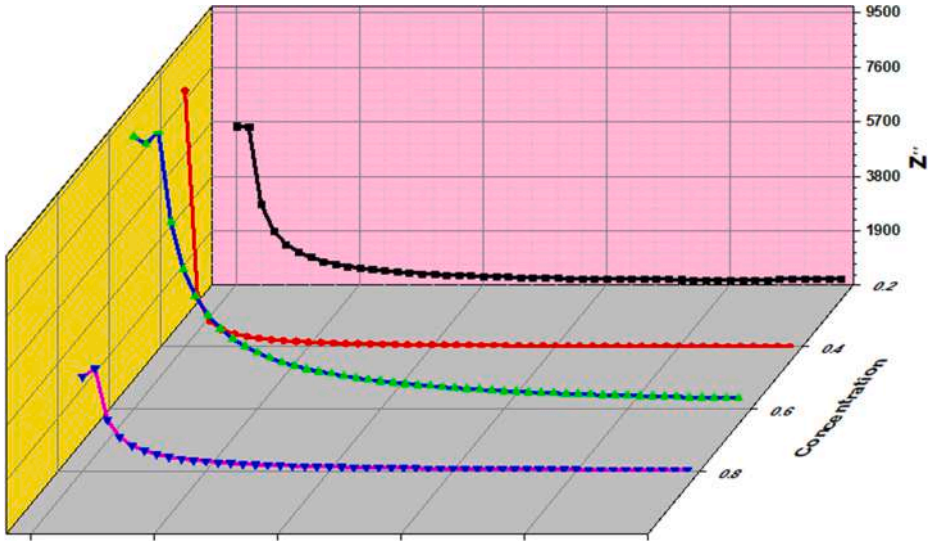


Fig. 16. Variation of imaginary part vs of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

confined within their potential well [51]. The character of modulus spectrums confirms the existence of a hopping process in the electrical conduction of materials.

When Bi^{3+} is substituted in nanocrystalline lead hexaferrite, the peaks have shifted to the lower frequency side [52]. The relaxation processes correspond to the grain boundary, and the Cole-Cole (-Z″ vs. Z′) plot has been used to further study grains. Fig. 17 shows the Cole-Cole plot of Bi^{3+} substituted lead hexaferrite. In the Cole-Cole plot, the impedance measurements at room temperature do not adopt the shape of a half circle, but rather display a straight line with a large slope, indicating insulating behaviour [53].

The presence of such loops suggests that the grain effect has played a significant role in the materials' conduction mechanism [53]. The slope of the lines reduces as the sample frequency increases, and they bend towards the real axis. The conductivity of the sample appears to be increasing in this graph [54]. With increasing frequency, the peak maxima of the plots fall and shift towards low values.

4. Conclusion

$PbFe_{12-x}Bi_xO_{19}$ (x = 0.2 to 0.8) nanoparticles were successfully produced using the microwave-assisted sol-gel auto combustion process. The X-ray investigation of materials with the space group P63/mmc revealed a single crystalline phase with no impurity. The absorption bands of hexaferrite are visible in FTIR spectra between 400 and 600 cm^{-1}. Because of the size and magnetic characteristics, the Pb-Bi hexaferrite nanoparticles clump together in the FE-SEM and HR-TEM studies; doping also altered the morphologies and borders of the grains. Magnetic characteristics (Ms and Mr) improved with Bi^{3+} concentration because Bi^{3+} ions occupy tetrahedral sites. The produced samples were found to have a high value of coercivity (Hc), indicating that they are suitable for recording media. The dielectric properties (ε′ and tan δ) were observed to reduce as the applied field frequency varies, whereas the conductivity improved.

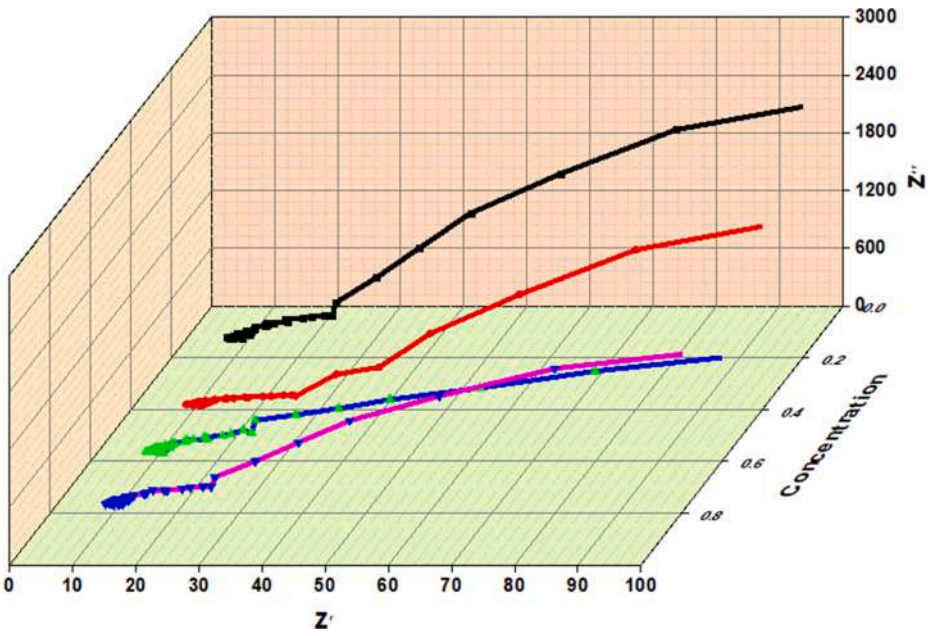


Fig. 17. Variation of real vs imaginary part of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors would like to thank the Sophisticated Test and Instrumentation Centre (STIC), Cochin University, Kerala, India, for the XRD and FE-SEM, as well as IIT Guwahati for the VSM instrumentation characterization.

References

[1] S. Güner, I.A. Auwal, A. Baykal, H. Sözeri, Synthesis, characterization and magneto optical properties of BaBixLaxYxFe12-3xO19 (0.0≤x≤0.33) hexaferrites, J. Magn. Magn. Mater. 416 (2016) 261–268, https://doi.org/10.1016/j.jmmm.2016.04.091.

[2] M. Lal, M. Shandilya, R. Rai, A. Ranjan, S. Sharma, M.A. Valente, Study of structural, electrical and magnetic properties of 1–x(Ba0.96Ca0.04TiO3)−x (BiFeO3) ceramics composites, J. Mater. Sci.: Mater. Electron. 29 (16) (2018) 13984–14002, https://doi.org/10.1007/s10854-018-9531-0.

[3] S. Sharma, M. Shandilya, R. Rai, Effect of Tb, Ti co-doping on the electrical and magnetic properties of (Bi, La)FeO3 multiferroic ceramics, J. Mater. Sci.: Mater. Electron. 26 (12) (2015) 9484–9494, https://doi.org/10.1007/s10854-015-3450-0.

[4] I.A. Auwal, A. Baykal, H. Güngüneş, S.E. Shirsath, Structural investigation and hyperfine interactions of BaBixLaxFe12−2xO19 (0.0≤x≤0.5) hexaferrites, Ceram. Int. 42 (2) (2016) 3380–3387, https://doi.org/10.1016/j.ceramint.2015.10.132.

[5] F. Sehar, S. Anjum, Z. Mustafa, S. Atiq, Co-existence of Ferroelectric and Ferromagnetic Properties of Bi+3 Substituted M-type Barium Hexaferrites, J. Supercond. Nov. Magn. 33 (7) (2020) 2073–2086, https://doi.org/10.1007/s10948-020-05452-y.

[6] I.J.S. Tech, T. Osotchan, S. Thongmee, On the Coercivity of the Bi-Doped BaFe t z- * Bi *, O t q 4 (1999) 54–58.

[7] D. Basandrai, Magnetic properties of bismuth substituted strontium ferrite nanoparticles, Eur. J. Mol. Clin. Med. 7 (2020) 3432–3437.

[8] A.S. Kakde, B.A. Shingade, N.S. Meshram, K.G. Rewatkar, Structural and magnetic properties of sn-zr substituted calcium nano-hexaferrite 1 (2014) 60–63.

[9] N.N. Sarkar, D.J. Roy, S.M. Butte, W.S. Barde, K.G. Rewatkar, Synthesis and Magnetic studies of Co-Sn doped Nanoscale Calcium Hexaferrites, 25 (2020) 57–67.

[10] D.M. Borikar, M.A. Borikar, A.S. Kakde, K.G. Rewatkar, Nano copper spinel ferrite : Synthesis & characterization by sol-gel auto combustion technique, 5 (n.d.) 7–10.

[11] M.A. Borikar, D.M. Borikar, N.S. Meshram, K.G. Rewatkar, Characterization of nanostructured spinel NiCrxFe2-xO4obtained by sol gel auto combustion method, J. Phys. Conf. Ser. 1913 (1) (2021) 012079, https://doi.org/10.1088/1742-6596/1913/1/012079.

[12] D.A. Mahajan, S.R. Choubey, B.T. Borkar, L.P. Damodare, A.B. Borkar, G.C. Vandile, X-ray Diffraction Studies of Synthesized M-type Compound, 4 (2019) 25–30.

[13] M.R. Sahoo, S. Kuila, K. Sweta, A. Barik, P.N. Vishwakarma, Effect of bismuth substitution in strontium hexaferrite, AIP Conf. Proc. 1953 (2018), https://doi.org/10.1063/1.5032572.

[14] Z. Mosleh, P. Kameli, A. Poorbaferani, M. Ranjbar, H. Salamati, Structural, magnetic and microwave absorption properties of Ce-doped barium hexaferrite, J. Magn. Magn. Mater. 397 (2016) 101–107, https://doi.org/10.1016/j.jmmm.2015.08.078.

[15] V.G. Kostishyn, L.V. Panina, A.V. Timofeev, L.V. Kozhitov, A.N. Kovalev, A. K. Zyuzin, Dual ferroic properties of hexagonal ferrite ceramics BaFe12O19 and SrFe12O19, J. Magn. Magn. Mater. 400 (2016) 327–332, https://doi.org/10.1016/j.jmmm.2015.09.011.

[16] S.K. Gore, R.S. Mane, M.u. Naushad, S.S. Jadhav, M.K. Zate, Z.A. Alothman, B.K. N. Hui, Influence of Bi3+-doping on the magnetic and Mössbauer properties of spinel cobalt ferrite, Dalt. Trans. 44 (14) (2015) 6384–6390.

[17] M.N. Ashiq, M. Javed Iqbal, I. Hussain Gul, Effect of Al-Cr doping on the structural, magnetic and dielectric properties of strontium hexaferrite nanomaterials, J. Magn. Magn. Mater. 323 (3-4) (2011) 259–263, https://doi.org/10.1016/j.jmmm.2010.08.054.

[18] A.S. Kakde, R.M. Belekar, G.C. Wakde, M.A. Borikar, K.G. Rewatkar, B.A. Shingade, Evidence of magnetic dilution due to unusual occupancy of zinc on B-site in NiFe2O4 spinel nano-ferrite, J. Solid State Chem. 300 (2021), 122279, https://doi.org/10.1016/j.jssc.2021.122279.

[19] S. Malhotra, M. Chitkara, I.S. Sandhu, N. Dawar, J. Singh, Investigation of structural, magnetic and dielectric properties of terbium doped strontium hexaferrite for high frequency applications, Indian, J. Sci. Technol. 9 (2016), https://doi.org/10.17485/ijst/2016/v9i27/96638.

[20] T. Vigneswari, P. Raji, Structural and magnetic properties of calcium doped nickel ferrite nanoparticles by co-precipitation method, J. Mol. Struct. 1127 (2017) 515–521, https://doi.org/10.1016/j.molstruc.2016.07.116.

[21] F. Abdollahi, M. Yousefi, M. Hekmati, A. Khajehnezhad, S.S.S. Afghahi, Magnetic and microwave absorption properties of barium hexaferrite doped with La3+ and Gd3+, J. Nanostruct. 9 (2019) 579–586, https://doi.org/10.22052/JNS.2019.03.019.

[22] M.N. Akhtar, A.B. Sulong, M. Ahmad, M.A. Khan, A. Ali, M.U. Islam, Impacts of Gd-Ce on the structural, morphological and magnetic properties of garnet nanocrystalline ferrites synthesized via sol-gel route, J. Alloy. Compd. 660 (2016) 486–495, https://doi.org/10.1016/j.jallcom.2015.11.146.

[23] M. Shandilya, S. Thakur, R. Rai, Study of phase transitional behavior and electrical properties of relaxor Ba0.85Ca0.15Zr0.05Ti0.95O3 lead free ceramic, Ferroelectr. Lett. Sect. 46 (1-3) (2019) 8–18, https://doi.org/10.1080/07315171.2019.1647705.

[24] P. Chaware, A. Nande, S.J. Dhoble, K.G. Rewatkar, Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu3+ doped strontium hexa-aluminate nanophosphors for lighting application, Opt. Mater. (Amst). 121 (2021), 111542, https://doi.org/10.1016/j.optmat.2021.111542.

[25] J. Jadhav, S. Biswas, A.K. Yadav, S.N. Jha, D. Bhattacharyya, Structural and magnetic properties of nanocrystalline Ni[sbnd]Zn ferrites: In the context of

cationic distribution, J. Alloy. Compd. 696 (2017) 28–41, https://doi.org/10.1016/j.jallcom.2016.11.163.
[26] M.A. Almessiere, Y. Slimani, A.D. Korkmaz, A. Baykal, H. Güngüneş, H. Sözeri, S. E. Shirsath, S. Güner, S. Akhtar, A. Manikandan, Impact of La3+ and Y3+ ion substitutions on structural, magnetic and microwave properties of Ni0.3Cu0.3Zn0.4Fe2O4 nanospinel ferrites synthesized: Via sonochemical route, RSC Adv. 9 (53) (2019) 30671–30684.
[27] M. Shandilya, R. Verma, Impedance modulated dielectric and magnetic properties of BCT-NF multiferroic composite, J. Magn. Magn. Mater. 527 (2021), 167782, https://doi.org/10.1016/j.jmmm.2021.167782.
[28] M. Shandilya, R. Rai, A. Zeb, Structural and dielectric relaxor properties of Ba1-xMgxTiO3 ceramics prepared through a hydrothermal route, Adv. Appl. Ceram. 117 (5) (2018) 255–263, https://doi.org/10.1080/17436753.2017.1405557.
[29] C. Singh, S.B. Narang, I.S. Hudiara, Y. Bai, K. Marina, Hysteresis analysis of Co-Ti substituted M-type Ba-Sr hexagonal ferrite, Mater. Lett. 63 (22) (2009) 1921–1924, https://doi.org/10.1016/j.matlet.2009.06.002.
[30] M.A. Almessiere, Y. Slimani, H. Güngüneş, S. Ali, A. Baykal, I. Ercan, AC susceptibility and hyperfine interactions of Mg-Ca ions co-substituted BaFe 12 O 19 nanohexaferrites, Ceram. Int. 45 (8) (2019) 10048–10055, https://doi.org/10.1016/j.ceramint.2019.02.050.
[31] M. Tahir, S. Riaz, U. Khan, S.S. Hussain, A. Nairan, A. Akbar, M. Saleem, S. Atiq, S. Naseem, Enhanced structural and magnetic ordering in as-synthesized Ca doped bismuth iron oxide nanoceramics, J. Alloy. Compd. 832 (2020), 154725, https://doi.org/10.1016/j.jallcom.2020.154725.
[32] Y. Kang, Y. Huang, R. Yang, C. Zhang, Journal of Magnetism and Magnetic Materials Synthesis and properties of core – shell structured Fe (CO) 5 / SiO 2 composites, J. Magn. Magn. Mater. 399 (2016) 149–154, https://doi.org/10.1016/j.jmmm.2015.09.061.
[33] P. Kumar, A. Gaur, R.K. Kotnala, Magneto-electric response in Pb substituted M-type barium-hexaferrite, Ceram. Int. 43 (1) (2017) 1180–1185, https://doi.org/10.1016/j.ceramint.2016.10.060.
[34] J.N. Christy, K.G. Rewatkar, P.S. Sawadh, Structural and Dielectric Properties of Substituted Calcium Hexaferrites, Int. J. Eng. Res. Technol. 8 (2019) 178–182.
[35] S.R. Gawali, P.R. Moharkar, R.R. Kherani, K.G. Rewatkar, Structural and Electrical Properties of M-Type Substituted Calcium Hexaferrites, Int. J. Res. Biosci. Agric. Technol. 3 (2015) 2672–2678, https://doi.org/10.29369/ijrbat.2015.03.ii.0066.
[36] M. Shandilya, R. Rai, K. Sharma, D. Thakur, Effect of addition of zinc ferrite on dielectric and magnetic properties of (Ba, Ca)TiO3 ceramics, Integr. Ferroelectr. 185 (1) (2017) 147–154, https://doi.org/10.1080/10584587.2017.1370350.
[37] A. Katoch, B.K. Borthakur, A. Singh, T. Singh, Dielectric Behavior of M-Type Hexaferrites Sr 1–x Dy x Fe 12 O 19, Doped with Rare Earth Ions 5 (2013) 53–57.
[38] J.S. Ghodake, R.C. Kambale, T.J. Shinde, P.K. Maskar, S.S. Suryavanshi, Magnetic and microwave absorbing properties of Co2+ substituted nickel-zinc ferrites with the emphasis on initial permeability studies, J. Magn. Magn. Mater. 401 (2016) 938–942, https://doi.org/10.1016/j.jmmm.2015.11.009.
[39] N. Humera, S. Riaz, S. Naseem, Effect of temperature on electrical properties of barium titanate nanoceramics, 5 (n.d.) 153–161.
[40] P. Shepherd, K.K. Mallick, R.J. Green, Dielectric properties of cobalt substituted M-type barium hexaferrite prepared by co-precipitation, J. Mater. Sci.: Mater. Electron. 18 (5) (2007) 527–534, https://doi.org/10.1007/s10854-006-9059-6.
[41] V. Jančárik, A. Grusková, J. Sláma, R. Dosoudil, Study of Sr and Ba hexaferrite prepared by low temperature auto-combustion method, J. Electr. Eng. 57 (2006) 163–166.
[42] R.B. Jotania, R.B. Khomane, A.S. Deshpande, C.C. Chauhan, B.D. Kulkarni, Physical and Magnetic Properties of Barium Calcium Hexaferrite Nano-particles Synthesized by Water-in-oil Reverse Micelle and Co-precipitation Techniques, J. Sci. Res. 1 (2008) 1–13, https://doi.org/10.3329/jsr.v1i1.1684.
[43] M. Javed Iqbal, M. Naeem Ashiq, I. Hussain Gul, Physical, electrical and dielectric properties of Ca-substituted strontium hexaferrite (SrFe 12O 19) nanoparticles synthesized by co-precipitation method, J. Magn. Magn. Mater. 322 (13) (2010) 1720–1726, https://doi.org/10.1016/j.jmmm.2009.12.013.
[44] S. Joshi, M. Kumar, S. Chhoker, G. Srivastava, M. Jewariya, V.N. Singh, Structural, magnetic, dielectric and optical properties of nickel ferrite nanoparticles synthesized by co-precipitation method, J. Mol. Struct. 1076 (2014) 55–62, https://doi.org/10.1016/j.molstruc.2014.07.048.
[45] Y. Bakış, I.A. Auwal, B. Ünal, A. Baykal, Conductivity and dielectric properties of SrLaxBixYxFe12−3xO19 ($0.0 \leq x \leq 0.33$) hexaferrites, Ceram. Int. 42 (10) (2016) 11780–11795, https://doi.org/10.1016/j.ceramint.2016.04.099.
[46] Q. Wen, W. Zhou, J. Su, Y. Qing, F. Luo, D. Zhu, High performance electromagnetic interference shielding of lamellar MoSi2/glass composite coatings by plasma spraying, J. Alloy. Compd. 666 (2016) 359–365, https://doi.org/10.1016/j.jallcom.2016.01.123.
[47] L.M. Ridgway, I. Harrison, High frequency dielectric properties of bismuth substituted barium hexaferrite, Lect. Notes Electr. Eng. 99 (2011) 995–1000, https://doi.org/10.1007/978-3-642-21747-0_129.
[48] P. Kuruva, P. Reddy Matli, B. Mohammad, S. Reddigari, S. Katlakunta, Effect of Ni-Zr codoping on dielectric and magnetic properties of SrFe12O19 via sol-gel route, J. Magn. Magn. Mater. 382 (2015) 172–178, https://doi.org/10.1016/j.jmmm.2015.01.050.
[49] K. Praveena, K. Sadhana, H.L. Liu, N. Maramu, G. Himanandini, Improved microwave absorption properties of TiO2 and Ni0.53Cu0.12Zn0.35Fe2O4 nanocomposites potential for microwave devices, J. Alloy. Compd. 681 (2016) 499–507, https://doi.org/10.1016/j.jallcom.2016.04.190.
[50] Y. Liu, X. Su, X. He, J. Xu, J. Wang, Y. Qu, C. Fu, Y. Wang, Dielectric and microwave absorption properties of ZrB 2 /Al 2 O 3 composite ceramics, J. Mater. Sci.: Mater. Electron. 30 (3) (2019) 2630–2637, https://doi.org/10.1007/s10854-018-0538-3.
[51] A. Tarasov, K. Titov, On the use of the Cole-Cole equations in spectral induced: Polarization, Geophys. J. Int. 195 (2013) 352–356, https://doi.org/10.1093/gji/ggt251.
[52] A.F. Ahmad, S. Ab Aziz, Z. Abbas, S.J. Obaiys, A.M. Khamis, I.R. Hussain, M.H. M. Zaid, Preparation of a chemically reduced graphene oxide reinforced epoxy resin polymer as a composite for electromagnetic interference shielding and microwave-absorbing applications, Polymers (Basel) 10 (2018), https://doi.org/10.3390/polym10111180.
[53] S.T. Assar, H.F. Abosheiasha, A.R. El Sayed, Effect of γ-rays irradiation on the structural, magnetic, and electrical properties of Mg–Cu–Zn and Ni–Cu–Zn ferrites, J. Magn. Magn. Mater. 421 (2017) 355–367, https://doi.org/10.1016/j.jmmm.2016.08.028.
[54] R. Khalil, F. Salman, R. Khalil, H. Hazaa, Dielectric studies and Cole-Cole plot analysis of silver-ion conducting glasses Magnesium Batteries View project Dielectric studies and Cole-Cole plot analysis of silver-ion conducting glasses, 3 (2014) 1–9. http://www.accessinterjournals.org/ajps.

Optical Materials xxx (xxxx) 111542

Contents lists available at ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat

Research Article

Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu^{3+} doped strontium hexa-aluminate nanophosphors for lighting application

Priti Chaware [a], Amol Nande [b,*], S.J. Dhoble [c], K.G. Rewatkar [a]

[a] Department of Physics, Dr. Ambedkar College, Nagpur, 440010, India
[b] Guru Nanak College of Science, Ballarpur, 442701, India
[c] Department of Physics, R T M Nagpur University, Nagpur, 440001, India

ARTICLE INFO

Keywords:
Nanophosphors
Eu^{3+}
Combustion synthesis
Photoluminescence
Hexa-aluminate
Photometry
Judd-Ofelt analysis

ABSTRACT

In this paper, the structural and luminescence properties of Eu^{3+}- doped $SrAl_{12}O_{19}$ nanophosphors are discussed. A series of $SrAl_{12}O_{19}$:xEu^{3+} (x = 0.5, 1, 1.5, 2 and 2.5 mol %) nanophosphors were prepared using urea assisted-combustion synthesis method. The elemental and phase identification were performed by X-ray diffraction. The peak positions in the X-ray diffraction pattern have confirmed the formation of hexagonal structure. The vibration of oxide bonds and the formation of the molecules were confirmed from FTIR spectra. The surface morphology and particle size distribution are estimated using Field Emission-Scanning Electron Microscopy (FE-SEM), High Resolution-Transmission Electron Microscopy (HR-TEM). The optical properties of prepared nanophosphors series are studied using photoluminescence spectra and UV–visible spectra analysis. The refractive index of the optimized concentration of nanophosphor is estimated using Herve and Vandamme relation. Further, Judd-Ofelt analysis was performed on photoluminescence emission spectra. The potential application of synthesized nanophosphors in light-emitting devices (LED) is verified using photometry analysis on obtained emission spectra. The obtained CCT number confirmed that these phosphors are useful as a red color LED.

1. Introduction

In recent years, luminescent materials have potential applications in the field of color display devices, high-efficiency solid-state lighting, storage devices, biological sensors, optoelectronic and photonic devices [1,2]. The solid-state lightning technology can replace the traditional lighting tools which are eco-friendly and provides elegant quality. In spite of many papers published on solid-state lighting devices the field still has a scope for research in color purity, photoluminescence quantum yield, intensity variation, and persistent luminescence properties.

The properties of phosphor are depending on both host materials and dopant or activator [3]. Thus, selecting an appropriate combination of host and dopant material is very important. Oxides, halides, silicates, aluminates, sulphates, and phosphates are considered good host materials, Out of which alkaline earth aluminates such as strontium-based aluminates ($SrO–Al_2O_3$) are considered promising hosts as it is non-toxic, thermally and chemically stable [4]. Strontium-based aluminate phosphors show extra-ordinary luminescent characteristics such as high quantum yield, efficient photoluminescence, and color purity. These phosphors have been used for solid-state lighting, display, and LED applications [5]. $SrO–Al_2O_3$ systems have been in different forms such as $SrAl_{12}O_{19}$, $SrAl_4O_7$, $Sr_4Al_{14}O_{25}$, $SrAl_2O_4$, and $Sr_3Al_2O_6$ [6] [–] [9]. All these forms are used as a host for nanophosphors.

Rare-earth materials are used as activators in nanophosphors. In most cases, the rare-earth dopant is responsible for a particular color emission such as Er^{3+} ion shows emission in a green region or Eu^{3+} ion has emission in the red region. Trivalent europium doped nano-size phosphor is ideally suited for various applications such as LEDs, WLED's, photovoltaic devices, photocatalysis devices, display panels, and biometric sensors due to their high quantum efficiency. Phosphors stimulated by Eu^{3+} are considered an ideal red source, as these phosphors show sharp emission lines in the red region. However, the emission wavelength and properties of Eu^{3+} and Eu^{2+} dopants depend on the host structure and its lattice [10,11].

Rare-Earth-doped strontium aluminate phosphors are usually prepared using various methods such as combustion, precipitation, sol-gel, and solid-state reaction method [12,13]. However, the synthesis methods for aluminates always required pre or post heating at temperature; thus, non-uniformity in particle size distribution is observed. The combustion method is one of the most efficient and rapid routes to prepare

* Corresponding author.
E-mail address: nande.av@gmail.com (A. Nande).

https://doi.org/10.1016/j.optmat.2021.111542
Received 13 July 2021; Received in revised form 27 August 2021; Accepted 30 August 2021
0925-3467/© 2021

UNCORRECTED PROOF

highly pure and homogeneous oxide nanopowder. Furthermore, this process is fast, cost-effective, energy-saving and gives fine products at the nano-scale [14].

There are only a few papers published in recent years that showed the luminescence studies of Eu^{3+}or Mn^{4+} ions doped $SrAl_{12}O_{19}$ synthesized using a solid-state process and a sol-gel technique [15] [–] [17]. In this paper, a series of Eu^{3+}-doped $SrAl_{12}O_{19}$ nanophosphors were synthesized using urea assisted combustion process. The morphological, structural, optical, and photoluminescence properties of the synthesized nanophosphors are studied in detail. Eu^{3+}-doped $SrAl_{12}O_{19}$ showed red color emission with Eu^{3+} ion as the emission center under ultraviolet excitation. Thus, these phosphors behaved as down-converting phosphors. Further, Judd-Ofelt (JO) parameters were estimated and studied from emission spectra of Eu^{3+} ions in $SrAl_{12}O_{19}$ nanophosphors [18,19]. As per our knowledge, only Bento F. dos Santos Jr. et al. [20] published a brief study of JO analysis for the Eu-doped $SrAl_2O_4$ system (but not on Eu^{3+}-doped $SrAl_{12}O_{19}$ nanophosphors). Thus, in this article, we report a detailed JO analysis of Eu^{3+}-doped $SrAl_{12}O_{19}$ nanophosphors. The JO analysis of emission data of Eu^{3+} ions in $SrAl_{12}O_{19}$ allowed us to calculate the intensity parameters. This analysis helps to understand the luminescence performance of Eu^{3+} into the $SrAl_{12}O_{19}$ host matrix. At the end of the paper, the photometry analysis shows that these nanophosphors can be used in LEDs for red color substituents.

2. Synthesis of nanophosphors

A series of $SrAl_{12}O_{19}$:x%Eu^{3+} (x = 0.5, 1, 1.5, 2, 2.5) nanophosphors were synthesized using a combustion method. Strontium nitrate [$Sr(NO_3)_2$], and aluminium nitrate nonahydrate[$Al(NO_3)_39H_2O$] was used as the oxidizers, while urea (CH_4N_2O) was used as the fuel for the method. Europium oxide (Eu_2O_3) was used as the dopant precursor. All the reagents were obtained A.R. grade and taken according to their stoichiometric ratio.

The schematic of the synthesis process is shown in Fig. 1. The precursor and initial reactant materials were dissolved in double distilled water and mixed in a china dish using porcelain mortar and pestle. Later, the homogeneous solution of the mixture was obtained by heating the mixture at 80 °C for 15–20 min. The mixture was kept in a preheated muffle furnace whose temperature was nearly 525 °C. As soon as the china dish was kept in the preheated furnace, the mixture reached the boiling point, which followed a decomposition process. This led to combustion reaction with the liberation of combustible gases such as nitrogen oxides and ammonium oxides. The combustion process is completed in a short period. The formed sample was foamy, and the foamy powder was removed as soon as the completion of the combustion process. The foamy powder was crushed to a fine powder which was sintered at 800 °C for 4 h. The final obtained product was taken for characterization, and the characterizations were done at room temperature.

The structural and morphological analyses of the nanophosphors were performed from XRD, TEM, SEM, and FTIR data. The UV–visible spectroscopy study was also performed to estimate the band-gap of nanophosphor. However, the photoluminescence properties of the nanophosphors were measured from a fluorescence spectrometer using a Xenon lamp (λ_{exc} = 330 nm) as an excitation source.

3. Result and discussion

3.1. Structural and morphological analysis

3.1.1. X-ray diffraction (XRD)

The measured XRD spectra of synthesized $SrAl_{12}O_{19}$:xEu^{3+}(x = 0.5, 1, 1.5, 2%) nanophosphors are precisely shown in Fig. 2. These spectra had an excellent match with Joint Committee Powder Diffraction Data Standard (JCPDS) file number 80–1195 [17]. The comparison of the experimental spectra with the provided JCPDS file depicted that the as-prepared nanophosphors have a hexagonal shape crystal structure. Fig. 2 also confirmed that the intensity of prominent peaks decreases with increasing Eu^{3+} concentrations. This indicates that the Eu^{3+} atoms are mainly involved in replacing a few prominent atoms of the host materials but not in overall crystal formation, consistent with previous research works [21].

To better understand the structural pattern of $SrAl_{12}O_{19}$, the XRD patterns of all as-synthesized nanophosphors are fitted using the Rietveld refinement function in the Full-Prof Software suite. An example of analyzed data for $SrAl_{12}O_{19}$ is shown in Fig. 3. Hexagonal crystal structure with space group P63/mmc (#194) had been considered for the refinement process; it has to be consistent with the JCPDS data file. Also, in the refinement process, peak shape was modeled as Pseudo-Voigt function. Varying lattice parameters (constants – a, b, c and angles α, β, γ), scale factor value, zero correction, half-width full maxima value, and the position of coordinates of an atom, the refine process car-

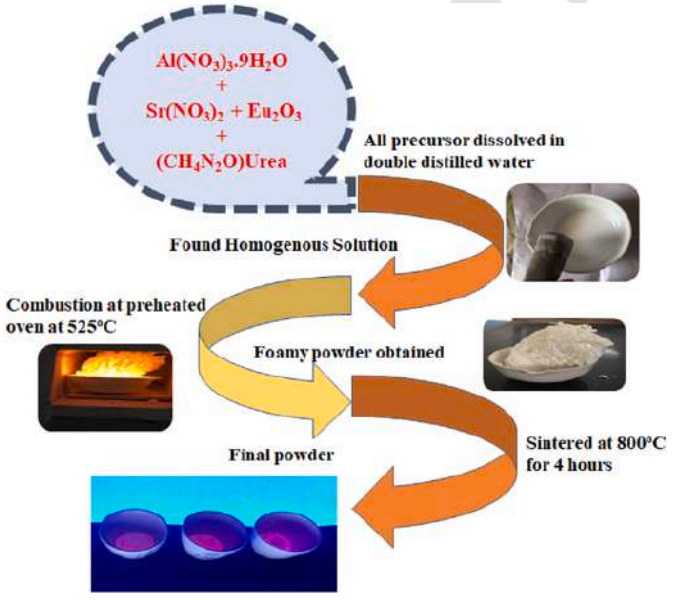


Fig. 1. A schematic for synthesis of $SrAl_{12}O_{19}$:x%Eu^{3+}(x = 0.5, 1.0, 1.5, and 2.0) nanophosphors.

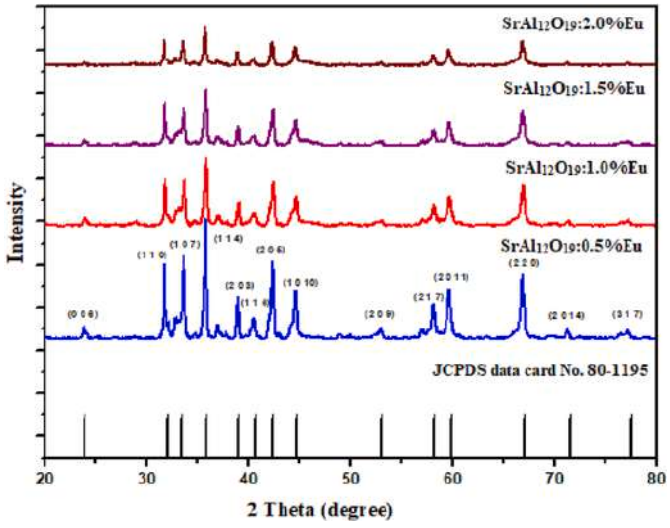


Fig. 2. X-ray diffraction patterns of $SrAl_{12}O_{19}$:x%Eu^{3+}(x = 0.5,1.0,1.5, and 2.0) nanophosphors with different concentration of Eu^{3+}.

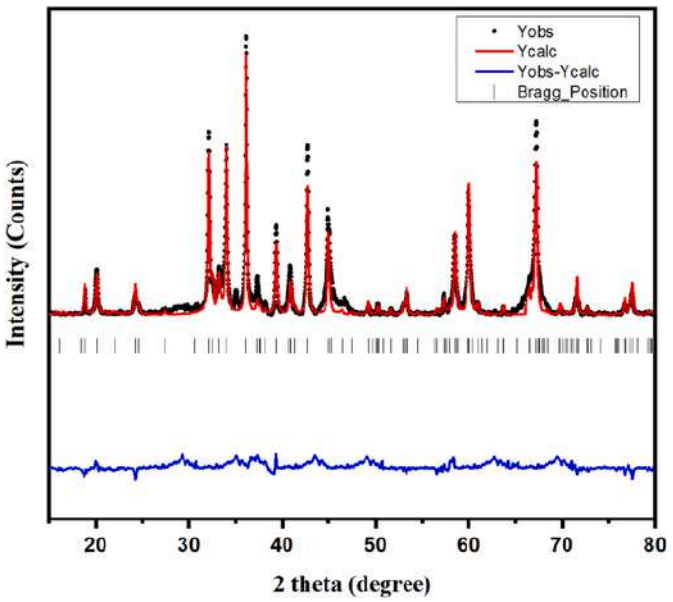


Fig. 3. X-ray Rietveld refinement pattern of the $SrAl_{12}O_{19}$.

ries out. Table 1 depicts the synthesized series's estimated parameters, which were matched with the reference data [22,23].

For all synthesized nanophosphors average crystallite size was calculated from Debye–Scherrer equation,

$$d = \frac{0.9\lambda}{\beta cos\theta} \quad (1)$$

here, d represents the average grain size of the crystallites, θ represents Bragg angle, λ represents the incident wavelength, and β represents full-width half-maximum (FWHM) of the prominent (114) diffraction peak.

Further, the XRD data were processed using the Rietveld refinement process. Table 2 provides the estimated average crystallite sizes, lattice parameter a and c values. The crystallite size decreases with increasing Eu^{3+} concentration, which further supports the atomic-site doping of Eu^{3+}. Nevertheless, the dopant does not change the complete crystalline structure. The estimated values of crystallite size varied from 30.8 to 39.1 nm. The estimated crystallite size further supports the formation of nanophosphors. The c/a ratio is considered a valuable term to confirm the formation of M-type hexagonal structure, consistent with the previously mentioned results [24,25]. The estimated value of a and c for all nanophosphors are ~5.6 Å (0.56 nm) and 22 Å (2.2 nm). From the estimated a and c values, c/a ratios were found to be constant and equal to ~3.95, which confirmed magneto-plumbite structure, i.e., M-type hexagonal structure (Table 2). From the above discussion, it can be claimed that the synthesized nanophosphors obey Vegard's law [26].

Table 1
Parameters obtained from the refinement of $SrAl_{12}O_{19}$.

Compound	$SrAl_{12}O_{19}$
Space group	P63/mmc (#194)
$a = b$ (Å)	5.57
c (Å)	22.029
V (Å^3)	683.48
Z	6
2θ interval	10–80
No. of reflection	100
χ^2	1.723
R_p	7.99
R_{wp}	8.51
Re	6.48

Table 2
Lattice parameters, FWHM, and Crystalline size of samples.

Concentration (mol%)	Lattice Parameter		c/a	FWHM (degree)	Crystalline size (nm) (nm)
	$a = b$ (Å)	c (Å)			
0.5	5.57	22.03	3.95	0.237	39.1
1	5.56	22.02	3.95	0.251	36.9
1.5	5.56	22.00	3.95	0.288	32.1
2.0	5.55	21.96	3.95	0.3	30.8

The proposed crystal structure of the nanophosphors is shown in Fig. 4. The hexagonal structure of nanophosphors unit cells is obtained by alternating spinel ($S = Al_6O_8^{2+}$) and hexagonal ($R = SrAl_6O_{11}^{2-}$) layers. Also, O^{2-} ions and Sr^{2+} ions are closely packed in the hexagonal layer, and Al^{3+} ions are oriented in the octahedral (12k, 2a, and 4f_2), trigonal-bipyramidal (2b), and tetrahedral (4f_1) sites. However, Al^{3+} ions are bound together with other Al^{3+} ions with super-exchange interactions through the O^{2-} ions via their magnetic moments.

3.1.2. Field Emission-Scanning Electron Microscopy (FE-SEM)

The FE-SEM images of the synthesized nanophosphors are depicted in Fig. 5 (a) and (b). These images suggested the formed nanophosphors are non-uniform shapes and agglomerated to big particles. Also, the images suggested that formed nanophosphors are in foamy nature. The obtained non-uniform and foamy nature could be due to the combustion process as during the process a large amount of gas is released from the self-propagating combustion. This led to a foamy structure with voids in between nanoparticles and some nanoparticles allotted at a smaller volume [27]. The "Image J" software package was used to analyzed and estimate a histogram for particle size distribution. Later the histogram was and fitted with the Gaussian distribution function to obtain the average particle size of the nanophosphors (as shown in Fig. 5 (c)). The estimated particle size of the nanophosphors was ~35 nm (with variation from 30 to 40 nm) which was a good match with the estimated crystalline value from the XRD patterns.

3.1.3. High Resolution-Transmission Electron Microscopy (HR-TEM)

The particle shape and size of synthesized nanophosphor were further confirmed using HR-TEM microscopy. Fig. 6 (a) and (b) show HR-TEM images and selected area electron diffraction pattern (SAED) obtained for $SrAl_{12}O_{19}$ nanophosphors. The estimated average particle

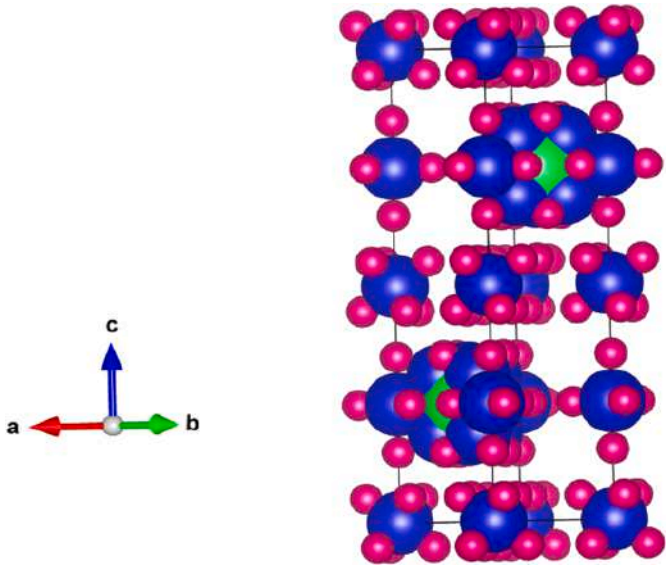


Fig. 4. Unit cells of the parent structures of $SrAl_{12}O_{19}$ (Green = Sr, Pink = O, Blue = Al).

UNCORRECTED PROOF

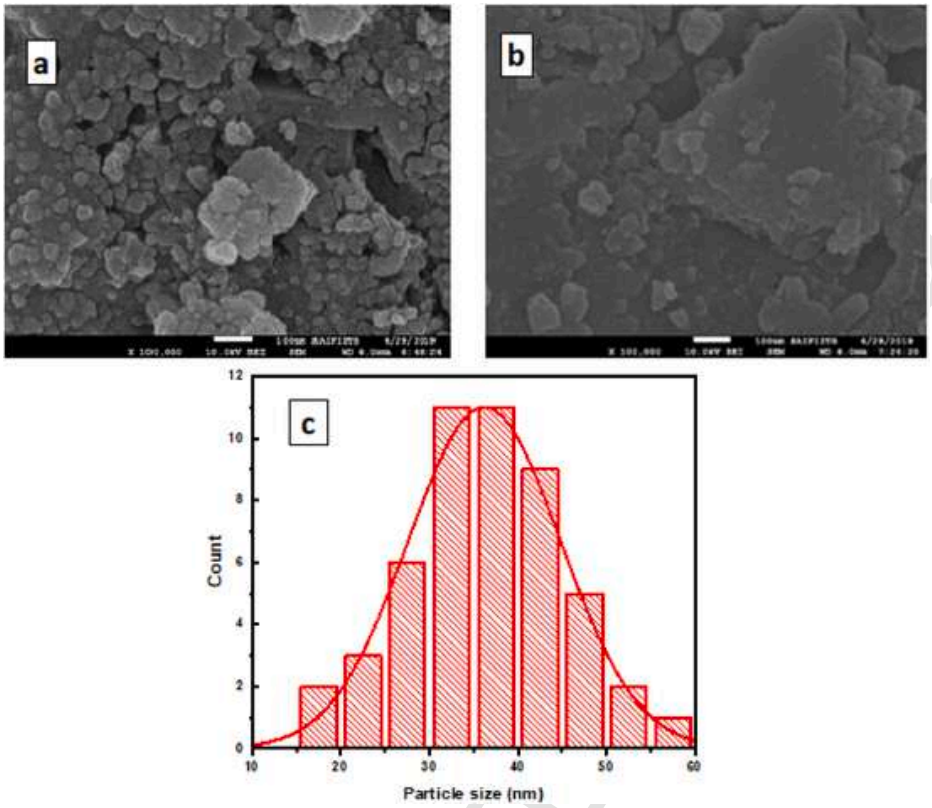


Fig. 5. (a) and (b) FE-SEM images of $SrAl_{12}O_{19}$nanophosphor. (c) Particles size distribution of nanophosphors was estimated using image-j software suit.

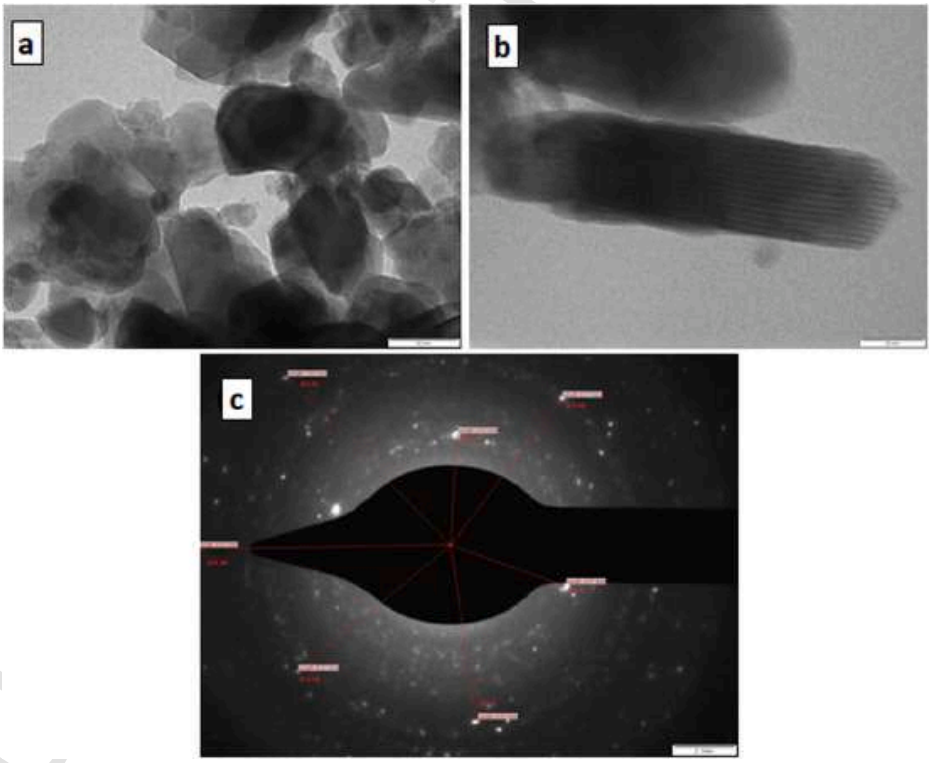


Fig. 6. (a) and (b) TEM micrographs and (c) SAED pattern of $SrAl_{12}O_{19}$nanophosphor.

size from the HR-TEM images is in a range of 35–60 nm (with an average particle size ~ 35 nm) for the $SrAl_{12}O_{19}$ nanoparticles. The estimated average particle size from the HR-TEM images is matched with the crystalline particle size obtained from the XRD analysis and FE-SEM images [28]. Further, HR-TEM images confirmed the irregular shape and agglomerated nature of synthesized nanoparticles.

The SAED pattern [as shown in Fig. 6 (c)] suggests the polycrystalline feature of $SrAl_{12}O_{19}$ nanophosphors, as it contains the number of

diffraction rings. Also, the estimated structure from the SAED pattern was a hexagonal shape which is consistent with the structure obtained from the Rietveld refinement analysis. Thus, we can say that $SrAl_{12}O_{19}$ nanoparticles have an M-type Hexa-aluminates structure.

3.1.4. Fourier transformation infrared spectroscopy (FTIR)

FTIR spectroscopy analysis was done to find out the functional group present in the compound. The FTIR spectrum of nanophosphor $SrAl_{12}O_{19}$, sintered at 800 °C, is shown in Fig. 7. The spectrum was noted from 4000 cm^{-1} to 400 cm^{-1} at room temperature. The broadband was observed at ~3461 cm^{-1}; due to the (O-H) stretching vibration of H_2O absorbed by the samples. This peak may be seen in all the spectra. The other peak was observed at 1636 cm^{-1} due to atmospheric water vapor. These bands are attributed to the antisymmetric stretching vibrations of free O-H bonds [29]. The peak detected at 1457 cm^{-1} corresponds to C-O vibrations obtained from residual carbon from the combustion process or by surface absorption of CO_2 molecule [29,30].

Fig. 7 shows that many absorption bands are seen in a range of 830–400 cm^{-1} due to the phonon energy of the metal-oxygen vibrations. These metal-oxygen vibration peaks are due to the $SrAl_{12}O_{19}$ crystals [14]. This also supports the previously mentioned studies.

3.2. Optical and luminescence analysis

3.2.1. Photoluminescence studies

The photoluminescence emission spectra of combustion derived $SrAl_{12}O_{19}$:xEu^{3+} (x = 0.5–2.5% mole) nanophosphors are shown in Fig. 8. The emission spectra were measured at an excitation wavelength of 397 nm. The characteristic emissions transitions of Eu^{3+} ion resulting from the spin forbidden f-f electronic transition were observed for the emission spectra. The emission peaks are observed at 590, 614, 647, 682, and 695 nm, which corresponds to $^5D_0 \rightarrow {}^7F_J$ (J = 1, 2, 3, 4) Eu^{3+} ions transitions. The transitions are - 590 nm belongs to $^5D_0 \rightarrow {}^7F_1$, 614 nm belongs to $^5D_0 \rightarrow {}^7F_2$, 647 nm belongs to $^5D_0 \rightarrow {}^7F_3$, and 682 nm and 695 nm belong to $^5D_0 \rightarrow {}^7F_4$ [10,31]. The dominant transition at 614 nm emits red, corresponds to the electric dipole transition $^5D_0 \rightarrow {}^7F_2$ of Eu^{3+}. The dominant transition due to electric dipole transition is higher than the magnetic dipole transition observed at 590 nm due to the $^5D_0 \rightarrow {}^7F_1$ transition. The dominant electric dipole transition confirms the presence of Eu^{3+} ions in lattice sites without inversion symmetry in the host lattice [32].

The luminescence intensity of nanophosphors highly depends on the dopant concentration. Fig. 8(a) depicted the intensities of all mentioned peaks increases with increasing Eu^{3+} concentration and the highest intensity observed for 2% Eu^{3+} ion concentration of $SrAl_{12}O_{19}$:Eu^{3+} nanophosphors. For a higher concentration of Eu^{3+}- dopant, the peak intensities decrease with increasing Eu^{3+}-dopant concentration. Fig. 9 shows intensity vs Eu^{3+} dopant concentration for the most prominent peak observed at 614 nm emission spectra. This figure clearly indicated the concentration quenching occurred for 2% Eu^{3+} molar concentration. Energy diffusion among Eu^{3+} ions is often responsible for the concentration quenching process. Also, non-radiative relaxation between adjacent Eu^{3+} ions increased for high-doping concentration. Thus, further, an increase in Eu^{3+} dopant in luminescent centers induces concentration quenching and decreases luminescent intensity [33,34].

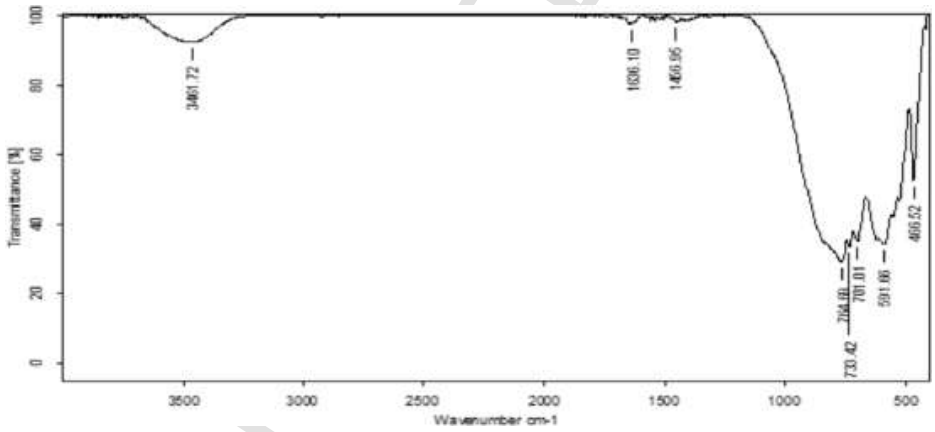


Fig. 7. FITR spectra of $SrAl_{12}O_{19}$nanophosphor.

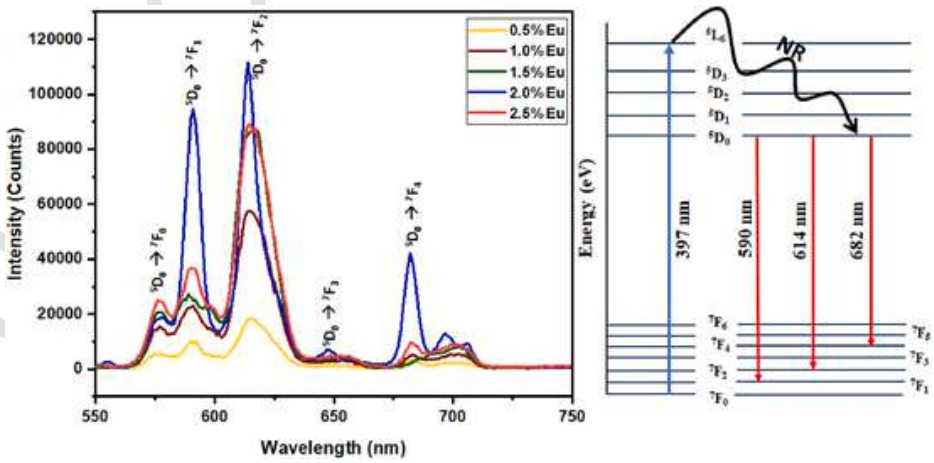


Fig. 8. a) Emission Spectra of $SrAl_{12}O_{19}$: x%Eu^{3+}(x = 0.5,1.0,1.5,2.0, and 2.5) measured at excitation wavelength 397 nm b) The schematic energy level diagram of Eu^{3+} ions in the $SrAl_{12}O_{19}$.

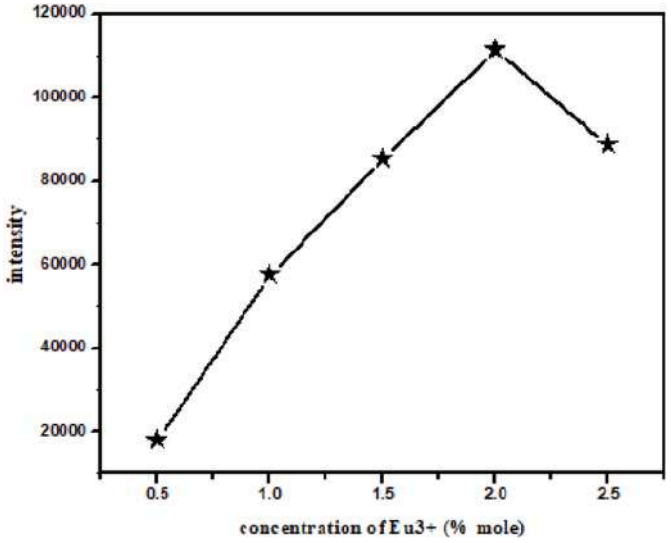


Fig. 9. Intensity vs concentration of Eu^{3+} ion for 614 nm emission peak.

Dexter's theory [35] suggests that the behavior of increasing emission intensity with increasing Eu^{3+}(dopant) concentration and decreasing emission intensity with a higher concentration of Eu^{3+}-dopant infers a non-radiative energy transfer between other Eu^{3+} ions. The exchange and a multipole–multipole interaction with radiation reabsorption between Eu^{3+}-dopant ions give rise to the non-radiative energy transfer [36]. The average distance between the closest Eu^{3+} ions is considered a critical distance where energy transfer occurs. The Blasse's formula [37] could be used to calculate the critical distance R_C for activators Eu^{3+} in $SrAl_{12}O_{19}$:xEu^{3+} can be estimated as;

$$R_c = 2\left(\frac{3V}{4\pi xN}\right)^{1/3} \quad (2)$$

here, x represents critical concentration, V represents the unit-cell volume, and N represents the number of cations. For our sample, $V = 683.48$ Å^3, $N = 6$, and the critical doping concentration for the prepared nanophosphors are estimated as 0.02. Thus, R_C of Eu^{3+} in $SrAl_{12}O_{19}$:xEu^{3+} nanophosphors is calculated ~22 Å. The energy migration of forbidden transitions with typical R_C ~5 Å is typically attributed to the exchange interaction between Eu^{3+} ions and if the R_C value is greater than 5 Å, multipole-multipole transitions are responsible for the concentration quenching mechanism [36]. Thus, the estimated R_C is 22 Å, suggesting the energy migration mechanism in $SrAl_{12}O_{19}$:xEu^{3+} is due to the electric multipole-multipole interactions.

A schematic energy level diagram of emission bands obtained in $SrAl_{12}O_{19}$:Eu^{3+} nanophosphors is displayed in Fig. 8 (b). The diagram suggests that on near-UV excitation of 397 nm wavelength, the electrons jumped from the ground state ($^7F_0$) to the higher energy $^5L_6$ state. Later, the electrons relaxed from the $^5L_6$ state to the lower energy state ($^5D_0$) level via non-radiative transition. From the $^5D_0$ state, electrons jumped to ^7F_J (J = 0,1, 2, 3, 4, 5, and 6) energy levels, providing three distinct emissions due to the $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$ transitions.

The excitation spectrum (measured at 614 nm emission wavelength) and emission spectrum (measured at 397 nm excitation wavelength) for optimized $SrAl_{12}O_{19}$:2%Eu^{3+} are shown in Fig. 10. The excitation spectrum depicts that the prominent peak was observed at 397 nm, the nanophosphors as a broad excitation over a wide wavelength range, corresponding to the visible region. The prominent excitation at 397 nm is allocated to $^7F_0 \rightarrow {}^5L_6$ transitions of Eu^{3+} metal ion. We already have discussed the emission spectrum in the previous paragraph. Also, Fig. 10 confirmed that the studied nanophosphors were down-conversion phosphors, as the energy peak observed for the excitation spectrum was higher than the energy observed for the emission spectrum.

3.2.2. Ultra-violet – visible spectroscopy

Optical absorption and band edge analysis use to understand the band composition and energy difference in amorphous materials and crystalline materials. The energy difference occurs due to the emission of photons with higher energy than the material's energy band. As a result, the absorption spectra reveal the material's atomic vibration and electrical properties [38].

The absorption coefficient was determined using the equation below.

$$(\alpha h\nu)^m = h\nu - E_g \quad (3)$$

here, α, $h\nu$ and E_g represent absorption coefficient, photon energy, and bandgap energy, respectively. m represents the transition parameter, and m values are 1/2 or 3/2 for indirect forbidden transitions, and 2 or 3 values are for allowed and direct forbidden transitions [33].

The measured UV–Visible spectrum for optimized 2% molar Eu^{3+} doped $SrAl_{12}O_{19}$ nanophosphor was re-plotted as $(\alpha h\nu)^2$ against energy ($h\nu$) to estimate the band of the nanophosphors as shown in Fig. 11. The estimated optical band gap for the nanophosphor is estimated as 3.62 eV, which is estimated by extrapolating a straight line at the sharp edge of the curve and intercepts at the axis provided the band gap value [39].

3.2.3. Refractive index

The optical properties and luminescence parameters like Jud-Ofelt (JO) parameters are further investigate using refractive index (n) materials. n value of synthesized nanophosphors is estimated using Herve and Vandamme relation [40,41].

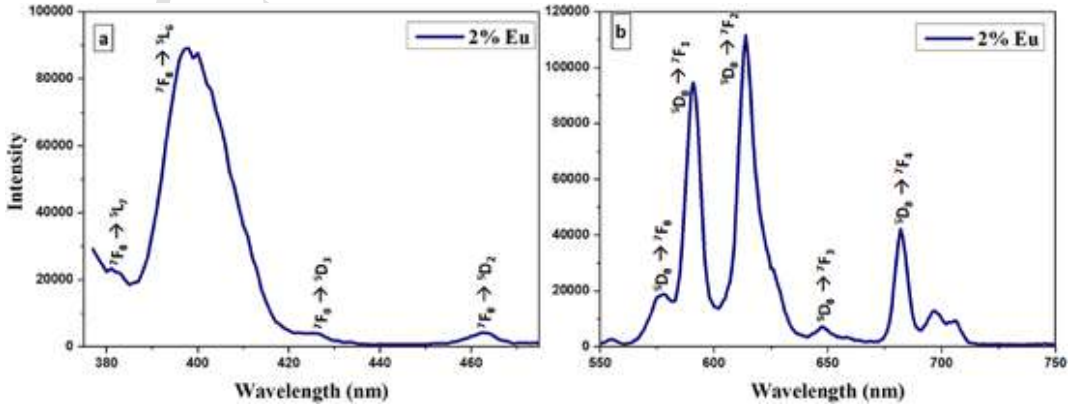


Fig. 10. Excitation and emission spectra of optimized $SrAl_{12}O_{19}$:2%Eu^{3+}nanophosphor.

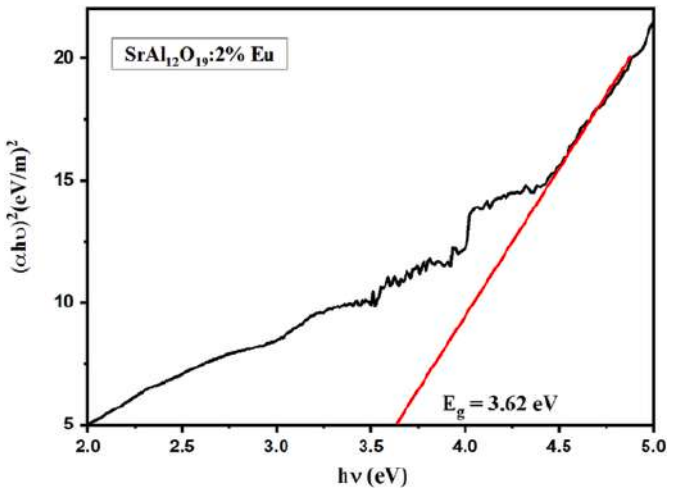


Fig. 11. UV–Vis Spectrum (Tauc Plot) of $SrAl_{12}O_{19}$:2%Eu phosphor.

$$n = \sqrt{1 + \left(\frac{A}{E_g + B}\right)^2} \tag{4}$$

here, A and B are the constants, and their values are respectively given as 13.6 and 3.4 eV. E_g represents the energy bandgap calculated from UV–Vis Spectra. The estimated refractive index for the 2% Eu^{3+} doped $SrAl_{12}O_{19}$ nanophosphor is 2.18.

3.2.4. Judd-Ofelt analysis

3.2.4.1. JO intensity parameters and asymmetric ratio. Judd-Ofelt (JO) analysis of $SrAl_{12}O_{19}$:xEu^{3+} nanophosphors helps to understand the bonding and structure of dopant-Eu^{3+} in the host matrix. The JO intensity parameters ($\Omega_{2,4,6}$) are estimated from emission spectra using JEOS application software [42]. The estimated intensity parameters provide detailed information about luminescence branching ratios, oscillator strengths, excited-state radiative lifetimes, and stimulated emission [19]. The intensity parameters are estimated for the ratio of the integrated intensities of transition $^5D_0$ – ^7F_J and $^5D_0$ – $^7F_1$, using the following equation (Eq. (5)) [42] [–] [44]:

$$\Omega_\lambda = \frac{D_{MD}\nu_1^3}{e^2\nu_\lambda^3 U^\lambda}\frac{9n^3}{n(n^2+2)^2}\frac{J_\lambda}{J_1} \tag{5}$$

where, $D_{MD} = 9.6 \times 10^{-6} Debye^2$, $J_\lambda = \int I_x(\nu)\,d\nu$, the integrated intensity of the transition and ν_x represents the barycenter of the emission transition and average wavenumber in cm^{-1} [45].

The Ω_2 intensity parameter is associated with the symmetry around the Eu^{3+} ion and it is affected by the degree of the covalence bond between Eu^{3+} and the host matrix. Further, the Ω_2 parameter relates to the short-range effects of Eu-O covalence. The Ω_4 and Ω_6 intensity parameters are related to the rigidity and viscosity of the host compound [44,46,47].

The asymmetric ratio or asymmetric factor is a vital parameter to understand symmetry. It is the ratio of the integral intensity of electrical dipole transition (EDT), i.e., $^5D_0 \rightarrow {}^7F_2$, to magnetic dipole transition (MDT), i.e., $^5D_0 \rightarrow {}^7F_1$. The asymmetric ratio quantifies the degree of distortion from the inversion symmetry of the Eu^{3+} ion's local surroundings in a matrix. It is the ratio of the integrated intensities of hypersensitive and magnetic dipole transitions [48,49]. It can be very small or large, depending upon the specific crystallographic site symmetry of Eu^{3+}. The asymmetric ratio R is estimated by the following formula [50,51]:

$$R = I_{EDT}/I_{MDT} \tag{6}$$

where I_{EDT} represents the intensity of EDT $^5D_0 \rightarrow {}^7F_2$, and I_{MDT} represents the intensity MDT $^5D_0 \rightarrow {}^7F_1$.

The calculated JO intensity parameters asymmetric values for different concentrations of Eu^{3+} are presented in Table-3. The estimated intensity parameters for $SrAl_{12}O_{19}$:x%Eu^{3+} nanophosphors show that the JO intensity parameter Ω_2 is greater than Ω_4. This implies that the Eu^{3+} and host interaction is more covalent and the existence of asymmetry around the Eu^{3+} ion site [44,46]. The obtained Ω_2 and Ω_4 are similar for all Eu^{3+} concentrations and do not observe any significant changes. In contrast to Ω_2, Ω_4 is not dependent on symmetry around the Eu^{3+} ion but the electron density on the surrounding host. For the current nanophosphors, the calculated values of Ω_4 are similar, suggesting electron density around Eu^{3+} is nearly the same for all the concentrations of Eu^{3+}.

The asymmetric ratio R is often used in determining the host material quality providing symmetry information around Eu^{3+} covalency. Usually, it is considered that the value of $R < 1.0$ is for symmetric, and > 1.0 is for asymmetric surroundings. Hence, the high asymmetric ratio indicated that the Eu^{3+} ion resides in locations with weak symmetry and no inversion center [52]. For all Eu^{3+} concentrations, the estimated values of R are greater than 1, indicating distortion in symmetry around Eu^{3+} ion in $SrAl_{12}O_{19}$. This increased in relative intensity of hypersensitive dipole transition [53].

3.2.4.2. Radiative transition, stimulated emission cross-section, radiative time-life, and branching ratio parameters. Using the intensity parameter, the radiative transition rates A_λ, which corresponds to the forced electric-dipole transitions, can be calculated as [54,55],

$$A_\lambda = \frac{64\pi^4\nu_\lambda^3}{3h}\frac{n(n^2+2)^2}{9}D_{ED}^\lambda,\ as\ D_{ED}^\lambda = e^2\Omega_\lambda U^\lambda \tag{7}$$

where, D_{ED} = dipole strength for electric dipole transition, h (Plancks constant) = 6.63×10^{-27} erg s. In Eq. (6), U^λ is abbreviation for $\left|J\left|U^\lambda\right|J\right|^2$square reduced matrix elements. The values of U^λ are independent of the chemical environment (i.e., host matrix) of dopant-Eu^{3+} ion [56]. Also, the total radiative transition probability A_λ, which is the sum of all radiative transition was used to estimate the radiative lifetime of the $^5D_0$ transition:

$$\tau = \frac{1}{\sum A_\lambda} \tag{8}$$

Further, total radiative transition probability A_λ use to estimate the branching ratio as $\beta = \frac{A_\lambda}{\sum A_\lambda}$[36]. The branching ratio provides information about the relative intensities of the emission peaks originating from an excited state. The stimulated emission cross-section is important $\sigma(\lambda_p)$ to estimate the performance at room temperature and rate of extraction from the lasing material. The $\sigma(\lambda_p)$ can be estimated as [52,57].:

$$\sigma(\lambda_p) = \frac{\lambda_p^4}{8\pi c n^2 \Delta\lambda_{eff}}A_\lambda \tag{9}$$

Table 3
The calculated J–O intensity parameters and asymmetric ratio for $SrAl_{12}O_{19}$:x%Eu^{3+}.

Concentration (mol%)	Ω_2 (x10^{-20}) (cm^{-2})	Ω_4 (x10^{-20}) (cm^{-2})	Asymmetric ratio (R)
0.5	2.825	1.2981	1.265
1.0	3.4499	1.0165	1.523
1.5	4.0473	0.9501	1.809
2.0	1.8122	1.3241	1.599
2.5	3.3781	1.1095	1.708

UNCORRECTED PROOF

where λ_p represents emission peak wavelength, and $\Delta\lambda_{eff}$ is the effective line-width found, which was obtained by considering the ratio of the area of the emission band to its maximum height.

The estimated values for different concentrations of Eu^{3+} ion of $SrAl_{12}O_{19}$:x%Eu^{3+} nanophosphors are presented in Table-4. The analysis depicts that the *A* and β were highest for the $^5D_0 \rightarrow {}^7F_2$ transition compared to other observed transitions. It was recognized that an emission level with the β value closer to 50% [58,59]. The radiative lifetime is nearly the same for all Eu^{3+} concentrations except for 0.2 mol Eu^{3+} concentrations. We observed 2.167 ms lifetime decay for 0.2 Eu^{3+} concentration suggesting a decrease in symmetry around Eu^{3+} ion which was consistent with the photoluminescence study [53,60].

Further, the trend of $\sigma(\lambda_p)$ for the $^5D_0$ emission transition were seen as $^7F_4 > {}^7F_1 > {}^7F_2$ for the synthesized nanophosphors. The maximum value of $\sigma(\lambda_p)$ is observed for the $^5D_0$-$^7F_1$ transition, and variations are uniform for all prepared Eu^{3+} concentrations. The obtained values of $\sigma(\lambda_p)$ are about one order of magnitude lower than those reported for Eu^{3+}:YAG, but $\sigma(\lambda_p)$ values are of the same order as for Eu^{3+}: $Y_4Al_2O_9$ [57,61]. The $\sigma(\lambda_p)$ values have an exciting application in low-threshold, high-gain devices [62].

3.2.5. Chromaticity analysis

The CIE chromaticity coordinates are essential characteristics in evaluating the luminous qualities of phosphors. The color coordinates are estimated from the emission spectrum using the chromaticity coordinate calculation method based on the CIE 1931 system - color calculator software [63].

The CIE chromaticity diagram of $SrAl_{12}O_{19}$:x%Eu^{3+} (x = 0.5,1.0,1.5,2.0, and 2.5) phosphors is shown in Fig. 12. The CIE chromaticity coordinates of $SrAl_{12}O_{19}$:x%Eu^{3+} phosphors (which were measured at excitation wavelength λex = 397 nm) with varying Eu^{3+} concentrations were presented in Table 5. The CIE values of $SrAl_{12}O_{19}$:Eu^{3+} red phosphor are very close to those of the commercial red-emitting phosphor Y_2O_3:Eu^{3+} (0.61, 0.39) [64,65]. Hence upon UV excitation, the $SrAl_{12}O_{19}$:Eu^{3+} phosphor exhibited bright red light, which will be used for color tuning in solid-state lighting applications.

The correlated color temperature (CCT) is usually used to identify the quality of emitted light for the glasses and can be calculated from the McCamy empirical equation [64]:

$$CCT = 437n^3 + 3601n^2 + 6861n + 5517 \quad (10)$$

where *n* is the inverse of the slope and is equal to $(x - x_e)/(y_e - y)$; the epicenter points are $x_e = 0.332$ and $y_e = 0.186$. The estimated values for different Eu^{3+} concentrations for the synthesized nanophosphors are presented in Table 5. The calculated CCT values show that these nanophosphors are can be useful for warm lighting application, as the standard CCT value for warm lighting application is smaller than 4000 K [66,67]. The highest CCT value was observed for 2% Eu^{3+} dopant concentration in $SrAl_{12}O_{19}$ nanophosphors with CCT value

Table 4
The calculated radiative emission rates, total radiative transition probability, lifetime, branching ratios, and stimulated emission cross-section for $SrAl_{12}O_{19}$:x%Eu^{3+}.

Transition		0.5%mol	1.0%mol	1.5%mol	2.0%mol	2.5%mol
$^5D_0 \rightarrow {}^7F_1$	$A\ (s^{-1})$	151.58	151.65	151.63	151.22	151.61
	β %	24.9	22.99	21.03	32.87	23.05
	$\sigma\ X10^{-22} cm^2$	5.35	8.93	7.88	1.84	6.01
$^5D_0 \rightarrow {}^7F_2$	$A\ (s^{-1})$	304.88	372.76	437.54	196.77	364.88
	β %	47.74	53.94	57.92	40.92	52.95
	$\sigma\ X10^{-22} cm^2$	1.71	4.04	4.59	1.98	2.31
$^5D_0 \rightarrow {}^7F_4$	$A\ (s^{-1})$	71.39	55.64	51.53	74.02	60.82
	β %	9.97	7.16	6.05	13.77	7.85
	$\sigma\ X10^{-22} cm^2$	3.22	3.19	3.97	1.72	2.70
Lifetime	$\tau\ (ms)$	1.639	1.515	1.386	2.167	1.504

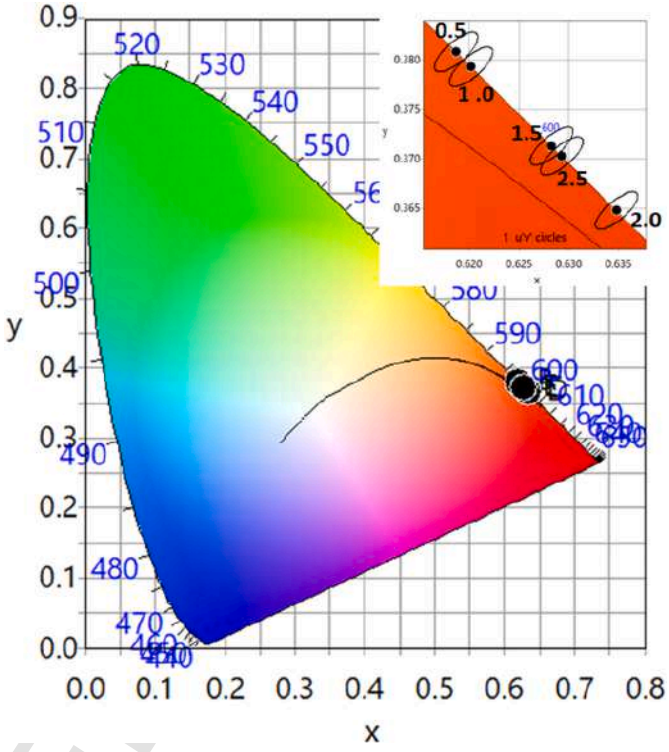


Fig. 12. CIE color chromaticity coordinate diagram for $SrAl_{12}O_{19}$:x%Eu^{3+} (x = 0.5,1.0,1.5,2.0, and 2.5).

Table 5
CIE chromaticity coordinates of the $SrAl_{12}O_{19}$:xEu^{3+} samples under 397 nm excitation.

Concentration	C_x	C_y	CCT
0.5	0.6187	0.3808	1825
1	0.6202	0.3793	1843
1.5	0.6293	0.3703	1983
2	0.6348	0.3648	2100
2.5	0.6283	0.3713	1964

2100. The chromaticity coordinate *x* and *y* were found as 0.6348 and 0.3648, respectively.

The synthesized red color nanophosphors can stand as a replacement for other available red color phosphors and with other suitable phosphors to compensate for the lack of red color if any. Therefore, $SrAl_{12}O_{19}$:x%Eu^{3+} red nanophosphors have the potential for applications in LEDs as the red phosphor.

3.3. Conclusion

A series of Eu^{3+} doped $SrAl_{12}O_{19}$nanophosphors were successfully synthesized using a urea assisted-combustion method. Later, the nanophosphors sintered at 800 °C for 4 h. The Rietveld refinement of the XRD results confirmed the polycrystalline structure of the prepared $SrAl_{12}O_{19}$ as hexagonal with a space group of P63/mmc. Further, XRD results of all dopant concentrations confirmed that the crystalline size decreased with increasing dopant concentration. The average crystalline size was found to be ~30.88–39.18 nm. FTIR analysis indicated the vibrations of metal-oxygen (M – O) groups, which form the magnetoplumbite structure phase. SEM and TEM micrographs confirmed the formation of nanophosphors within the hexagonal plates, and the crystalline grains were, on average, in the nano-size range of 35–60 nm. Further, the estimated bandgap using the absorption edge of UV–vis–NIR spectra and data processing was found to be 3.6 eV. The photoluminescence studies showed that two distinct emission peaks

UNCORRECTED

were observed at 590 and 614 nm, corresponding to the Eu^{3+} ions' $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ transitions, respectively. The temperature at which the $SrAl_{12}O_{19}$ nanophosphors were synthesized and the concentration of Eu^{3+} ions seemed to affect the two distinct emission peaks. A concentration quenching effect of Eu^{3+} ions in the $SrAl_{12}O_{19}$ phosphors was observed when x was larger than 2.0% mole. The emission and excitation spectra for optimized 2% Eu^{3+} showed that the formed nanophosphors were down-converting nanophosphors that fall in the red color region. From Judd-Ofelt's analysis, it observed that $\Omega_2 > \Omega_4$, which indicates high covalency in Eu^{3+} and ligands (i.e., in Eu and O). The high value of the asymmetric ratio suggested that Eu^{3+} locate at the site with distorted symmetry. The radiative transition rate and branching ratio are higher for the $^4D_0 \rightarrow {}^7F_2$ transition but the emission cross-section is maximum for the $^5D_0 \rightarrow {}^7F_1$ transition for all Eu^{3+} concentrations. The CIE-photometry analysis confirmed that the given phosphors are suitable for applications in LEDs as red phosphor, which could potentially replace industrial nanophosphors.

CRediT authorship contribution statement

Priti Chaware: Approval of the version of the manuscript to be published, Writing – original draft, Funding acquisition, Data curation, Formal analysis, and interpretation of data. **Amol Nande:** Approval of the version of the manuscript to be published, Writing – original draft, Writing – review & editing, Conceptualization, Funding acquisition, Data curation, Formal analysis, and interpretation of data. **S.J. Dhoble:** Approval of the version of the manuscript to be published, Writing – review & editing, Conceptualization, Data curation, Formal analysis, and interpretation of data. **K.G. Rewatkar:** Approval of the version of the manuscript to be published, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.optmat.2021.111542.

References

[1] B. Zhang, Q. Liu, W. Yan, Y. Chen, A. Shen, H. Zhang, Relation between structure conversion and spectra-tuning properties of Eu^{2+}-doped strontium aluminate phosphor, J. Mater. Sci. 52 (2017) 8188–8199, https://doi.org/10.1007/s10853-017-1027-4.

[2] V.B. Pawade, H.C. Swart, S.J. Dhoble, Review of rare earth activated blue emission phosphors prepared by combustion synthesis, Renew. Sustain. Energy Rev. 52 (2015) 596–612, https://doi.org/10.1016/j.rser.2015.07.170.

[3] M.K. Jang, E.D. Kim, Y.D. Huh, Photoluminescence properties of tunable emission $(Sr_{1-x}Eu_x)_2Ga_2S_5$ phosphors, Optik 226 (2021) 165930, https://doi.org/10.1016/j.ijleo.2020.165930.

[4] S. Singh, V. Tanwar, A.P. Simantilleke, H. Kumar, D. Singh, Synthesis and photoluminescence behavior of of $SrMg_2Al_{16}O_{27}$:Eu^{2+} nanocrystalline phosphor, Optik 225 (2021), https://doi.org/10.1016/j.ijleo.2020.165873.

[5] M.V.D.S. Rezende, J.B. Amaral, M.E.G. Valerio, R.A. Jackson, Optical properties of Pr and Eu-doped $SrAl_{12}O_{19}$: a theoretical study, Opt. Mater. 48 (2015) 105–109, https://doi.org/10.1016/j.optmat.2015.07.032.

[6] D. Dutczak, T. Jüstel, C. Ronda, A. Meijerink, Eu^{2+} luminescence in strontium aluminates, Phys. Chem. Chem. Phys. 17 (2015) 15236–15249, https://doi.org/10.1039/c5cp01095k.

[7] M. Capron, A. Douy, Strontium dialuminate $SrAl_4O_7$: synthesis and stability, J. Am. Ceram. Soc. 85 (2002) 3036–3040, https://doi.org/10.1111/j.1151-2916.2002.tb00575.x.

[8] Y. Tian, P. Zhang, Z. Zheng, Y. Chai, A novel approach for preparation of $Sr_3Al_2O_6$:Eu^{2+}, Dy^{3+} nanoparticles by sol-gel-microwave processing, Mater. Lett. 73 (2012) 157–160, https://doi.org/10.1016/j.matlet.2011.12.100.

[9] A.H. Wako, F.B. Dejene, H.C. Swart, Structural and luminescence properties of $SrAl_2O_4$:Eu^{2+},Dy^{3+},Nd^{3+} phosphor thin films grown by pulsed laser deposition, Phys. B Condens. Matter 480 (2016) 116–124, https://doi.org/10.1016/j.physb.2015.09.049.

[10] C.Y. Lin, S.H. Yang, J.L. Lin, C.F. Yang, Effects of the concentration of Eu^{3+} ions and synthesizing temperature on the luminescence properties of $Sr_{2-x}Eu_xZnMoO_6$ phosphors, Appl. Sci. 7 (2017), https://doi.org/10.3390/app7010030.

[11] M. Misevicius, V. Balevicius, Solid-state synthesis of $SrAl_4O_7$ and luminescence of Eu^{3+}-doped samples, Mater. Chem. Phys. 249 (2020) 122998, https://doi.org/10.1016/j.matchemphys.2020.122998.

[12] K.-Y. Yeh, C.-C. Yang, W.-R. Liu, M.G. Brik, Novel blue-emitting phosphors - $BaBeSiO_4$:Eu^{2+}: luminescence properties and its application for UV-light emitting diodes, Opt. Mater. Express 6 (2016), https://doi.org/10.1364/OME.6.000416.

[13] H. Ali, A.E. Giba, M.A. Khedr, Influence of calcination temperature on the photoluminescence spectral response of Sm-doped YAG nanocrystals as red-emitting phosphor, Optik 218 (2020), https://doi.org/10.1016/j.ijleo.2020.165106.

[14] K. Dev, A. Selot, G.B. Nair, V.L. Barai, N. Singh, F.Z. Haque, M. Aynyas, S.J. Dhoble, Study of luminescence properties of dysprosium-doped $CaAl_{12}O_{19}$ phosphor for white light-emitting diodes, Luminescence 34 (2019) 804–811, https://doi.org/10.1002/bio.3675.

[15] K. Mori, H. Onoda, T. Toyama, N. Osaka, Y. Kojima, Synthesis and fluorescence studies of Eu^{3+}-doped $SrAl_{12}O_{19}$ phosphor, Optik 180 (2019) 183–188, https://doi.org/10.1016/j.ijleo.2018.11.047.

[16] V. Singh, G. Sivaramaiah, N. Singh, J.L. Rao, P.K. Singh, M.S. Pathak, D.A. Hakeem, EPR and PL studies on UVB-emitting gadolinium-doped $SrAl_{12}O_{19}$ phosphors, Optik 158 (2018) 1227–1233, https://doi.org/10.1016/j.ijleo.2017.12.185.

[17] L. Wang, Y. Xu, D. Wang, R. Zhou, N. Ding, M. Shi, Y. Chen, Y. Jiang, Y. Wang, Deep red phosphors $SrAl_{12}O_{19}$:Mn^{4+},M (M = Li^+, Na^+, K^+, Mg^{2+}) for high colour rendering white LEDs, Phys. Status Solidi Appl. Mater. Sci. 210 (2013) 1433–1437, https://doi.org/10.1002/pssa.201228815.

[18] B.R. Judd, Optical absorption intensities of rare-earth ions, Phys. Rev. 127 (1962) 750–761, https://doi.org/10.1103/PhysRev.127.750.

[19] G.S. Ofelt, Intensities of crystal spectra of rare-earth ions, J. Chem. Phys. 37 (1962) 511–520, https://doi.org/10.1063/1.1701366.

[20] B.F. Dos Santos, M.V. Dos Santos Rezende, P.J.R. Montes, R.M. Araujo, M.A.C. Dos Santos, M.E.G. Valerio, Spectroscopy study of $SrAl_2O_4$:Eu^{3+}, J. Lumin. 132 (2012) 1015–1020, https://doi.org/10.1016/j.jlumin.2011.09.008.

[21] V. Singh, M. Seshadri, M. Radha, N. Singh, S.H. Nandyala, Intense infrared, visible up and down emissions in Er^{3+}/Yb^{3+} co-doped $SrAl_{12}O_{19}$ obtained by urea assisted combustion route, J. Mater. Sci. Mater. Electron. 29 (2018) 16516–16522, https://doi.org/10.1007/s10854-018-9745-1.

[22] A. Jain, S.P. Ong, G. Hautier, W. Chen, W.D. Richards, S. Dacek, S. Cholia, D. Gunter, D. Skinner, G. Ceder, K.A. Persson, Commentary: the materials project: a materials genome approach to accelerating materials innovation, Apl. Mater. 1 (2013), https://doi.org/10.1063/1.4812323.

[23] J. Park, A.N. Cormack, Crystal defect chemistry of strontium hexaaluminate magnetoplumbite, Mater. Sci. Technol. 11 (2000) 176–181.

[24] T.R. Wagner, T.J. Styranec, Preparation and crystal structure analysis of $Ba_2BiGa_{11}O_{20}$, J. Solid State Chem. 138 (1998) 313–320, https://doi.org/10.1006/jssc.1998.7790.

[25] I.A. Auwal, S. Güner, H. Güngüneş, A. Baykal, $Sr_{1-x}La_xFe_{12}O_{19}$ ($0.0 \leq x \leq 0.5$) hexaferrites: synthesis, characterizations, hyperfine interactions and magneto-optical properties, Ceram. Int. 42 (2016) 12995–13003, https://doi.org/10.1016/j.ceramint.2016.05.074.

[26] J.H. You, S.I. Yoo, Magnetic properties of Zn-substituted Y-type hexaferrites, $Ba_2Zn_xFe_{2-x}Fe_{12}O_{22}$, J. Magn. Magn Mater. 471 (2019) 255–261, https://doi.org/10.1016/j.jmmm.2018.09.064.

[27] N.R. Panchal, R.B. Jotania, Physical properties of strontium hexaferrite nano magnetic particles synthesized by a sol-gel auto-combustion process in presence of non ionic surfactant, Nanosci. Nanotechnol. Lett. 4 (2012) 623–627, https://doi.org/10.1166/nnl.2012.1361.

[28] S.N. Kamde, A.K. Nandanwar, P.G. Agone, K.G. Rewatkar, Effect of Cr^{3+} doped on structural, magnetic and electrical properties of sol-gel synthesized $SrFe_{12}O_{19}$ hexaferrite nanoparticles, Integrated Ferroelectrics Int. J. 203 (2019) 150–155, https://doi.org/10.1080/10584587.2019.1674959.

[29] K. Dev, A. Selot, G.B. Nair, C.M. Mehare, F.Z. Haque, M. Aynyas, S.J. Dhoble, Synthesis and photoluminescence study of Dy^{3+} activated $SrAl_{12}O_{19}$ phosphor, Optik 194 (2019) 1–10, https://doi.org/10.1016/j.ijleo.2019.163051.

[30] V.B. Pawade, S.J. Dhoble, Novel blue-emitting $SrMg_2Al_{16}O_{27}$:Eu^{2+} phosphor for solid-state lighting, Luminescence 26 (2011) 722–727, https://doi.org/10.1002/bio.1304.

[31] C.H. Lu, W.T. Hsu, J. Dhanaraj, R. Jagannathan, Sol-gel pyrolysis and photoluminescent characteristics of europium-ion doped yttrium aluminum garnet nanophosphors, J. Eur. Ceram. Soc. 24 (2004) 3723–3729, https://doi.org/10.1016/j.jeurceramsoc.2003.12.009.

[32] Y.H. Zhou, J. Lin, S.B. Wang, H.J. Zhang, Preparation of $Y_3Al_5O_{12}$:Eu phosphors by citric-gel method and their luminescent properties, Opt. Mater. 20 (2002) 13–20, https://doi.org/10.1016/S0925-3467(02)00020-4.

[33] P. Kaur, A. Khanna, M. Fábián, Effects of annealing temperature on structural and photoluminescence properties of Eu, Dy and Sm doped $CaWO_4$ nanoparticles, Ceram. Int. 46 (2020) 27262–27274, https://doi.org/10.1016/j.ceramint.2020.07.211.

[34] R.S. Yadav, R.K. Verma, A. Bahadur, S.B. Rai, Structural characterizations and intense green upconversion emission in Yb^{3+}, Pr^{3+}co-doped Y_2O_3 nano-phosphor, Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 137 (2015) 357–362, https://doi.org/10.1016/j.saa.2014.08.078.

[35] D.L. Dexter, J.H. Schulman, Theory of concentration quenching in inorganic phosphors, J. Chem. Phys. 22 (1954) 1063–1070, https://doi.org/10.1063/1.1740265.

UNCORRECTED PROOF

[36] Y. Zhang, J. Xu, B.B. Yang, Q. Cui, T. Tian, Luminescence properties and energy migration mechanism of Eu^{3+} activated $Bi_4Si_3O_{12}$ as a potential phosphor for white LEDs, Mater. Res. Express 5 (2018) 207–211, https://doi.org/10.1088/2053-1591/aaab8a.
[37] G. Blasse, Energy transfer in oxidic phosphors, Phys. Lett. 28 (1968) 444–445, https://doi.org/10.1016/0375-9601(68)90486-6.
[38] J. Tauc, Optical properties of amorphous semiconductors, in: J. Tauc (Ed.), Amorph. Liq. Semicond., Springer US, Boston, MA, 1974, pp. 159–220, https://doi.org/10.1007/978-1-4615-8705-7_4.
[39] H.K. Obayes, R. Hussin, H. Wagiran, M.A. Saeed, Strontium ion concentration effects on structural and spectral properties of $Li_4Sr(BO_3)_3$ glass, J. Non-Cryst. Solids 427 (2015) 83–90, https://doi.org/10.1016/j.jnoncrysol.2015.07.026.
[40] P. Hervé, L.K.J. Vandamme, General relation between refractive index and energy gap in semiconductors, Infrared Phys. Technol. 35 (1994) 609–615, https://doi.org/10.1016/1350-4495(94)90026-4.
[41] M.M.S. Sanad, M.M. Rashad, Tuning the structural, optical, photoluminescence and dielectric properties of Eu^{2+}-activated mixed strontium aluminate phosphors with different rare earth co-activators, J. Mater. Sci. Mater. Electron. 27 (2016) 9034–9043, https://doi.org/10.1007/s10854-016-4936-0.
[42] A. Ćirić, S. Stojadinović, M. Sekulić, M.D. Dramićanin, JOES: an application software for Judd-Ofelt analysis from Eu^{3+} emission spectra, J. Lumin. 205 (2019) 351–356, https://doi.org/10.1016/j.jlumin.2018.09.048.
[43] K. Binnemans, Interpretation of europium(III) spectra, Coord. Chem. Rev. 295 (2015) 1–45, https://doi.org/10.1016/j.ccr.2015.02.015.
[44] Ž. Antić, R. Krsmanović, V. Dorević, T. Dramićanin, M.D. Dramićanin, Optical properties of Y_2O_3:Eu^{3+} red emitting phosphor obtained via spray pyrolysis, Acta Phys. Pol., A (2009) 622–624, https://doi.org/10.12693/APhysPolA.116.622.
[45] Y. Zhang, J. Xu, B.B. Yang, Q. Cui, T. Tian, Luminescence properties and energy migration mechanism of Eu^{3+} activated $Bi_4Si_3O_{12}$ as a potential phosphor for white LEDs, Mater. Res. Express 5 (2018) 26202, https://doi.org/10.1088/2053-1591/aaab8a.
[46] M. Kumar, T.K. Seshagiri, S.V. Godbole, Fluorescence lifetime and Judd-Ofelt parameters of Eu^{3+} doped $SrBPO_5$, Phys. B Condens. Matter 410 (2013) 141–146, https://doi.org/10.1016/j.physb.2012.10.040.
[47] K. Vuković, S. Ćulubrk, M. Sekulić, M.D. Dramićanin, Analysis of luminescence of Eu^{3+} doped $Lu_2Ti_2O_7$ powders with Judd-Ofelt theory, J. Res. Phys. 38–39 (2016) 23–32, https://doi.org/10.1515/jrp-2015-0003.
[48] P.A. Tanner, Some misconceptions concerning the electronic spectra of tri-positive europium and cerium, Chem. Soc. Rev. 42 (2013), https://doi.org/10.1039/c3cs60033e.
[49] H.Q. Liu, L.L. Wang, S.G. Chen, B.S. Zou, Optical properties of nanocrystal and bulk ZrO_2: Eu^{3+}, J. Alloys Compd. 448 (2008) 336–339, https://doi.org/10.1016/j.jallcom.2006.11.171.
[50] S.Y. Zheng, J.W. Chiou, Y.H. Li, Correlation among photoluminescence and the electronic and atomic structures of Sr_2SiO_4:xEu^{3+} phosphors: X-ray absorption and emission studies, Sci. Rep. 10 (2020) 1–12, https://doi.org/10.1038/s41598-020-69428-7.
[51] I.E. Kolesnikov, A.V. Povolotskiy, D.V. Mamonova, Asymmetry ratio as a parameter of Eu^{3+} local environment in phosphors, J. Rare Earths 36 (2018) 474–481, https://doi.org/10.1016/j.jre.2017.11.008.
[52] W.F. Krupke, Optical absorption and fluorescence intensities in several rare-earth-doped Y_2O_3 and LaF_3 single crystals, Phys. Rev. 145 (1966) 325–337, https://doi.org/10.1103/PhysRev.145.325.
[53] R. Saraf, C. Shivakumara, S. Behera, H. Nagabhushana, N. Dhananjaya, Photoluminescence, photocatalysis and Judd-Ofelt analysis of Eu^{3+}-activated layered BiOCl phosphors, RSC Adv. 5 (2015) 4109–4120, https://doi.org/10.1039/c4ra10163d.
[54] S.S. Babu, P. Babu, C.K. Jayasankar, W. Sievers, T. Tröster, G. Wortmann, Optical absorption and photoluminescence studies of Eu^{3+}-doped phosphate and fluorophosphate glasses, J. Lumin. 126 (2007) 109–120, https://doi.org/10.1016/j.jlumin.2006.05.010.
[55] D.K. Singh, J. Manam, Structural and photoluminescence studies of red emitting $CaTiO_3$:Eu^{3+} perovskite nanophosphors for lighting applications, J. Mater. Sci. Mater. Electron. 27 (2016) 10371–10381, https://doi.org/10.1007/s10854-016-5123-z.
[56] W.T. Carnall, G.L. Goodman, K. Rajnak, R.S. Rana, A systematic analysis of the spectra of the lanthanides doped into single crystal LaF_3, J. Chem. Phys. 90 (1989) 3443–3457, https://doi.org/10.1063/1.455853.
[57] M. Kaczkan, S. Turczyński, M. Malinowski, Spectroscopic properties and Judd–Ofelt analysis of Eu^{3+} in $Y_4Al_2O_9$ crystals, J. Lumin. 196 (2018) 111–115, https://doi.org/10.1016/j.jlumin.2017.12.027.
[58] B. Han, B. Liu, J. Zhang, P. Li, H. Shi, Comparative photoluminescence properties and judd–Ofelt analysis of Eu^{3+} ion-activated metal molybdate phosphors A_2MoO_6:Eu^{3+} (A = La, Y, Gd and Bi), J. Electron. Mater. 46 (2017) 4039–4046, https://doi.org/10.1007/s11664-017-5390-3.
[59] J. Adam, W.A. Sibley, Optical transition of Pr3 + ions in Flurozirconate glass, J. Non-Cryst. Solids 76 (1985) 267–279, https://doi.org/10.1016/0022-3093(85)90004-3.
[60] C.R. Kesavulu, K.K. Kumar, N. Vijaya, K.S. Lim, C.K. Jayasankar, Thermal, vibrational and optical properties of Eu^{3+}-doped lead fluorophosphate glasses for red laser applications, Mater. Chem. Phys. 141 (2013) 903–911, https://doi.org/10.1016/j.matchemphys.2013.06.021.
[61] A. Yousif, S. Som, V. Kumar, H.C. Swart, Comparison and analysis of Eu^{3+} luminescence in $Y_3Al_5O_{12}$ and $Y_3Ga_5O_{12}$ hosts material for red lighting phosphor, Mater. Chem. Phys. 166 (2015) 167–175, https://doi.org/10.1016/j.matchemphys.2015.09.042.
[62] M. Ferhi, C. Bouzidi, K. Horchani-Naifer, H. Elhouichet, M. Ferid, Judd-Ofelt analysis of spectroscopic properties of Eu^{3+} doped $KLa(PO_3)_4$, J. Lumin. 157 (2015) 21–27, https://doi.org/10.1016/j.jlumin.2014.08.017.
[63] O.S.R.A.M. Sylvania L.E.D. ColorCalculator https://www.osram.us/cb/tools-and-resources/applications/led-colorcalculator/index.jsp 2019
[64] C.S. McCamy, Correlated color temperature as an explicit function of chromaticity coordinates, Color Res. Appl. 17 (1992) 142–144, https://doi.org/10.1002/col.5080170211.
[65] X. Huang, Q. Sun, B. Devakumar, Preparation, crystal structure, and photoluminescence properties of high-brightness red-emitting Ca_2LuNbO_6:Eu^{3+} double-perovskite phosphors for high-CRI warm-white LEDs, J. Lumin. 225 (2020) 117373, https://doi.org/10.1016/j.jlumin.2020.117373.
[66] I. Ahemen, D.K. De, F.B. Dejene, B. Viana, White light tunable emissions from ZnS:Eu^{3+} nanophosphors over 330-465nm excitation range for white LED applications, Mater. Res. Express 3 (2016), https://doi.org/10.1088/2053-1591/3/4/045016.
[67] N.A. Matrose, K. Obikese, Z.A. Belay, O.J. Caleb, Spectral investigations of less explored rod-shaped green emitting Ba_2SiO_4:Tb^{3+} phosphors for LED and Photovoltaic applications, Sci. Total Environ. (2019) 135907, https://doi.org/10.1016/j.scitotenv.2019.135907.

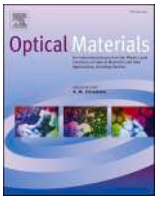
UNCORRECTED PROOF

Optical Materials 133 (2022) 112945

Contents lists available at ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat



Research Article

Photoluminescence and Judd-Ofelt analysis of Eu^{3+} doped akermanite silicate phosphors for solid state lighting

P.J. Chaware [a,*], Y.D. Choudhari [a], D.M. Borikar [a], K.G. Rewatkar [b]

[a] Dr. Ambedkar College, Nagpur, India
[b] Vidya Vikas Arts, Commerce and Science College, Samudrapur, India

ARTICLE INFO

Keywords:
Silicate
Judd-Ofelt
Rietveld refinement
XRD
Photoluminescence
CIE coordinates

ABSTRACT

After aluminates, alkaline-earth silicates are the most researched category of luminescent inorganic phosphors. Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors synthesized by the combustion process. For the as-prepared phosphors, XRD and Rietveld refinement revealed a single phase with akermanite type structure belonging to tetragonal crystallography. UV–Vis spectroscopy was used to calculate the optical bandgap. $Ca_2MgSi_2O_7$:x%Eu and $Sr_2MgSi_2O_7$:x%Eu (x = 0.5 - 2.5) phosphors produced orange-red light with emission peaks at 590 nm, 614 nm, and 702 nm, which corresponded to the Eu^{3+} transitions $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$, respectively. Using a modified Judd-Ofelt technique based on the emission spectrum, the key spectroscopic properties (transition probabilities, radiative lifetimes, and branching ratios) associated with the $^5D_0$ orange-red emitting level were found. $\Omega_2 < \Omega_4$ reveals that Eu^{3+} ions occupy high symmetry locations in the generated sample under the doping level studied in this work. There has also been a decrease in the Ω_4 parameter. It implies that the $^5D_0 \rightarrow {}^7F_2$ transition is more efficient than the $^5D_0 \rightarrow {}^7F_4$. This indicates that the red color emission has been improved. The estimated CIE coordinates corroborated the PL emission in the orange-red region.

1. Introduction

In recent years, due to their remarkable luminous qualities, rare-earth ion-doped inorganic phosphors have been utilized in various applications (e.g.- illumination, displays, the electronics sector, sensing technologies, biomedical application, and detection) [1–3]. As a solid-state lighting technology, white-light-emitting diodes (wLEDs) have many applications due to their energy efficiency, eco-friendliness, and durability. Upon receiving excitation from an external energy source, inorganic phosphors serve as photoluminescent materials, generating light through the host lattice or the added dopant ions. Dopant ions are the most common source of emission. As a result, a single host lattice might have a distinct color emission based on the type of dopant utilized [4,5]. The majority of commercially available phosphor materials are host lattices such as oxides, silicates, aluminates, sulfides, oxy-sulfides, nitrides, etc. Due to their excellent photoluminescence qualities, good chemical stability, and comparative ease of synthesis compared to other matrices, silicate matrices have attracted considerable interest in producing effective luminous materials [6–8]. Silica-based materials can be studied under standard synthetic conditions, and their constitution, shape, and size can be easily modified to increase the photoluminescence efficiency of phosphor materials. The silicate compounds doped with alkaline earth ions have broad uses in solid-state lasers and nonlinear optical systems. Impurity elements play a vital role in the optical properties of transition metals in solids for laser applications, as they can change the host material's properties. In recent years, alkaline earth-based silicate phosphors have garnered considerable interest due to their resistance to acid, alkali, and oxygen [9,10]. Today, trivalent rare-earth (RE) elements are widely used as dopants in producing luminous materials that any excitation radiation can activate. These materials are produced by doping various host matrices with Re^{3+} ions. Many scientists have studied RE-doped phosphors over the years. The element europium is unique among lanthanides in that its valence fluctuates. In addition to their shared characteristics, their luminescence properties recognize the various valences of rare earth elements. Because of its red-light emission property, Eu^{3+} ion has been utilized extensively in color television, panel displays, crts, and fluorescent powders of three primary colors. Therefore, it is crucial to develop more efficient red-emitting phosphors suitable for the production of white LEDs [11,12]. There has been substantial research into silicate-based

* Corresponding author.
E-mail addresses: pritichaware@gmail.com (P.J. Chaware), yograjchoudhari476@gmail.com (Y.D. Choudhari), drdmborikar@gmail.com (D.M. Borikar), kgrewatkar@gmail.com (K.G. Rewatkar).

https://doi.org/10.1016/j.optmat.2022.112945
Received 21 July 2022; Received in revised form 25 August 2022; Accepted 26 August 2022
0925-3467/© 2022 Elsevier B.V. All rights reserved.

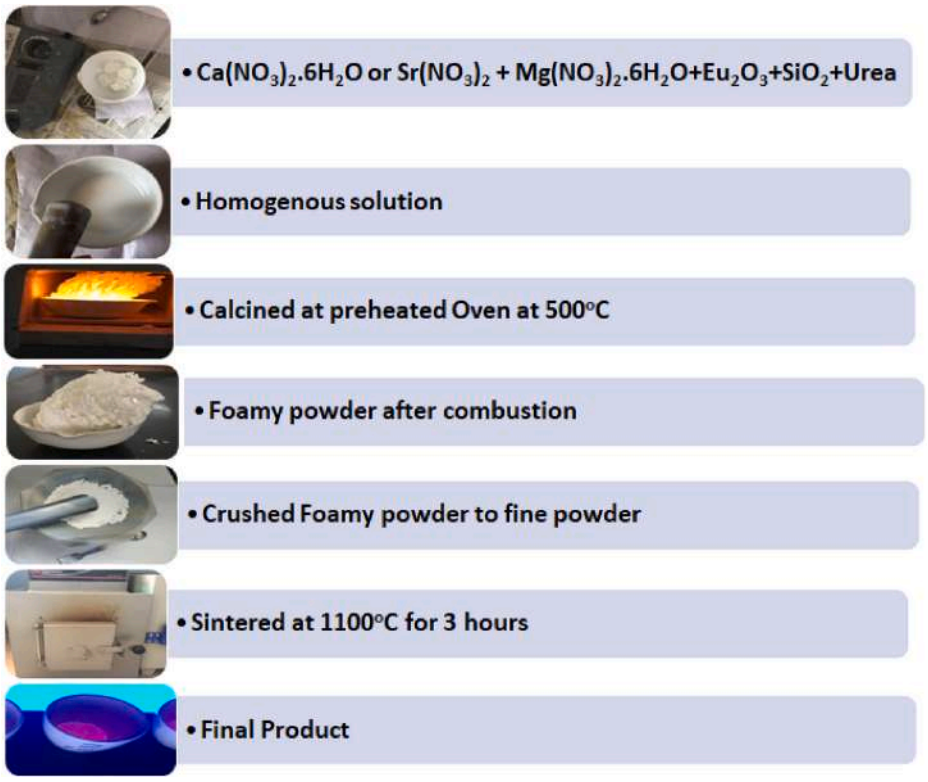


Fig. 1. Flow chart of the synthesis process for Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors.

materials due to their high quantum efficiency, water resistance, low cost, and great chemical and thermal stability. Materials such as Eu^{3+} are the most intriguing subject for red phosphors, which are commonly employed as a red-emitting activator through the $^5D_0 \rightarrow {}^7F_2$ transition at around 614 nm.

Despite extensive experimental and theoretical research, there are no precise descriptions of absorption and emission spectra for Eu^{3+}-activated silicate phosphor to compute the Judd–Ofelt (J-O) parameters. On Eu^{3+} ions in silicate akermanite systems, data on the radiative transition rates, emission branching ratios, and critical distance are not yet available. Important spectroscopic features are required to quantitatively assess the luminescence performance of Eu^{3+} ion in various hosts and design materials for specific optical devices.

In the present work, we report examining the spectroscopic characteristics of Eu^{3+}-doped calcium magnesium silicates and strontium magnesium phosphors synthesized by the combustion process, which enabled absorption measurements. Since activator ion concentration is one of the critical parameters that substantially impact the luminous behavior of phosphors, we explored the photoluminescence characteristics to determine the optimal activator ion concentration. The Judd–Ofelt (J-O) analysis of emission data of Eu^{3+} ions in silicates was done using photoluminescence data, allowing us to determine the intensity parameters. This technique enabled us to calculate the spontaneous transition probabilities (A_R), luminescence branching ratio (β_R), and radiative lifetime (τ_R).

2. Experimental

Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors prepared by combustion method and sintered at 1100 °C. The total oxidizing and reducing valencies of the ingredients were used to calculate the stoichiometry of the redox mixture used for the combustion process as the stoichiometric balance that requires numerical co-efficient is provided by this so that the energy released by the combustion is maximum and the equivalence ratio is unity. Phosphor powders were made using analytical grade calcium nitrate ($Ca(NO_3)_2{\cdot}6H_2O$), Strontium nitrate ($Sr(NO_3)_2$), silica powder (SiO_2), magnesium nitrate ($Mg(NO_3)_2{\cdot}6H_2O$), and Europium oxide (Eu_2O_3). In the first step, a mole of silica powder was dissolved in a concentrated nitric acid solution in a round-bottom flask (RBF). The contents of the RBF were then stirred on a magnetic stirrer for the creation of silica gel, which took around 10 min. Then Eu_2O_3 was dissolved in HNO_3. In contrast, a stoichiometric quantity of europium nitrate and comparable metal nitrates of Sr, Ca, and Mg were homogenously combined in a silica crucible with distilled water. The silica crucible nitrate mixture was then gently added to the flask containing gel, and this combined solution was agitated for roughly 30 min. To achieve consistent mixing of the predecessors, stirring was used. To achieve consistent mixing of the predecessors, stirring was used. The flask's precursors were put back into the silica crucible, which was then warmed on a heating plate to produce a semi-solid paste. At 400–500 °C, the gaseous compounds generated by the breakdown of metal nitrates are hypergolic. When heated to 500 °C, the redox combination boils, froths, and ultimately dehydrates, generating a gel that ignites to produce a massive powder. The entire combustion process was finished in a short period, say 5–10 min. After the combustion, the dish was immediately removed from the furnace, and the resultant voluminous and fluffy powder was crushed using a mortar and pestle in a fine powder; this calcinated phosphor powder was then sintered at 1100 °C for 3 h. The prepared powder was used for further characterization. The detailed flow chart of the combustion process is shown in Fig. 1.

3. Result and discussion

3.0.1. Structural analysis and morphological

The phase and size of the sintered specimen were determined using the XRD technique. The Rietveld refinement method and the FullProf suite—2000 software was used to compute the structural parameters. The morphology and shape of the nanocrystals were studied using scanning electron microscopy.

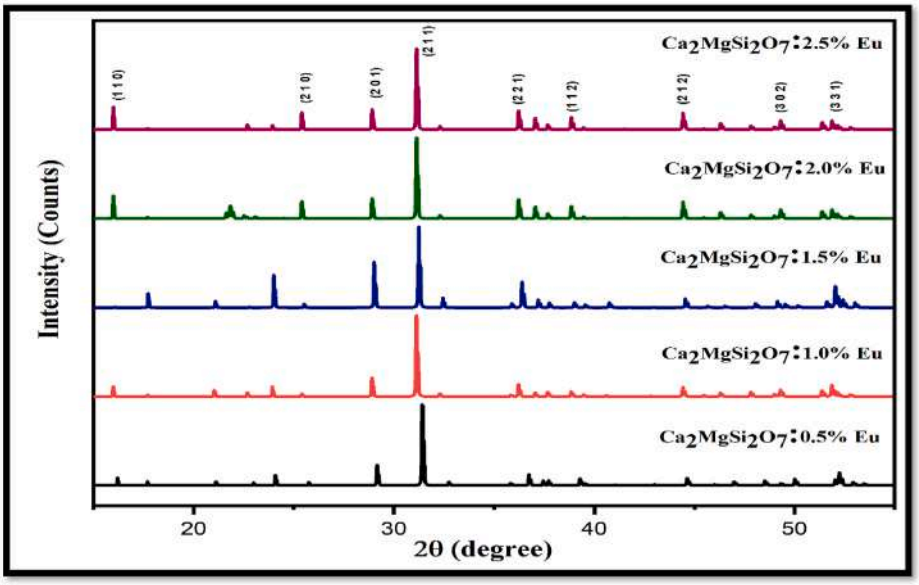


Fig. 2. XRD patterns of $Ca_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5,1.0,1.5, 2.0, and 2.5) phosphors.

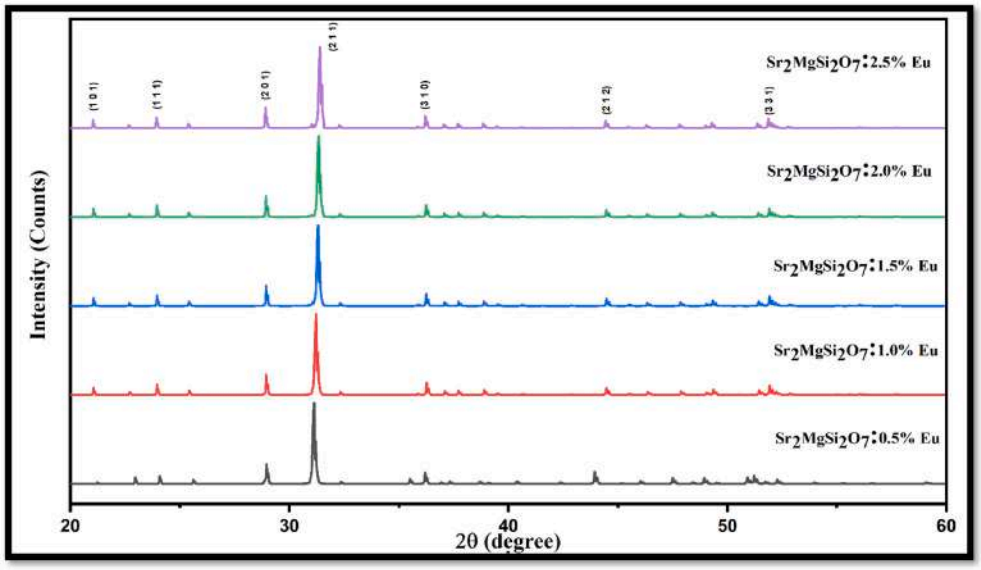


Fig. 3. XRD patterns of $Sr_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5,1.0,1.5, 2.0, and 2.5) phosphors.

3.0.2. X-ray diffraction analysis

The XRD patterns of Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors prepared by combustion method and sintered at 1100 °C are shown in Fig. 2 and Fig. 3 respectively. The position and intensity of diffraction peaks of the synthesized phosphors are well-matched with the Joint Committee Powder Diffraction Standard file (JCPDS: 75–1736) [13–15]. The prepared phosphors have an akermanite-type structure that belongs to tetragonal crystallography and has the space group $P42_1m$. This structure is a member of the melilite group and forms a layered compound. It is colorless and optically clear to translucent. $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ both have an akermanite structure. This structure has one calcium or strontium site that is coordinated by eight oxygen ions. Doped rare-earth ions (Eu^{3+}) have almost no influence on the phase structure of pure $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors. There were no further crystalline phases found. The average crystallite size was calculated from the XRD pattern using the Debye Scherrer relation $D = 0.9\lambda/\beta \cos\theta$, where λ is the wavelength of the incident X-ray radiation (0.154 nm), β is the full width at half maximum in radiation, and θ is the Bragg's angle.

Further, the diffraction data of synthesized silicate powder were examined using the Rietveld refinement (software FULLPROF) and the pseudo-Voigt function for profiling to get descriptions of structural and microstructural parameters. Fig. 4 and Fig. 5 show the Rietveld refinement of XRD patterns for $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors calcined powder respectively. Scale factor, zero correction, displacement, lattice constant, atomic coordinates, and ion occupancy are all updated during refining. During the research, no breach of space-group symmetry was discovered in the meta-stable condition. The lattice has three crystallographically independent cationic lattice sites: M^{2+} (where M = Ca and Sr), Mg^{2+}, and Si^{4+}. M_1 and M_2 atoms are connected to 8 Oxygen and 6 Oxygen atoms, respectively, to form 8-coordinated M_1O_8 and 6-coordinated M_2O_6 polyhedra; the average M − O distance is 2.573 Å. Furthermore, Si and O are joined to create SiO_4 tetrahedra, Mg and O

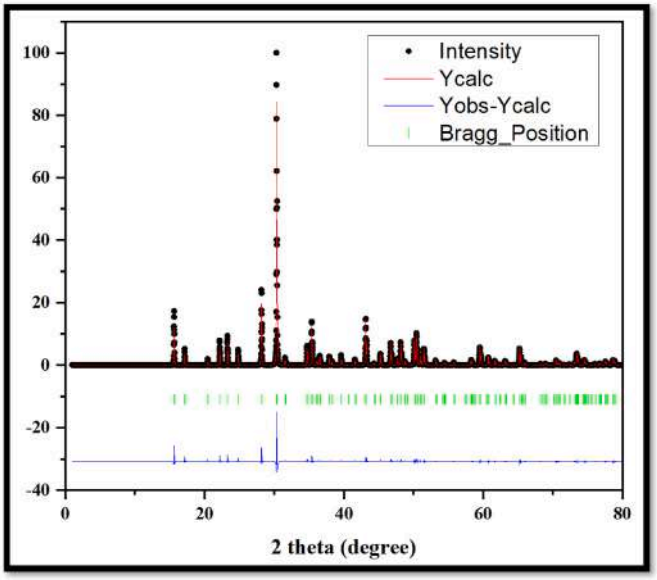


Fig. 4. Rietveld refinement of the $Ca_2MgSi_2O_7$:x%Eu^{3+}.

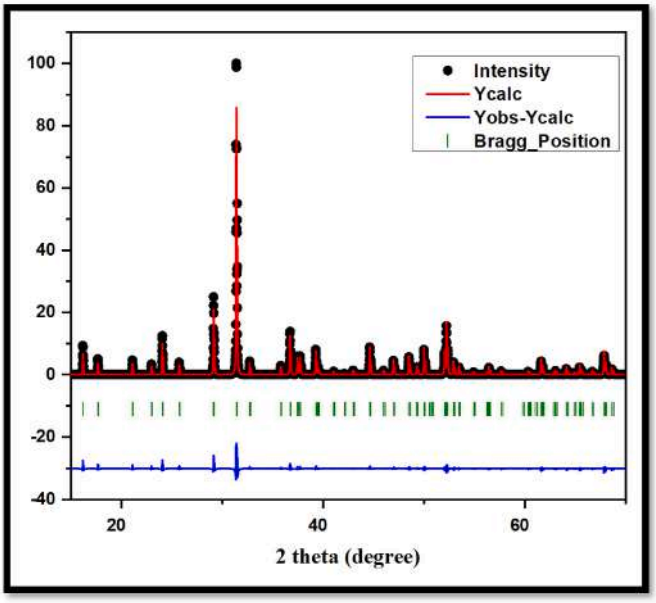


Fig. 5. Rietveld refinement of the $Sr_2MgSi_2O_7$:x%Eu^{3+}.

are connected to produce MgO_4 tetrahedra, and the two tetrahedra are connected to form the (Si/Mg) O_7 group by sharing an O atom; the average Mi-O distances are 1.916 Å (Mi = Mg) and 1.624 Å (Mi = Si), on average. M atoms are interspersed with these groups and closely packed together to produce a thick skeleton. The effective ionic radii of the eight-coordinated Ca^{2+} (r = 1.12 Å), Eu^{3+} (r = 1.06 Å), and Sr^{2+} (r = 1.26 Å) are all identical. In addition, as compared to Eu^{3+}, the effective ionic radii of Mg^{2+} and Si^{4+} in each coordination environment are comparatively modest. Taking the effective ionic radii of cations with various coordination numbers into account, it is possible to determine that the two doped rare-earth ions should occupy M^{2+} rather than Mg^{2+} (r = 0.57) and Si^{4+} (r = 0.26), which have modest ionic radii [16,17]. Fig. 6 depicts the arrangement of the unit cell of $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors, which are a tetragonal structure drawn with the program VESTA [18]. Table 1 and Table 2 provide the estimated average crystallite sizes, lattice parameter *a* and *c* values, and volume of $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors respectively. The average crystallite sizes were calculated using the plane of the most intense peak (211).

3.0.3. Scanning electron microscopy

The luminescence properties of phosphor particles are known to be affected by particle morphology, such as size, shape, size distribution, flaws, and so on. The surface morphology of the $Ca_2MgSi_2O_7$:2%Eu^{3+} and $Sr_2MgSi_2O_7$:2%Eu^{3+} phosphor is seen in Fig. 7 and Fig. 8 respectively. The sample's microstructure reveals the fundamental character of the combustion process. In this case, the form of the particles is irregular spherical, and they are firmly packed together. The agglomeration particles, empty spaces, and pores were caused by gases emitted during the combustion process. When gas escapes under high pressure during the combustion process, pores occur, and microscopic particles form around the pores. The particles are non-uniform and irregular forms can be traced to the non-uniform distribution of temperature and mass flow in the combustion flame [19,20].

3.0.4. Energy dispersive X-ray techniques (EDX)

EDX spectra were used to determine the chemical makeup of the powder sample. The elemental composition of a sample region as tiny as a few nanometers may be identified and quantified using EDX. The energy dispersive X-ray analysis plots for synthesized $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor calcined at 1100 °C are shown in Fig. 9 and Fig. 10 respectively. Table 3 and Table 4 show the chemical composition of $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor. For all the samples EDXA result shows almost the same ratio of chemicals was taken through stoichiometry. The presence of europium (Eu) may be seen in the EDX spectra. There was no additional emission other than calcium (Ca), magnesium (Mg), silicon (Si), and oxygen (O) in the phosphor's $Ca_2MgSi_2O_7$:2.0%Eu EDX spectra. In the presence of Ca, Mg, Si, O, and Eu, strong peaks are seen in the EDX spectra, indicating the production of $Ca_2MgSi_2O_7$:2.0%Eu phosphor. Similar results found in $Sr_2MgSi_2O_7$:2.0%Eu, strontium (Sr), magnesium (Mg), silicon (Si), and oxygen (O) are clearly shown in the EDX spectra and no additional emission seemed. In the spectrum, intense peaks are present which confirm the formation of $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor.

3.1. Optical and photoluminescence study

Optical absorption spectroscopy is a valuable tool for studying metals, semiconductors, and insulators in bulk, colloidal, thin-film, and nanostructure forms. The absorbed intensity as a function of wavelength, from ultraviolet to near-infrared, is important for understanding the electrical structure and transitions between the valence and conduction bands of materials. Luminescence studies are valuable for determining the electrical structure of a substance. It reveals not only the transitions between the conduction and valence bands but also the localized states caused by impurities or doping.

We examined the photoluminescence characteristics to determine the optimum concentration of the dopant ion since it is one of the most significant aspects that substantially impacts the luminous behavior of phosphors. The Judd-Ofelt (J-O) hypothesis was applied to rare-earth ions in several possible host materials. The intensity parameters were calculated using a J-O analysis of both absorption and emission data of Eu^{3+} ions in synthesized samples. The CIE 1931 chromaticity diagram was used to understand the distinct color-tunable characteristic of the produced nanophosphors.

3.1.1. UV–visible spectroscopy

The energy difference between the conduction band and the valence band is determined by the bandgap. Electrons are typically jumped from

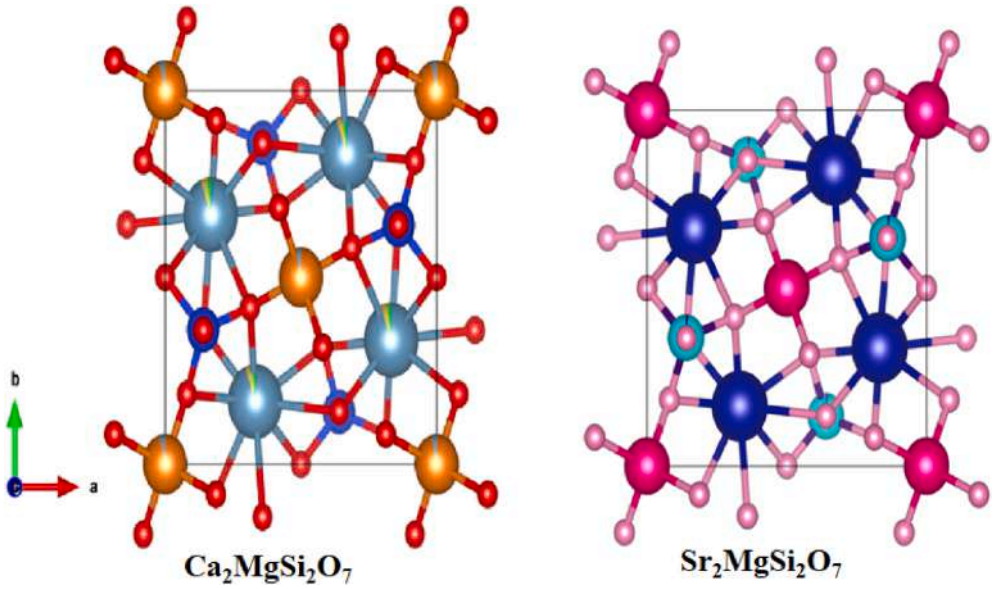


Fig. 6. Unit cells structures of silicates.

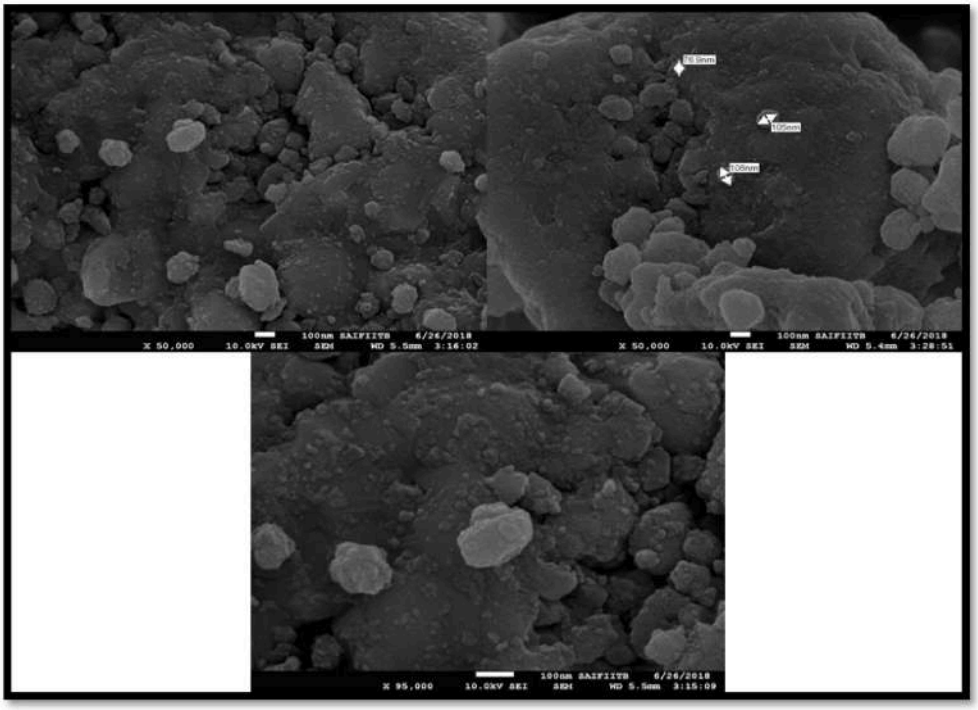


Fig. 7. SEM image of the $Ca_2MgSi_2O_7$:2%Eu^{3+} phosphor.

one band to another as long as a required minimum quantity of energy is given for the transition. The optical band gap was computed from absorption spectra using absorption edge values (edge, in nm). The wavelength range in absorption spectra is 200 nm–500 nm.

The Tauc relation is used to compute the bandgap energy [21]. According to the Tauc equation (6.2.1), the absorption coefficient and incident photon energy hν are related by the following:

$$(\alpha h\nu)^m = h\nu - Eg \quad (1)$$

where a = absorption coefficient, hν = photon energy, Eg = bandgap energy, m = 1/2 or 3/2 for indirect permitted and indirect forbidden transitions, and m = 2 or 3 for direct allowed and direct forbidden transitions [11,22].

Fig. 11 and Fig. 12 show the Tauc plot of $[(\alpha h\nu)^2]$ vs energy (eV) using equations (6.2.1), to construct a straight line with the energy intercept of the direct bandgap. The bandgap of $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor is 4.67 eV, and 4.79 eV, respectively.

3.1.2. Photoluminescence spectroscopy

The PLE and PL spectra of $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x% Eu^{3+} phosphor are displayed in Fig. 13 and Fig. 14 respectively. The PLE spectra shows series of sharp peak between 350 and 500 nm which were attributed to f-f transitions: $^7F_0 \rightarrow {}^5D_4$ (362 nm), $^7F_0 \rightarrow {}^5L_7$ (383 nm), $^7F_0 \rightarrow {}^5L_6$ (394 nm), $^7F_0 \rightarrow {}^5D_3$ (416 nm), and $^7F_0 \rightarrow {}^5D_2$ (467 nm) [23]. The

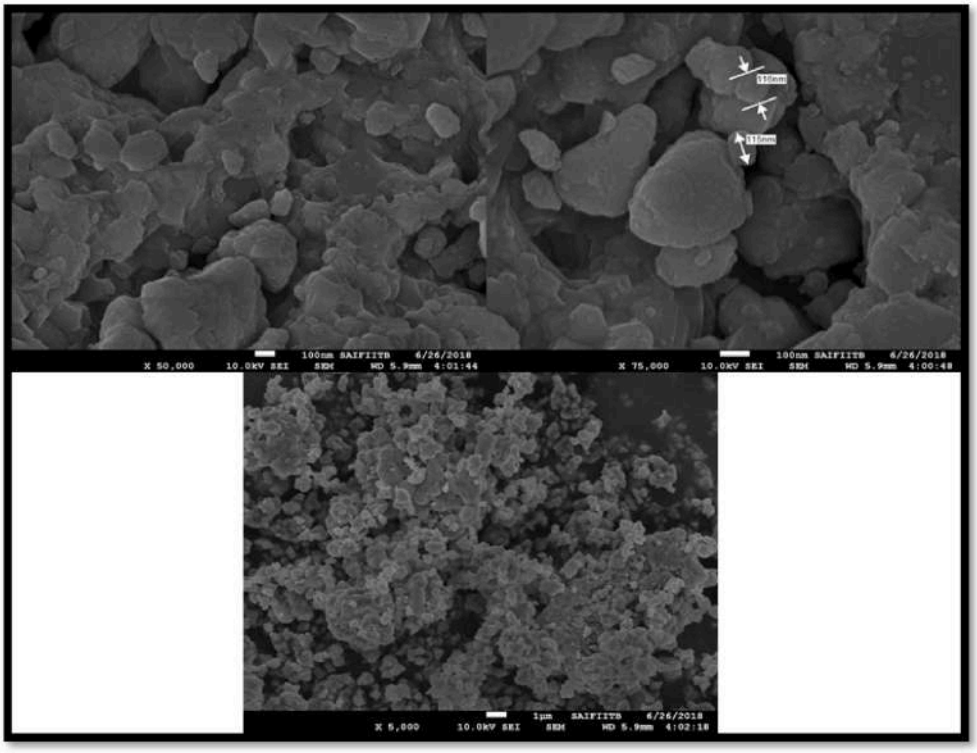


Fig. 8. SEM image of the $Sr_2MgSi_2O_7$:2%Eu^{3+} phosphor.

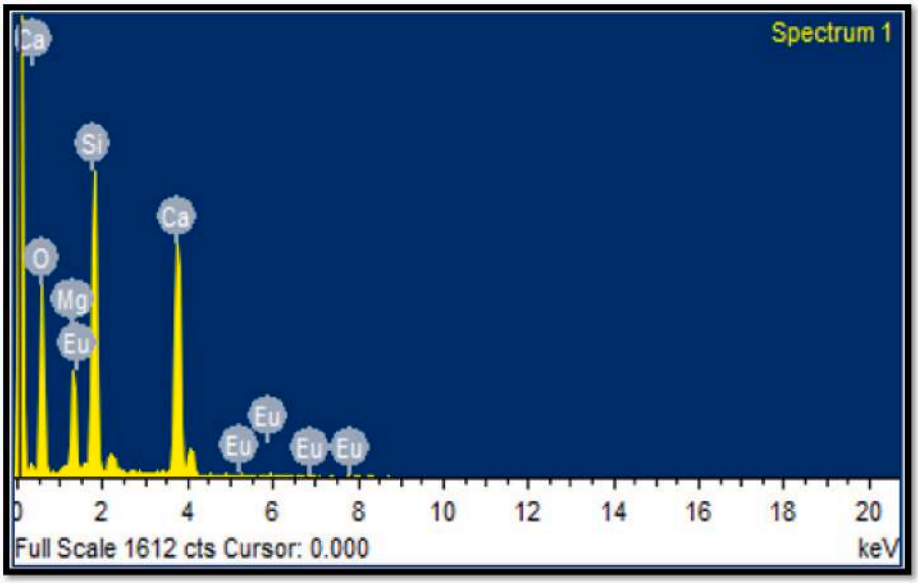


Fig. 9. The energy dispersive X-ray analysis plots for synthesized $Ca_2MgSi_2O_7$:2%Eu^{3+}phosphor.

highest powerful excitation peak (467 nm) coincided with the $^7F_0 \rightarrow {}^5D_2$ transition. One higher exciting peak at 394 nm suggests that an n-UV chip may efficiently excite the phosphor. The emission spectra showed three groups of emission lines 590 nm, 614 nm, and 702 nm, which are attributed to the $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$ transition of Eu^{3+} ions at the excitation wavelength of 467 nm, respectively. The transition $^5D_0 \rightarrow {}^7F_1$ is a magnetic-dipole transition is enabled by the parity selection rule when the Eu^{3+} ions are placed at a location with an inversion symmetric center, resulting in orange-red emission of about 590 nm. Whereas the transition $^5D_0 \rightarrow {}^7F_2$ is an electric-dipole transition that is hypersensitive to the crystal field and its intensity is sensitive to the crystal field. Fundamentally, if the Eu^{3+} ions are located at a site without an inversion symmetric center, the parity selection rule can be lifted because the opposite parity 5d configuration is mixed into the 4f configuration, and the f→f forbidden transition is partially allowed, the hypersensitive $^5D_0 \rightarrow {}^7F_2$ electric dipole transition will be permitted, resulting in red emission around 612 nm. The highest emission at the transition $^5D_0 \rightarrow {}^7F_2$ suggests that the Eu^{3+} ions occurred in the host lattice at low symmetry locations without an inversion center [13,24,25].

The doping concentration affects the performance of a luminescent material, therefore determining the optimum concentration for

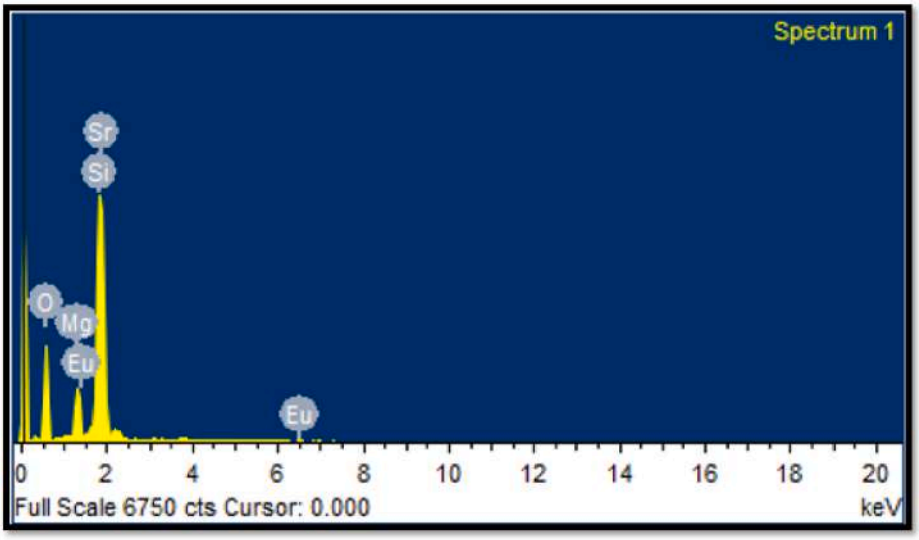


Fig. 10. The energy dispersive X-ray analysis plots for synthesized $Sr_2MgSi_2O_7$:2%Eu^{3+}phosphor.

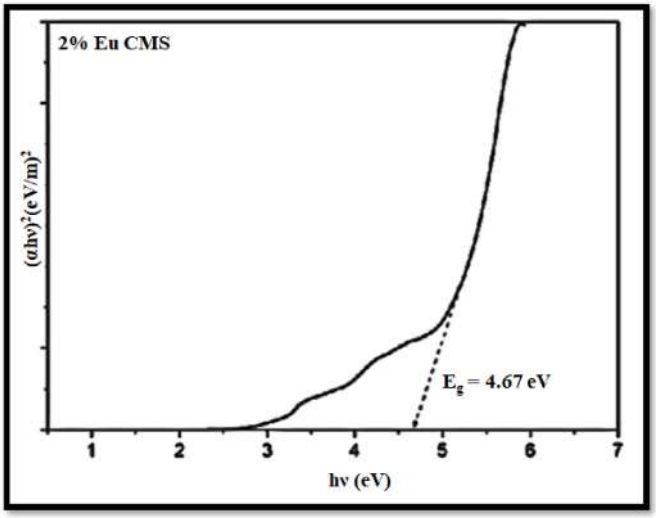


Fig. 11. The Tauc Plot of $Ca_2MgSi_2O_7$:2.0%Eu^{3+} phosphor.

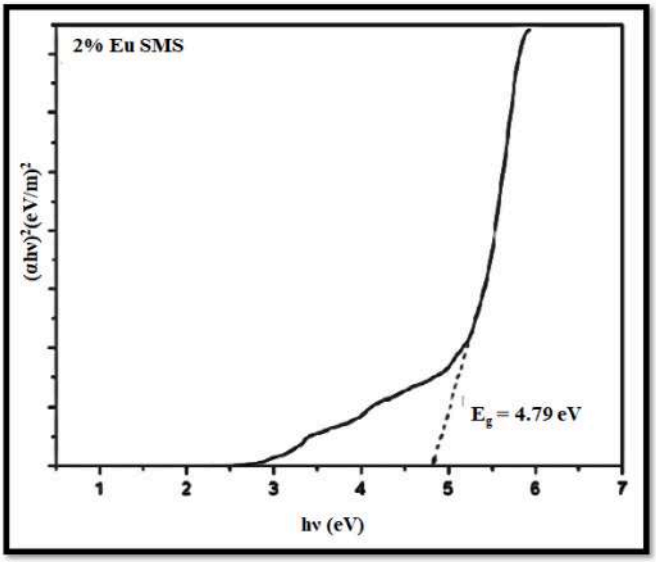


Fig. 12. The Tauc Plot of $Sr_2MgSi_2O_7$:2%Eu^{3+} phosphor.

luminescence is essential. As the Eu^{3+} doping concentration increases, the PL intensity increases up to 2 mol percent and then decreases shown in Fig. 15. The concentration quenching mechanism is mainly caused by the increase in non-radiative relaxation between nearby Eu^{3+} ions.

According to Blasse [26,27], if the activator is solely administered to Z ion sites, where x_c is the critical concentration, N is the number of Z ions in the unit cell, and V is the unit cell volume. The critical transfer distance (Rc) is calculated using the following equation:

$$R_c = 2\left(\frac{3V}{4\pi xN}\right)^{1/3} \quad (2)$$

R_c are computed as 19.422 and 19.425 for $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} respectively using V = 307.2688 for $Ca_2MgSi_2O_7$ and V = 306.8913 for $Sr_2MgSi_2O_7$, Z = 4, and $x_c = 0.02$. As R_c is found at more than 5, the exchange interaction does not affect the energy migration between Eu^{3+} ions in prepared phosphor, because the exchange interaction is generally dominant only for short distances in a forbidden transition [28–30], and the mechanism of radiation re-absorption is only effective when the fluorescence spectra are broadly overlapping. As a result, radiation reabsorption does not occur. Consequently, the process of energy transfer is caused by electric multipolar interactions such as dipole-dipole, dipole-quadrupole, and quadrupole-quadrupole [31]. If energy transfer happens between the same types of activators, the strength of the multipole-multipole interactions may be inferred from the change in emission intensity [28].

According to Dexter's theory, the relationship between luminescent intensity (I) and activator concentration (x) can be expressed by the following equation.

$$\frac{I}{x} = k\left[1 + \beta(x)^{\theta/3}\right]^{-1} \quad (3)$$

where I denote emission intensity; x denotes activator concentration; k and β are constants for the same interaction for a given host crystal; θ = 3 represents energy transfer among nearest-neighbor ions [31], while θ = 6, 8, and 10 represent dipole-dipole, dipole-quadrupole, and quadrupole-quadrupole interactions, respectively [32]. The slope of the relationship between log (I/x) and log (x) for $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} are −0.947 and −1.013 respectively, as illustrated in Fig. 16. Using Eq. (6), the value of is determined to be 2.841 and 3.039

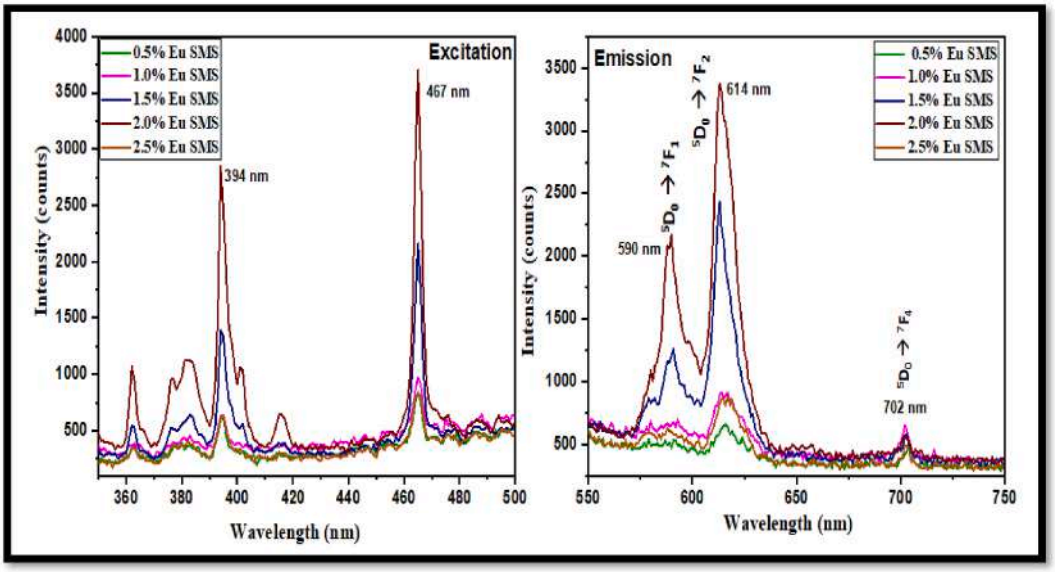


Fig. 13. The excitation and emission spectra of $Ca_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5) Phosphors.

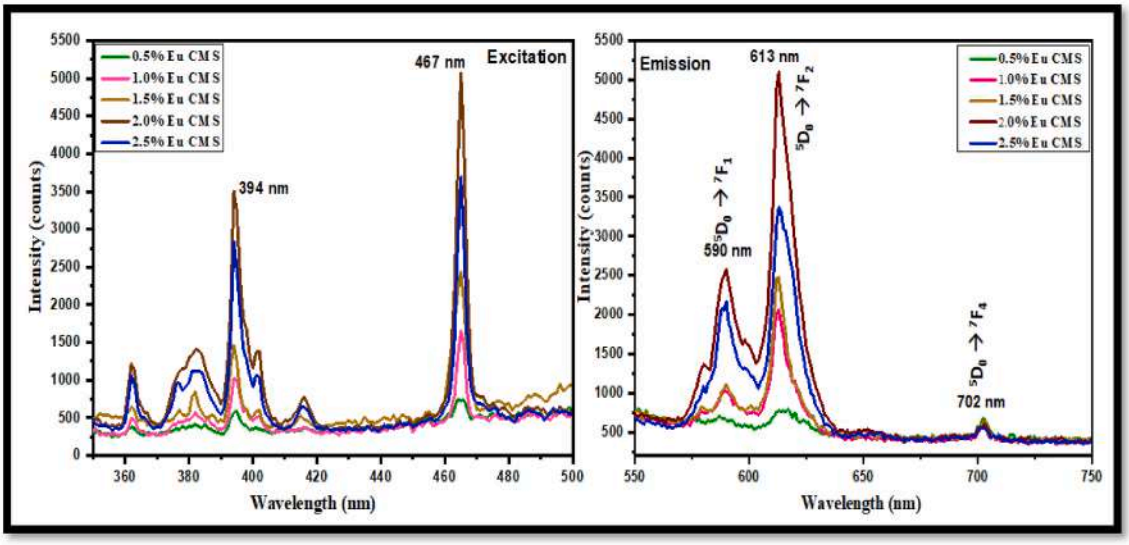


Fig. 14. The excitation and emission spectra of $Sr_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5) Phosphors.

respectively for $Ca_2MgSi_2O_7$:x%$Eu^{3+}$and $Sr_2MgSi_2O_7$:x%Eu^{3+}, which are nearly equal to 3. This finding suggests that the major mechanism of concentration quenching of $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x% Eu^{3+} is energy transfer among nearest neighbor ions.

3.1.3. Judd-Ofelt analysis

The notion of Judd-Ofelt theory is utilized to determine the nature of luminescence behavior and the site symmetry of Eu ions in the host lattice. J-O theory is used to characterize the strength of the f-f transition in rare-earth ions. The J-O intensity parameters Ω_2 and Ω_4 can provide information on the local structure and bonding in the vicinity of rare-earth ions. J-O theory is used to predict radiative characteristics such as radiative lifespan (τ_{rad}), radiative transition rates (A_T), and branching ratios (β_R) for different levels of Eu^{3+} ions.

The JO intensity parameters are estimated using the following equation (Eq. (4)) [33–36]:

$$\Omega_\lambda = \frac{D_{MD}\nu_1{}^3}{e^2\nu_\lambda{}^3U^\lambda}\frac{9n^3}{n(n^2+2)^2}\frac{J_\lambda}{J_1} \quad (4)$$

According to the J-O [14,15] hypothesis, the structural change surrounding rare-earth ions and the covalency of the rare earth sites impact the Ω_J parameters and spontaneous emission probability. In J-O characteristics, Ω_2 is sensitive to the environment and is connected to the covalency of the Eu^{3+} ion, whereas Ω_4 is related to the rigidity of the medium [33,37,38].

The asymmetric ratio is the ratio of the integral intensity of the electric dipole transition (EDT), $^5D_0 \rightarrow {}^7F_2$, to the magnetic dipole transition (MDT), $^5D_0 \rightarrow {}^7F_1$. In a matrix, the asymmetric ratio measures the degree of distortion near the surroundings of the Eu^{3+} ion [39,40]. Depending on the precise crystallographic site symmetry of Eu^{3+}, it might be very small or very large. The asymmetric ratio R [41,42],:

$$R = I_{EDT}/I_{MDT} \quad (5)$$

where I_{EDT} represents the intensity of EDT $^5D_0 \rightarrow {}^7F_2$, and I_{MDT} represents the intensity MDT $^5D_0$-$^7F_1$. The radiative transition A_λ can be expressed using the intensity parameter Ω_J, which is related to electric-dipole transitions, and can be calculated as [43,44],

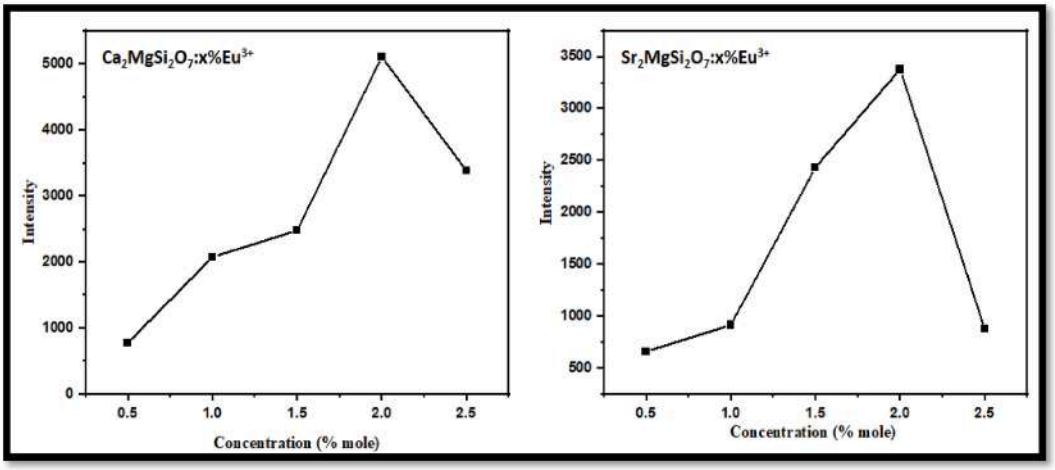


Fig. 15. Variation of PL emission (613 nm) Eu^{3+} Intensity for different concentration.

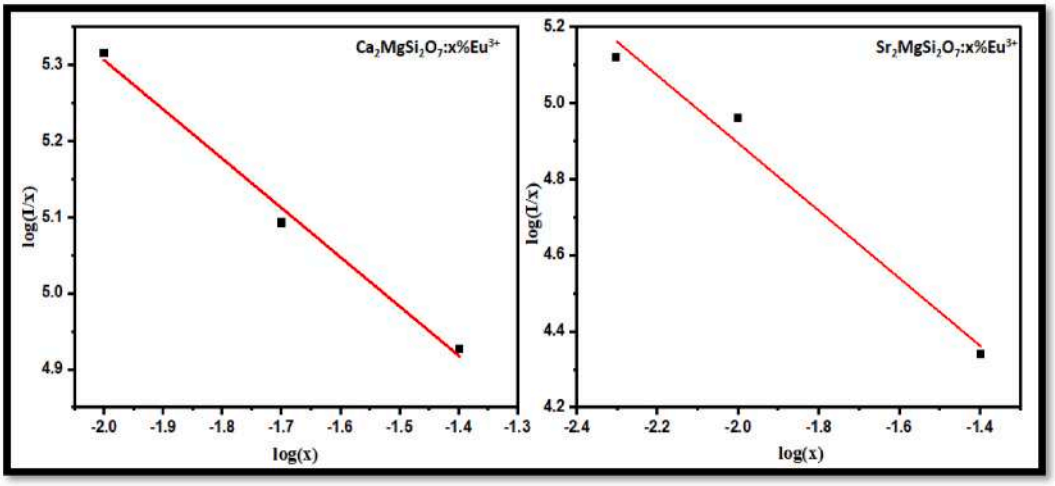


Fig. 16. The linear fitted curve of log (I/x) on log (x) of synthesized samples.

$$A_\lambda = \frac{64\pi^4 \nu_\lambda{}^3}{3h} \frac{n(n^2+2)^2}{9} D_{ED}{}^\lambda, \; as \; D_{ED}{}^\lambda = e^2 \Omega_\lambda U^\lambda \tag{6}$$

where, D_{ED} = dipole strength for ET), $h = 6.63x10^{-27}$ erg s. In Eq. (6), U^λ is abbreviation for $|J|U^\lambda|J|^2$ square reduced matrix elements which are independent of the chemical environment of dopant-Eu^{3+} ion [45]. The radiative time of the $^5D_0$ transition estimate using the sum of all radiative transition A_λ:

$$\tau = \frac{1}{\sum A_\lambda} \tag{7}$$

The branching ratio is the ratio of each transition to the total radiative transition given by, $\beta = \frac{A_\lambda}{\sum A_\lambda}$.

The values of J-O intensity parameters, radiative emission rates, lifetime, branching, and asymmetry ratios for different concentrations of Eu^{3+} in $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} are given in Table 5 and Table 6 respectively. The estimated intensity parameters for prepared phosphors show that the Ω_2 value gradually increases with increasing Eu^{3+} ion, indicating that the covalence degree of the Eu^{3+} site in both materials rises monotonically with doping level. Within the doping level investigated in this study, $\Omega_2 < \Omega_4$ demonstrates that Eu^{3+} ions occupy high symmetry positions in the synthesized sample. There is also a drop in the Ω_4 parameter. It suggests that the $^5D_0 \rightarrow {}^7F_2$ transition is more efficient than the $^5D_0 \rightarrow {}^7F_4$ transition. This implies that the red color emission has been enhanced [46].

The asymmetric ratio R is used to determine the quality of the host material by providing symmetry information around the Eu^{3+} covalency. If R < 1.0 is often considered to be for symmetric surroundings, R > 1.0 is considered to be for asymmetric surroundings. As a result of the high asymmetric ratio, the Eu^{3+} ion is found at sites with poor symmetry and no inversion center [47]. The predicted values of R for all Eu^{3+} concentrations are more than one, demonstrating symmetry distortion around the Eu^{3+} ion in the host lattice. This increased the relative strength of the hypersensitive dipole transition.

Also from the table, it is found that there is an increase in the overall radiative transition probability with an increase in Eu^{3+} concentration. This increase in transition probability might be attributed to the increase in lattice distortion, suggesting a loss in the local symmetry of Eu^{3+} ions. It is observed also from this study that the branching ratios (β) are considerably higher for the $^5D_0 \rightarrow {}^7F_2$ transition [48].

3.1.4. CIE

The CIE chromaticity coordinates are critical in determining the luminous properties of phosphors. The chromaticity coordinate calculation technique based on the CIE 1931 system - color calculator software is used to estimate the color coordinates from the emission spectrum [49].

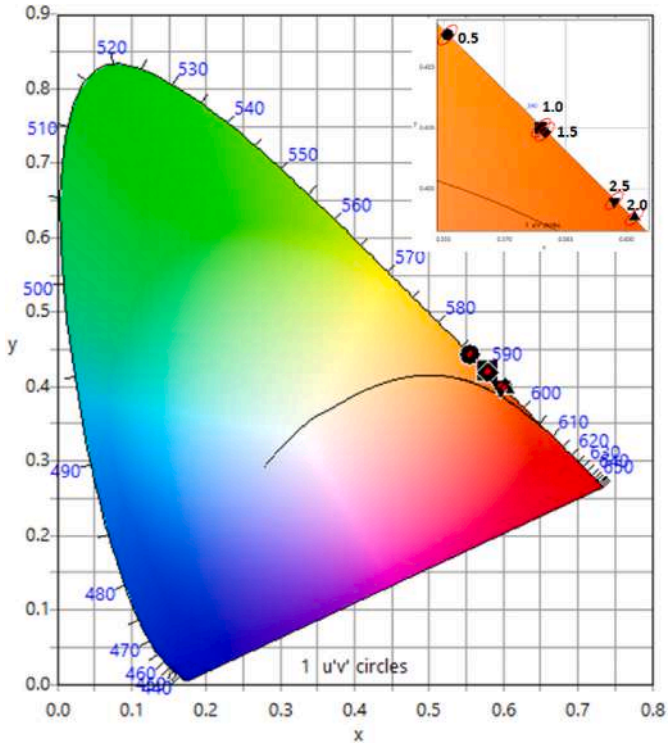


Fig. 17. The chromaticity coordinate diagram for $Ca_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5).

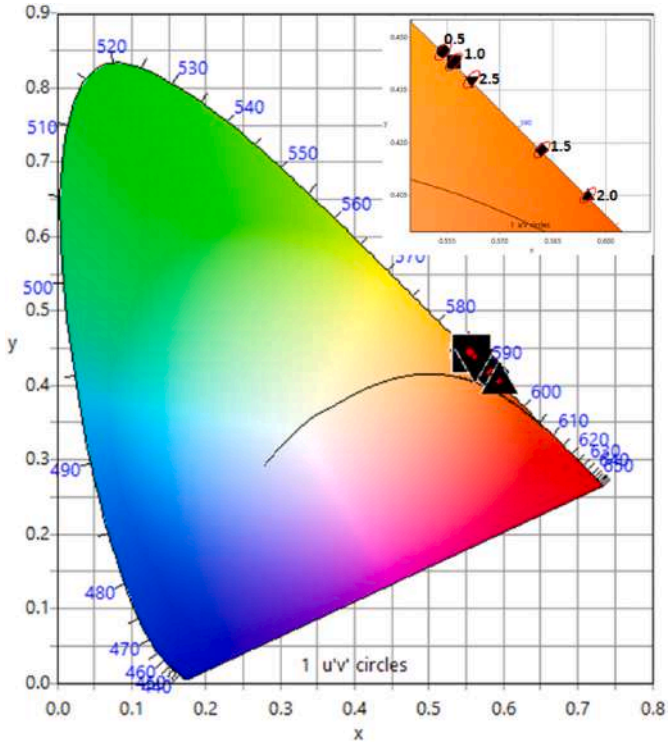


Fig. 18. The chromaticity coordinate diagram for $Sr_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5).

The CIE chromaticity diagram of $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} phosphors are shown in Fig. 17 and Fig. 18 respectively. The CIE chromaticity coordinates of $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors (which were measured at excitation wavelength

Table 1
the estimated crystallite sizes, lattice parameter, and volume of $Ca_2MgSi_2O_7$ phosphors.

Symbol	Lattice parameter		Volume ($Å^3$)	X-ray density (g/cm^3)	Crystalline size (nm)
	a = b (Å)	c (Å)			
CMS 1	7.7903	5.0262	305.0339	7.761784	57.43
CMS 2	7.8102	5.0245	306.4906	7.724894	57.41
CMS 3	7.8362	5.0087	307.5644	7.697925	46.34
CMS 4	7.8306	5.0071	307.0268	7.711402	54.71
CMS 5	7.8228	5.027	307.6333	7.6962	58.56

Table 2
the estimated average crystallite sizes, lattice parameter a and c values, and volume of $Sr_2MgSi_2O_7$ phosphors.

Symbol	Lattice parameter		Volume ($Å^3$)	X-ray density (g/cm^3)	Crystalline size (nm)
	a = b (Å)	c (Å)			
SMS 1	7.818	5.0051	305.9173	7.73937	57.49
SMS 2	7.826	5.0045	306.507	7.724481	56.66
SMS 3	7.83	5.0019	306.661	7.720602	57.28
SMS 4	7.832	5.0031	306.8913	7.714809	53.47
SMS 5	7.838	5.0062	307.5521	7.698232	54.76

Table 3
The atomic weight percentages of cations Ca2MgSi2O7:2.0%Eu3+.

Element	Weight %	Atomic %
O K	33.84	63.58
Mg K	4.29	5.24
Si K	13.58	14.55
Ca K	47.03	16.18
Eu L	1.25	0.44
Totals	99.99	

Table 4
The atomic weight percentages of cations Sr2MgSi2O7:2.0%Eu3+.

Element	Weight %	Atomic %
O K	42.40	64.55
Mg K	5.92	5.34
Si K	15.81	13.88
Sr K	34.88	15.02
Eu L	1.13	1.21
Totals	99.99	

λex = 397 nm) with varying Eu^{3+} concentrations were presented in Table 7 and Table 8 respectively.

The correlated color temperature (CCT) is usually used to identify the quality of emitted light for the glasses and can be calculated from the McCamy empirical equation [49]:

$$CCT = 437n^3 + 3601n^2 + 6861n + 5517 \quad (9)$$

Where n is the inverse of the slope and is equal to $(x - x_e)/(y_e - y)$; the epicenter points are $x_e = 0.332$ and $y_e = 0.186$. The estimated values for different Eu^{3+} concentrations for the $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors are presented in Table 7 and Table 8 respectively.

It is noticeable in the CIE chromaticity coordinate diagram that $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} phosphors excited at 397 nm shift to a pure red region with the increasing Eu^{3+} content. Hence the synthesized red color nanophosphors can be used to supplement other available red color phosphors, as well as with other suitable phosphors to compensate for any lack of red color. These color and spectrum data suggest that synthesized phosphors with more pure red chromaticity and

Table 5
The J–O intensity parameters and radiative parameter of $Ca_2MgSi_2O_7$:x%Eu^{3+}.

Concentration (mol%)	J–O intensity parameters (cm^{-2})		*Transition*	A (s^{-1})	β %	$\tau(s)$	Asymmetric ratio (R)
	Ω_2(x10^{-20})	Ω_4(x10^{-20})					
0.5	**2.1962**	**5.0064**	$^5D_0$-$^7F_1$	**14.488**	**23.91**	**0.0165**	**1.461**
			$^5D_0$-$^7F_2$	**21.384**	**35.28**		
			$^5D_0$-$^7F_4$	**24.733**	**40.81**		
1.0	**2.5325**	**4.0224**	$^5D_0$-$^7F_1$	**14.487**	**24.49**	**0.0169**	**1.608**
			$^5D_0$-$^7F_2$	**24.774**	**40.89**		
			$^5D_0$-$^7F_4$	**19.879**	**33.61**		
1.5	**2.7015**	**3.8074**	$^5D_0$-$^7F_1$	**14.486**	**24.23**	**0.01672**	**1.692**
			$^5D_0$-$^7F_2$	**26.473**	**44.28**		
			$^5D_0$-$^7F_4$	**18.821**	**31.48**		
2.0	**2.8045**	**2.7729**	$^5D_0$-$^7F_1$	**14.491**	**26.01**	**0.01794**	**1.763**
			$^5D_0$-$^7F_2$	**27.511**	**49.38**		
			$^5D_0$-$^7F_4$	**13.710**	**24.61**		
2.5	**2.7623**	**2.5209**	$^5D_0$-$^7F_1$	**14.493**	**26.81**	**0.0185**	**1.78**
			$^5D_0$-$^7F_2$	**27.095**	**50.13**		
			$^5D_0$-$^7F_4$	**12.464**	**23.06**		

Table 6
The J–O intensity parameters and radiative parameter of $Sr_2MgSi_2O_7$:x%Eu^{3+}.

Concentration (mol%)	J–O intensity parameters (cm^{-2})		*Transition*	A (s^{-1})	β %	$\tau(s)$	Asymmetric ratio (R)
	Ω_2(x10^{-20})	Ω_4(x10^{-20})					
0.5	**2.2813**	**4.8646**	$^5D_0$-$^7F_1$	**14.481**	**21.61**	**0.0165**	**1.458**
			$^5D_0$-$^7F_2$	**21.228**	**30.29**		
			$^5D_0$-$^7F_4$	**20.503**	**26.01**		
1.0	**2.3656**	**4.7353**	$^5D_0$-$^7F_1$	**14.482**	**21.63**	**0.0164**	**1.513**
			$^5D_0$-$^7F_2$	**22.650**	**32.35**		
			$^5D_0$-$^7F_4$	**19.503**	**24.81**		
1.5	**2.6084**	**3.7808**	$^5D_0$-$^7F_1$	**14.486**	**23.78**	**0.0170**	**1.65**
			$^5D_0$-$^7F_2$	**27.007**	**42.50**		
			$^5D_0$-$^7F_4$	**11.517**	**16.11**		
2.0	**2.625**	**2.9433**	$^5D_0$-$^7F_1$	**14.502**	**27.39**	**0.0182**	**1.653**
			$^5D_0$-$^7F_2$	**24.87**	**45.03**		
			$^5D_0$-$^7F_4$	**7.718**	**12.415**		
2.5	**2.6151**	**3.1148**	$^5D_0$-$^7F_1$	**14.486**	**21.69**	**0.0180**	**1.651**
			$^5D_0$-$^7F_2$	**23.749**	**34.02**		
			$^5D_0$-$^7F_4$	**17.89**	**22.84**		

Table 7
CIE chromaticity coordinates of the $Ca_2MgSi_2O_7$:x%Eu^{3+}.

Concentration	C_x	C_y	CCT
0.5	0.556	0.443	1948
1	0.579	0.42	1672
1.5	0.58	0.419	1661
2	0.602	0.398	1440
2.5	0.597	0.402	1484

Table 8
CIE chromaticity coordinates of the $Sr_2MgSi_2O_7$:x%Eu^{3+}.

Concentration	C_x	C_y	CCT
0.5	0.554	0.446	1979
1	0.557	0.443	1940
1.5	0.582	0.418	1645
2	0.595	0.405	1509
2.5	0.562	0.438	1877

gain are a superior choice for luminescence applications.

4. Conclusion

In this work, Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors were sintered at 1100 °C after being synthesized by the combustion process. For the as-prepared phosphors, XRD and Rietveld refinement revealed a single phase with akermanite type structure belonging to tetragonal crystallography. UV–Vis spectroscopy was used to calculate the optical bandgap. $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphors have band gaps of 4.67 eV and 4.79 eV, respectively. $Ca_2MgSi_2O_7$:x%Eu and $Sr_2MgSi_2O_7$:x%Eu phosphors produced orange-red light with emission peaks at 590 nm, 613 nm, and 702 nm, which corresponded to the Eu3+ transitions $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$, respectively. The main spectroscopic features (transition probabilities, radiative lifetimes, and branching ratios) associated with the $^5D_0$ orange-red emitting level were determined using a modified Judd-Ofelt approach based on the emission spectrum. $\Omega_2 < \Omega_4$ reveals that Eu^{3+} ions occupy high symmetry locations in the generated sample under the doping level studied in this work. There has also been a decrease in the Ω_4 parameter. It implies that the $^5D_0 \rightarrow {}^7F_2$ transition is more efficient than the $^5D_0 \rightarrow {}^7F_4$. This indicates that the red color emission has been improved. The estimated CIE coordinates corroborated the PL emission in the orange-red region.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

[1] R. Shukla, S.K. Gupta, H. Yadav, P. Ranjane, R.M. Kadam, S.N. Achary, A.K. Tyagi, A carnegieite type red emitting $NaAlSiO_4:Eu^{3+}$ phosphor: concentration dependent time resolved photoluminescence and Judd-Ofelt analysis, J. Lumin. 209 (2019) 283–290, https://doi.org/10.1016/j.jlumin.2019.02.002.

[2] Z. Shi, J. Wang, H. Jiang, X. Guan, Y. Lu, J. Shi, Photoluminescence characteristics and energy transfer mechanism of Eu^{3+}:$NaY(WO_4)_2$ microparticles, J. Mater. Sci. Mater. Electron. 30 (2019) 3169–3176, https://doi.org/10.1007/s10854-018-00597-y.

[3] P. Chaware, K.G. Rewatkar, Structural, and photoluminescence study of $SrAl_2O_4$: Eu^{3+} phosphors synthesized by combustion method, Int. J. Chem. Math. Phys. (IJCMP). 5 (2021) 1–6, https://doi.org/10.22161/ijcmp.5.6.1.

[4] I. Prasad Sahu, D.P. Bisen, N. Brahme, Structural characterization and optical properties of $Ca_2MgSi_2O_7:Eu^{2+}$, Dy^{3+} phosphor by solid-state reaction method, Luminescence 30 (2015) 526–532, https://doi.org/10.1002/bio.2771.

[5] L. Fernández-Rodríguez, A. Durán, M.J. Pascual, Silicate-based persistent phosphors, Open. Ceram. 7 (2021), 100150, https://doi.org/10.1016/j.oceram.2021.100150.

[6] D. Singh, S. Sheoran, V. Tanwar, S. Bhagwan, Optical characteristics of Eu(III) doped MSiO3 (M = Mg, Ca, Sr and Ba) nanomaterials for white light-emitting applications, J. Mater. Sci. Mater. Electron. 28 (2017) 3243–3253, https://doi.org/10.1007/s10854-016-5914-2.

[7] D. Pandey, Comparison study of the thermo- luminescent property of the long after glow phosphors $Ca_2MgSi_2O_7$:Eu with different concentration, (n.d.) 119–123.

[8] D. Singh, S. Sheoran, S. Bhagwan, S. Kadyan, Optical characteristics of sol-gel derived M3SiO5:Eu3+ (M = Sr, Ca and Mg) nanophosphors for display device technology, Cogent Phys. (2016) 1–12, https://doi.org/10.1080/23311940.2016.1262573, 0.

[9] M.M.S. Sanad, D.A. Rayan, M.M. Rashad, Optical and photoluminesce properties of Eu2+-activated strontium magnesium silicate phosphors using different rare earth co-activators, Opt. Quant. Electron. 51 (2019) 1–14, https://doi.org/10.1007/s11082-019-1913-x.

[10] G. Tiwari, N. Brahme, R. Sharma, D.P. Bisen, S.K. Sao, S.J. Dhoble, A study on the luminescence properties of gamma-ray-irradiated white light emitting Ca2Al2SiO7:Dy3+ phosphors fabricated using a combustion-assisted method, RSC Adv. 6 (2016) 49317–49327, https://doi.org/10.1039/c6ra04913c.

[11] R.E.M. Khaidir, Y.W. Fen, M.H.M. Zaid, K.A. Matori, N.A.S. Omar, M.F. Anuar, S.A. A. Wahab, A.Z.K. Azman, Optical band gap and photoluminescence studies of Eu 3 + -doped zinc silicate derived from waste rice husks, Optik 182 (2019) 486–495, https://doi.org/10.1016/j.ijleo.2019.01.061.

[12] V. Singh, MdM. Haque, D.-K. Kim, ChemInform abstract: investigation of a new red-emitting, Eu 3+ -activated MgAl 2 O 4 phosphor, ChemInform 39 (2008) 47–49, https://doi.org/10.1002/chin.200812009.

[13] T.T. Hao Tam, N.D. Hung, N.T.K. Lien, N.D. Trung Kien, P.T. Huy, Synthesis and optical properties of red/blue-emitting $Sr_2MgSi_2O_7:Eu^{3+}/Eu^{2+}$ phosphors for white LED, J. Sci.: Adv. Mater. Dev. 1 (2016) 204–208, https://doi.org/10.1016/j.jsamd.2016.06.009.

[14] M. Li, L. Wang, W. Ran, Z. Deng, J. Shi, C. Ren, Tunable luminescence in Sr2MgSi2O7: Tb3+, Eu3+phosphors based on energy transfer, Materials 10 (2017), https://doi.org/10.3390/ma10030227.

[15] R. Shrivastava, J. Kaur, Characterization and studies on long-lasting properties of Ca2MgSi2O7: Eu2+, Dy3+ phosphors, Ferroelectrics 494 (2016) 52–60, https://doi.org/10.1080/00150193.2016.1135537.

[16] G. Tiwari, N. Brahme, R. Sharma, D.P. Bisen, S.K. Sao, S. Tigga, Luminescence properties of dysprosium doped di-calcium di-aluminum silicate phosphors, Opt. Mater. 58 (2016) 234–242, https://doi.org/10.1016/j.optmat.2016.05.033.

[17] T.T. Hao Tam, N.D. Hung, N.T.K. Lien, N.D. Trung Kien, P.T. Huy, Synthesis and optical properties of red/blue-emitting $Sr_2MgSi_2O_7:Eu^{3+}/Eu^{2+}$ phosphors for white LED, J. Sci.: Adv. Mater. Dev. 1 (2016) 204–208, https://doi.org/10.1016/j.jsamd.2016.06.009.

[18] K. Momma, F. Izumi, VESTA 3 for three-dimensional visualization of crystal, volumetric and morphology data, J. Appl. Crystallogr. 44 (2011) 1272–1276, https://doi.org/10.1107/S0021889811038970.

[19] D. Pandey, N. Brahme, R. Sharma, A. Pandey, Synthesis photoluminescence study of Ca2MgSi 2 O7 : Ce, Adv. Phys. Lett. 3 (2016) 18.

[20] I.P. Sahu, D.P. Bisen, N. Brahme, Europium doped di-calcium magnesium di-silicate orange–red emitting phosphor by solid state reaction method, J. Radiat. Res. Appl. Sci. 8 (2015) 381–388, https://doi.org/10.1016/j.jrras.2015.02.007.

[21] J. Tauc, Optical properties of amorphous semiconductors, in: J. Tauc (Ed.), Amorphous and Liquid Semiconductors, Springer US, Boston, MA, 1974, pp. 159–220, https://doi.org/10.1007/978-1-4615-8705-7_4.

[22] R. Neema, M. Saleem, P.K. Sharma, M. Mittal, Structure, Optical Bandgap and Luminescence Studies of SrAl2O4: Eu3+, Dy3+ Nanophosphor, 3Rd International Conference on Condensed Matter and Applied Physics, vol. 2220, 2020, 020159, https://doi.org/10.1063/5.0002749. Icc-2019.

[23] J. Cheng, J. Zhang, X. Bian, Z. Zhai, J. Shi, Spectrochimica Acta Part A : Molecular and Biomolecular Spectroscopy Photoluminescence Properties , Judd-Ofelt Analysis , and Optical Luminescent Materials, 2020, p. 230.

[24] K. Mondal, J. Manam, Enhancement of photoluminescence in Eu3+ co-activated $Ca_2MgSi_2O_7:Dy^{3+}$ phosphors for solid state lighting application, J. Mol. Struct. 1125 (2016) 503–513, https://doi.org/10.1016/j.molstruc.2016.07.028.

[25] S. Stojadinović, N. Tadić, A. Ćirić, R. Vasilić, Photoluminescence properties of Eu3 + doped HfO2 coatings formed by plasma electrolytic oxidation of hafnium, Opt. Mater. 77 (2018) 19–24, https://doi.org/10.1016/j.optmat.2018.01.014.

[26] G. Blasse, B.C. Grabmaier, Luminescent Materials, Springer Berlin Heidelberg, 1994, https://doi.org/10.1007/978-3-642-79017-1.

[27] G. Blasse, Energy transfer in oxidic phosphors, Phys. Lett. 28 (1968) 444–445, https://doi.org/10.1016/0375-9601(68)90486-6.

[28] D. Deng, H. Yu, Y. Li, Y. Hua, G. Jia, S. Zhao, H. Wang, L. Huang, Y. Li, C. Li, S. Xu, Ca<sub4$(PO_4)_2$O:Eu^{2+} red-emitting phosphor for solid-state lighting: structure{,} luminescent properties and white light emitting diode application, J. Mater. Chem. C 1 (2013) 3194–3199, https://doi.org/10.1039/C3TC30148F.

[29] Q. Zhang, X. Ding, Y. Wang, Novel highly efficient blue-emitting $SrHfSi_2O_7:Eu^{2+}$ phosphor: a potential color converter for WLEDs and FEDs, Dyes Pigments 163 (2019) 168–175, https://doi.org/10.1016/j.dyepig.2018.11.052.

[30] S. Ray, P. Tadge, S. Dutta, T.M. Chen, G.B. Nair, S.J. Dhoble, Synthesis, luminescence and application of $BaKYSi_2O_7:Eu^{2+}$: a new blue-emitting phosphor for near-UV white-light LED, Ceram. Int. 44 (2018) 8334–8343, https://doi.org/10.1016/j.ceramint.2018.02.022.

[31] D.L. Dexter, J.H. Schulman, Theory of concentration quenching in inorganic phosphors, J. Chem. Phys. 22 (1954) 1063–1070, https://doi.org/10.1063/1.1740265.

[32] L. Ozawa, P.M. Jaffe, The mechanism of the emission color shift with activator concentration in $\mathplus$3, Activ. Phosphors. 118 (1971) 1678, https://doi.org/10.1149/1.2407810.

[33] Ž. Antić, R. Krsmanović, V. Dor ević, T. Dramićanin, M.D. Dramićanin, Optical properties of $Y_2O_3:Eu^{3+}$ red emitting phosphor obtained via spray pyrolysis, Acta Phys. Pol., A (2009) 622–624, https://doi.org/10.12693/APhysPolA.116.622.

[34] A. Ćirić, S. Stojadinović, M. Sekulić, M.D. Dramićanin, JOES: an application software for Judd-Ofelt analysis from Eu^{3+} emission spectra, J. Lumin. 205 (2019) 351–356, https://doi.org/10.1016/j.jlumin.2018.09.048.

[35] K. Binnemans, Interpretation of europium(III) spectra, Coord. Chem. Rev. 295 (2015) 1–45, https://doi.org/10.1016/j.ccr.2015.02.015.

[36] P. Chaware, A. Nande, S.J. Dhoble, K.G. Rewatkar, Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu^{3+} doped strontium hexa-aluminate nanophosphors for lighting application, Opt. Mater. 121 (2021), 111542, https://doi.org/10.1016/j.optmat.2021.111542.

[37] M. Kumar, T.K. Seshagiri, S.v Godbole, Fluorescence lifetime and Judd-Ofelt parameters of Eu^{3+} doped $SrBPO_5$, Phys. B Condens. Matter 410 (2013) 141–146, https://doi.org/10.1016/j.physb.2012.10.040.

[38] K. Vuković, S. Čulubrk, M. Sekulić, M.D. Dramićanin, Analysis of luminescence of Eu^{3+} doped $Lu_2Ti_2O_7$ powders with Judd-Ofelt theory, J. Res. Phys. 38–39 (2016) 23–32, https://doi.org/10.1515/jrp-2015-0003.

[39] P.A. Tanner, Some misconceptions concerning the electronic spectra of tri-positive europium and cerium, Chem. Soc. Rev. 42 (2013), https://doi.org/10.1039/c3cs60033e.

[40] H.Q. Liu, L.L. Wang, S.G. Chen, B.S. Zou, Optical properties of nanocrystal and bulk ZrO_2: Eu^{3+}, J. Alloys Compd. 448 (2008) 336–339, https://doi.org/10.1016/j.jallcom.2006.11.171.

[41] S.Y. Zheng, J.W. Chiou, Y.H. Li, Correlation among photoluminescence and the electronic and atomic structures of $Sr_2SiO_4:xEu^{3+}$ phosphors: X-ray absorption and emission studies, Sci. Rep. 10 (2020) 1–12, https://doi.org/10.1038/s41598-020-69428-7.

[42] I.E. Kolesnikov, E.v. Golyeva, E.v. Borisov, E.Y. Kolesnikov, E. Lähderanta, A. v. Kurochkin, M.D. Mikhailov, Photoluminescence properties of Eu^{3+}-doped $MgAl_2O_4$ nanoparticles in various surrounding media, J. Rare Earths 37 (2019) 806–811, https://doi.org/10.1016/j.jre.2018.10.019.

[43] S.S. Babu, P. Babu, C.K. Jayasankar, W. Sievers, T. Tröster, G. Wortmann, Optical absorption and photoluminescence studies of Eu^{3+}-doped phosphate and fluorophosphate glasses, J. Lumin. 126 (2007) 109–120, https://doi.org/10.1016/j.jlumin.2006.05.010.

[44] D.K. Singh, J. Manam, Structural and photoluminescence studies of red emitting $CaTiO_3:Eu^{3+}$ perovskite nanophosphors for lighting applications, J. Mater. Sci. Mater. Electron. 27 (2016) 10371–10381, https://doi.org/10.1007/s10854-016-5123-z.

[45] W.T. Carnall, G.L. Goodman, K. Rajnak, R.S. Rana, A systematic analysis of the spectra of the lanthanides doped into single crystal LaF_3, J. Chem. Phys. 90 (1989) 3443–3457, https://doi.org/10.1063/1.455853.

[46] E. Cantelar, J.A. Sanz-garcía, J. Enrique, Structural , Photoluminescent Properties and Judd-Ofelt Analysis of Eu 3 þ -activated CaF 2 Nanocubes, 2020, p. 813.

[47] W.F. Krupke, Optical absorption and fluorescence intensities in several rare-earth-doped Y_2O_3 and LaF_3 single crystals, Phys. Rev. 145 (1966) 325–337, https://doi.org/10.1103/PhysRev.145.325.

[48] M. Ferhi, C. Bouzidi, K. Horchani-Naifer, H. Elhouichet, M. Ferid, Judd-Ofelt analysis of spectroscopic properties of Eu^{3+} doped $KLa(PO_3)_4$, J. Lumin. 157 (2015) 21–27, https://doi.org/10.1016/j.jlumin.2014.08.017.

[49] C.S. McCamy, Correlated color temperature as an explicit function of chromaticity coordinates, Color Res. Appl. 17 (1992) 142–144, https://doi.org/10.1002/col.5080170211.

Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Analysis of structural, electric and magnetic features of Bi^{3+} substituted nanocrystalline calcium hexaferrite

Y.D. Choudhari [a,*], K.G. Rewatkar [b]

[a] Department of Physics, Dr. Ambedkar College, DeekshaBhoomi, Nagpur-10, India
[b] Vidya Vikas Arts Commerce and Science College, Samudrapur, India

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Calcium hexaferrite
Bismuth
XRD
FE-SEM
HR-TEM
VSM, etc.

ABSTRACT

Calcium hexaferrite ($CaFe_{12-x}BixO_{19}$, x=0.2–0.8) was successfully brewed through a microwave-induced sol–gel auto-combustion technique with Bi^{3+} as a substitute. The impact of added Bi^{3+} ions on the structure, morphology, magnetic, and dielectric properties of calcium hexaferrite was analyzed using an X-ray powder diffractometer (XRD), Field emission scanning electron microscopy (FE-SEM), vibrating sample Magnetometry (VSM), Fourier transforms infrared spectroscopy (FT-IR), and impedance study. The peak position in the XRD pattern confirms the development of single-phase hexagonal ferrite nanoparticles with a space group of P63/mmc and an average crystalline size of 46–56 nm. Magnetic analysis revealed that when the Bi^{3+} ion is added to Ca ferrite, the material's coercive force improves, but the saturation magnetization decreases. The dielectric constant, electric conductivity, and loss tangent of the substance were determined for frequencies ranging from 20 Hz to 1 MHz, indicating appropriate for various applications, including permanent magnets and high-density magnetic recording media.
Copyright © 2022 Elsevier Ltd. All rights reserved.
Selection and peer-review under responsibility of the scientific committee of the International Conference on Emerging Trends in Material Science and Technology – 2022.

1. Introduction

Ferrites are the most commonly used high-performance magnetic compounds; they appear to be stiff, fragile, ceramic-like materials that are structurally sensitive due to much higher electrical resistance values than metallic materials. Because the unique features of nanomaterials seem significantly size-dependent, achieving sustained grip on the size and shape of the nanoparticle during the manufacturing process is a necessity for their practical deployment [1]. Hexagonal materials have been subdivided into five distinct groups, based on their chemical formulas and degree of crystallinity: M, W, X, Y, and Z. M-type hexaferrite, such as $BaFe_{12}O_{19}$ and $SrFe_{12}O_{19}$, have sparked the most interest in the industrial and scientific community. Calcium is readily available on our planet compared to other elements such as barium and strontium. M-type calcium hexaferrite is a potential material for low-cost permanent magnets because of their chemical stability and uniaxial solid magnetocrystalline anisotropy along the hexagonal c-axis [2]. It is magnetically, electrically, mechanically durable, and thermally stable. This hexaferrite's electric and magnetic characteristics could be acclimated by substituting paramagnetic and diamagnetic cations for iron (Fe^{3+}) [3].

The Al-doped calcium Nano Hexaferrite prepared by solution combustion technique using metal nitrates as oxidants including ODH as reducing agents by Ch. Mamatha et al, they address specific conclusion there was a reduction in saturation magnetization (Ms), coercivity (Hc), dc electrical resistivity, activation energy furthermore Retentivity (Mr) raises with the increment in Al concentration [4]. The Mg^{2+} and Ti^{4+} ions doped M-type Ca hexagonal ferrites were produced using the citrate sol–gel method by Ali Sharbati1 and Gholam Reza Amiri1 et al. characterized the material by using XRD, VSM, TEM, furthermore additionally study the microwave absorption properties. The magnetic properties like saturation magnetization improved while coercive force contracted with Mg–Ti content, for nanocomposite 0.6 and 0.9 cm, the minimal reflection loss is −31.5 and −39 dB, respectively [5]. Christy et al. used the microwave-aided auto combustion sol–gel method was to produce calcium hexaferrite supplemented with cobalt and zirconium. The particle sizes of the synthesized samples were less than 50 nm. The synthesizing compounds can be utilized in a medium with a high density of recording due to their ability to achieve a suitable signal-to-noise ratio. As the frequency grew, the

* Corresponding author.
E-mail address: yograjchoudhari476@gmail.com (Y.D. Choudhari).

https://doi.org/10.1016/j.matpr.2022.02.416
2214-7853/Copyright © 2022 Elsevier Ltd. All rights reserved.
Selection and peer-review under responsibility of the scientific committee of the International Conference on Emerging Trends in Material Science and Technology – 2022.

Please cite this article as: Y.D. Choudhari and K.G. Rewatkar, Analysis of structural, electric and magnetic features of Bi^{3+} substituted nanocrystalline calcium hexaferrite, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2022.02.416

dielectric constant and dielectric loss tangent declined, showing that these nanocomposites are appropriate for high-frequency applications [6]. In the current study the microwave-induced sol–gel auto-combustion method used to produce M-type calcium hexaferrite with the formula $CaBi_xFe_{12-x}O_{19}$ (x = 0.2–0.8). The sol–gel auto combustion process is advantageous than the others, this is a simplistic, secure, and quick procedure that gains high homogeneity, purity, time efficiency. The effect of bismuth substitution at the Fe^{3+} sites on the structure and electrical properties of calcium hexaferrite has been explored.

2. Experimental

2.1. Material preparation

It was conceivable to synthesis $CaBi_xFe_{12-x}O_{19}$ (x = 0.2–0.8) M-type bismuth substituted calcium hexaferrite using the microwave-induced sol–gel auto-combustion process. The synthesis procedure uses a hybrid combination in which metal nitrates operate as an oxidizing reactant and urea acts as a reducing reactant to ignite ignition. In a beaker, equimolar quantities of AR grade $Ca(NO_3)_2{\cdot}4H_2O$, $Fe(NO_3)_3{\cdot}9H_2O$, and $Bi(NO_3)_3{\cdot}9H_2O$ and urea are mixed in deionized water [7,8]. A microwave oven was used to burn the gel; at first, the solution boils at 70–90 °C and dehydrates, then decomposes, releasing a considerable quantity of fumes in the process as shown in Fig. 1. When the mixture achieves the implication of self-initiated burning, it starts inflaming [9]. It emits a large amount of heat, vaporizing the entire solution instantly and turning into a solid at a temperature above 500 °C. Bismuth substituted calcium hexaferrite powder can be made in a microwave oven in less than a few minutes by burning the material. The composite material was crushed in a pestle and mortar to make nanoparticles. Nanocomposite materials were produced by calcining the fine particles in an electric furnace for 5 hr at 800 °C [10,11].

2.2. Characterization

A Bruker AXS, D8 Advance X-ray diffractometer (STIC Kochi) was used to record the ferrites' x-ray diffraction (XRD) patterns. The samples' surface morphology and elemental composition were studied using a Jeol-6390LA field emission scanning electron

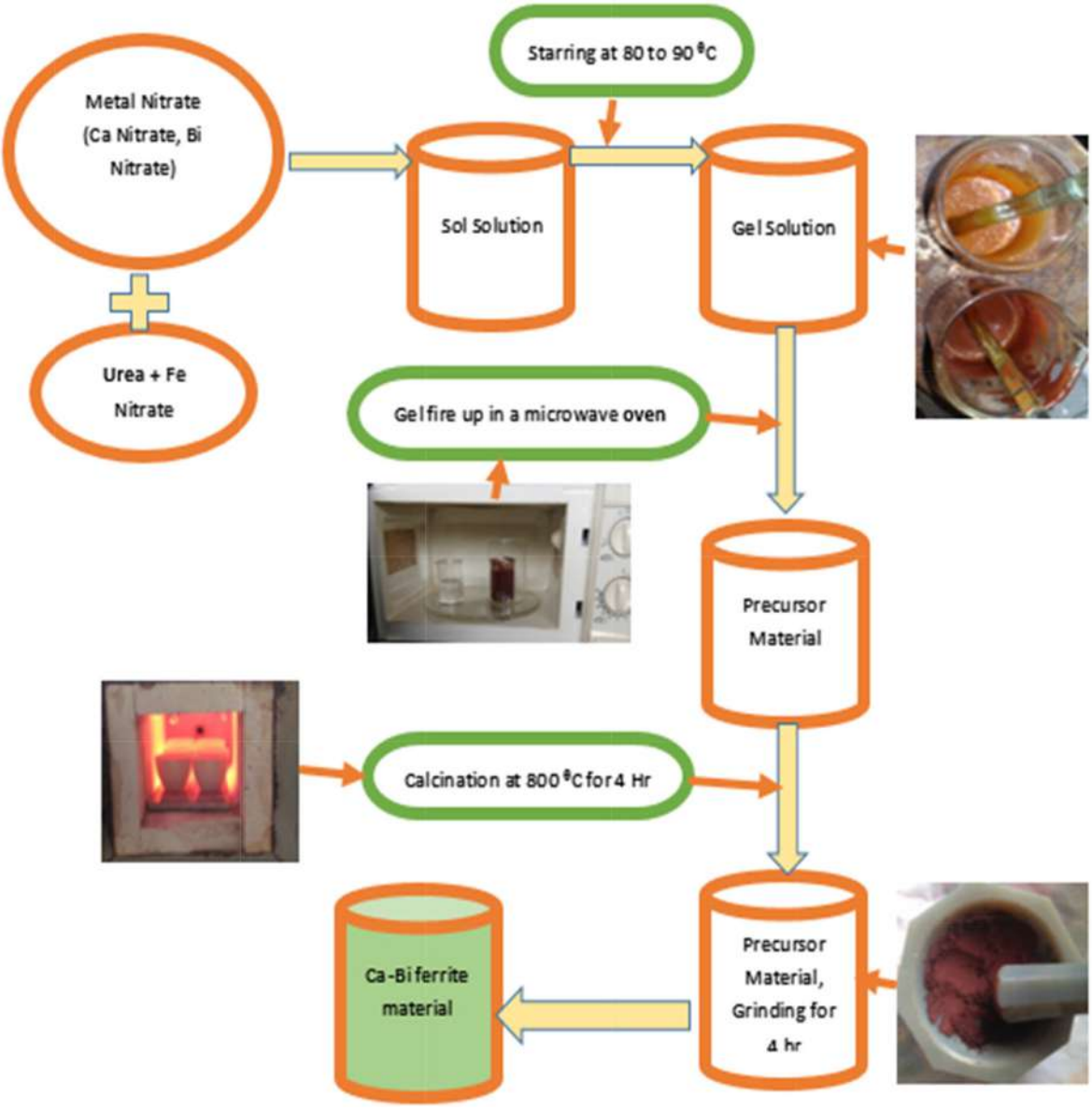


Fig. 1. Flowchart for the synthesis of $CaBixFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

microscope (FE-SEM) equipped with energy dispersive spectroscopy (EDX). A JEOL JEM-2100F transmission electron microscope was used to examine particle size. A vibrating sample magnetometer, Lakeshore 7410 model (CIF-IITG), was used to make the magnetic measurements. The ferrite powders were crafted in the shape of pellets (with a diameter of 10 mm and a thickness of 2–4 mm) for electrical measurements. A Wayne Kerr, 6500B impedance analyzer was used to conduct electrical measurements.

3. Results and discussions

3.1. Structural analysis

XRD spectroscopy was utilized to assess the phase and structural composition of Ca-Bi hexaferrite; the trend is displayed in Fig. 2. The observed peaks were referenced to JCPDS file **49–1586**. The crystallinity size (D) was calculated using the scherrer formula based on the position of the maximum peak intensity [12].

$$\boldsymbol{D = K\lambda/\beta\cos\theta}$$

where β (FWHM) stands for full width at half maximum, θ represents Bragg's angle of maximum intensity peak, and The symbol λ represents the wavelength of Cu Kα rays [13]. The lattice constants (a and c), surface area (Sa), and unit cell volume (Vc) has been derived via

$$\frac{\mathbf{1}}{\mathbf{d^2}} = \frac{\mathbf{4}}{\mathbf{3}}\left(\frac{\mathbf{h^2 + k^2 + hk}}{\mathbf{a^2}}\right) + \frac{\mathbf{l^2}}{\mathbf{c^2}}$$

$$\boldsymbol{S_a = 6000/D * X_d}$$

$$\boldsymbol{V_c = 0.866 * a^2 c}$$

The magnetoplumbite structure and space group P63/mmc (SG:194) were adapted to index the X-ray diffraction patterns of calcium hexaferrite. The (107) plane had the highest intensity diffraction peak for the Ca-Bi hexaferrite specimen [14]. The XRD studies comprised of M-type hexaferrite standard reflecting planes (006), (107), (002), (1000), (213), (126), and (307). The Bi^{3+} percentage had a significant impact on the diffraction peak intensity in the (107) and (200) planes. Table 1 shows the crystallite size, lattice parameters a and c, lattice volume, c/a ratio, surface area, bulk density, and X-ray density (Xd) of Bi^{3+} doped calcium hexaferrite. As seen in x-ray diffraction patterns, the prominent (107) peak point was displaced to a lower inclination with Bi^{3+} ion replacements [15]. The peak location shifted due to variations in Fe^{3+} (0.64 Å) ionic radii and Bi^{3+} (1.06 Å) ions. This movement produced homogeneous strain and elastic deformation in the structure, causing the lattice constants a and c, lattice volume, and crystallinity size to drop as the Bi^{3+} ion density rises [16]. All specimen has crystallite sizes in the nanoscale range. This magnetoplumbite crystal structure contains five Fe positions: 2a, 2b, 12k, $4f_1$, and $4f_2$. $4f_1$ is a tetrahedral site, 2b is a bi-pyramidal site, and 2a, 12k, and $4f_2$ are octahedral [9]. The correlation coefficient (c/a) was within the estimated limit of 3.84–4.06, indicating the creation of an M-type hexagonal structure [17].

Along with the same trend as seen in Table 1, the X-ray density of the substituted calcium hexaferrite improves with rising substituent concentration, as shown in Fig. 3(b). The increase in x-ray density caused by bismuth substitution is attributable to the molar mass of the substituted materials. The x-ray density of the resulted substances surpassed the bulk density (m), suggesting the formation of the pores [18]. The porosity remains consistent while the bulk density increases as the Bi^{3+} content increases. The FTIR spectra of Ca-Bi hexaferrite nanoparticles at 400–650 cm^{-1} are shown in Fig. 4. As a result, it can be determined, peak formation inside the span of 400–600 cm^{-1} might be attributed to Ca–O and Fe–O in hexaferrite structure, which includes tetrahedral and octahedral site [19]. As an additional point of interest, the peak that shown out at 1500–1700 cm^{-1} corresponded to an anti-symmetric stretching bond between O and H. The unique characteristic band locations alter slightly because the wavenumber is related to the atomic weight, and Bi^{3+} ions have a larger atomic mass than Fe^{3+} ions. The hexagonal structure was affirmed by FT-IR analysis of all compositions [20].

3.2. Morphological analysis

The topology and phase structure of the materials have been explored using FE-SEM and HR-TEM. Fig. 5 shows FESEM-EDX

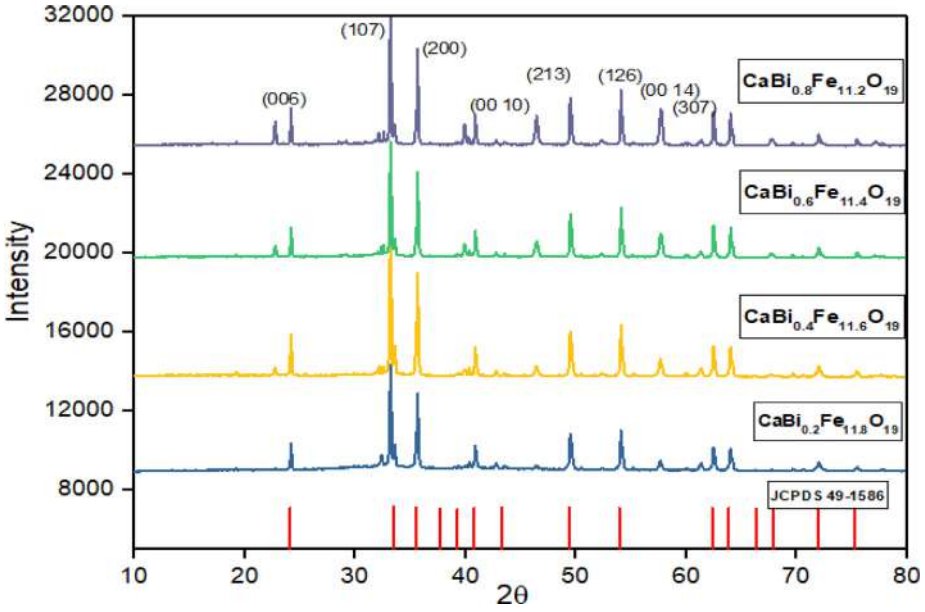


Fig. 2. XRD image of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Table 1
Lattice parameter, x-ray density bulk density and particle size of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Compound name		$CaBi_{0.2}Fe_{11.8}O_{19}$	$CaBi_{0.4}Fe_{11.6}O_{19}$	$CaBi_{0.6}Fe_{11.4}O_{19}$	$CaBi_{0.8}Fe_{11.2}O_{19}$
Lattice parameter	a = b (Å)	5.8320	5.8132	5.8115	5.8112
	C (Å)	22.3584	22.3603	22.3618	22.1542
Crystalline Size (nm)		55.76 ± 0.03	53.23 ± 0.05	49.76 ± 0.11	46.21 ± 0.07
c*/*a		3.846 ± 0.012	3.846 ± 0.007	3.848 ± 0.005	4.062 ± 0.011
Molecular Weight (**gm**/**mol**)		1044.845	1075.472	1106.099	1136.726
Volume ($Å^3$)		653.994	649.840	649.50	643.61
X-ray density ($\mathbf{gm/mol^3}$)		5.305	5.495	5.655	5.862
Bulk Density ($\mathbf{gm/mol^3}$)		3.152	3.327	3.356	3.422
Porosity (%)		40.58 ± 0.02	39.45 ± 0.06	40.65 ± 0.15	41.62 ± 0.05
Surface area ($*10^7$ cm^2/g)		20.28	20.51	21.32	22.14

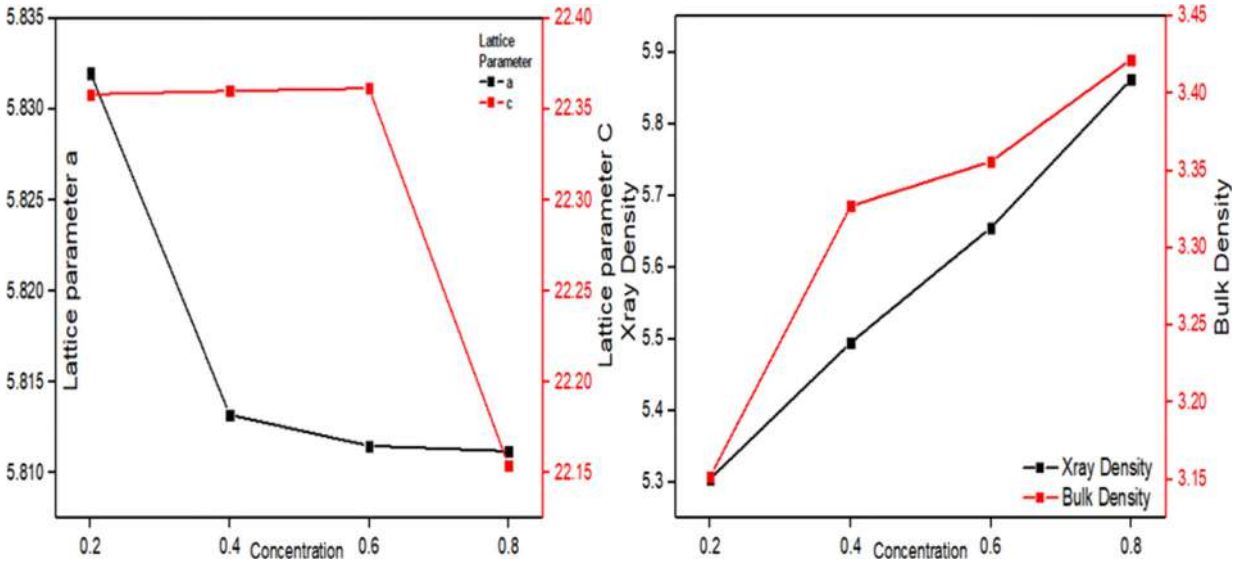


Fig. 3. (a) Concentration vs Lattice parameter. (b) Concentration vs X-ray density and Bulk density $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

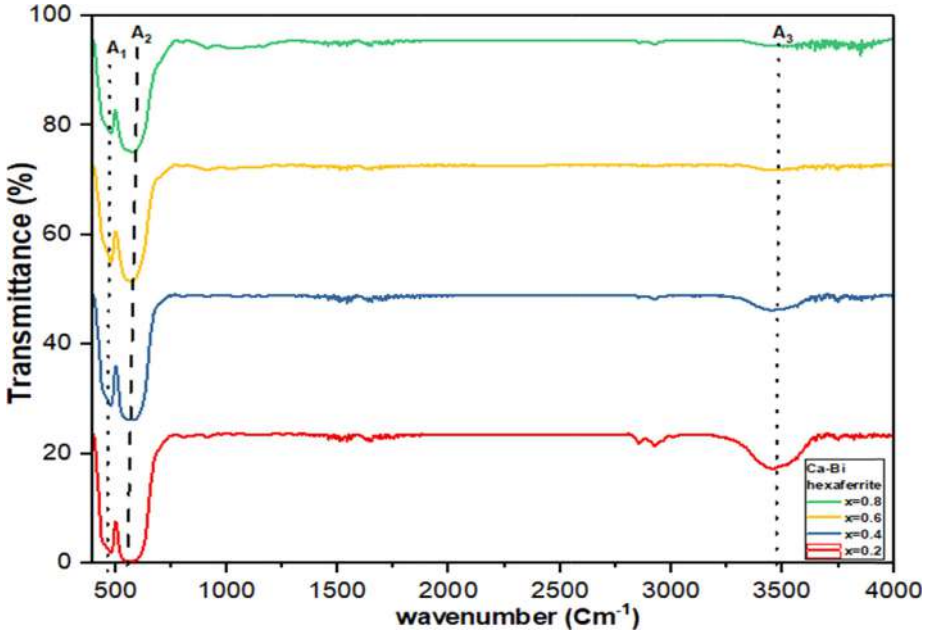


Fig. 4. FTIR spectra of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

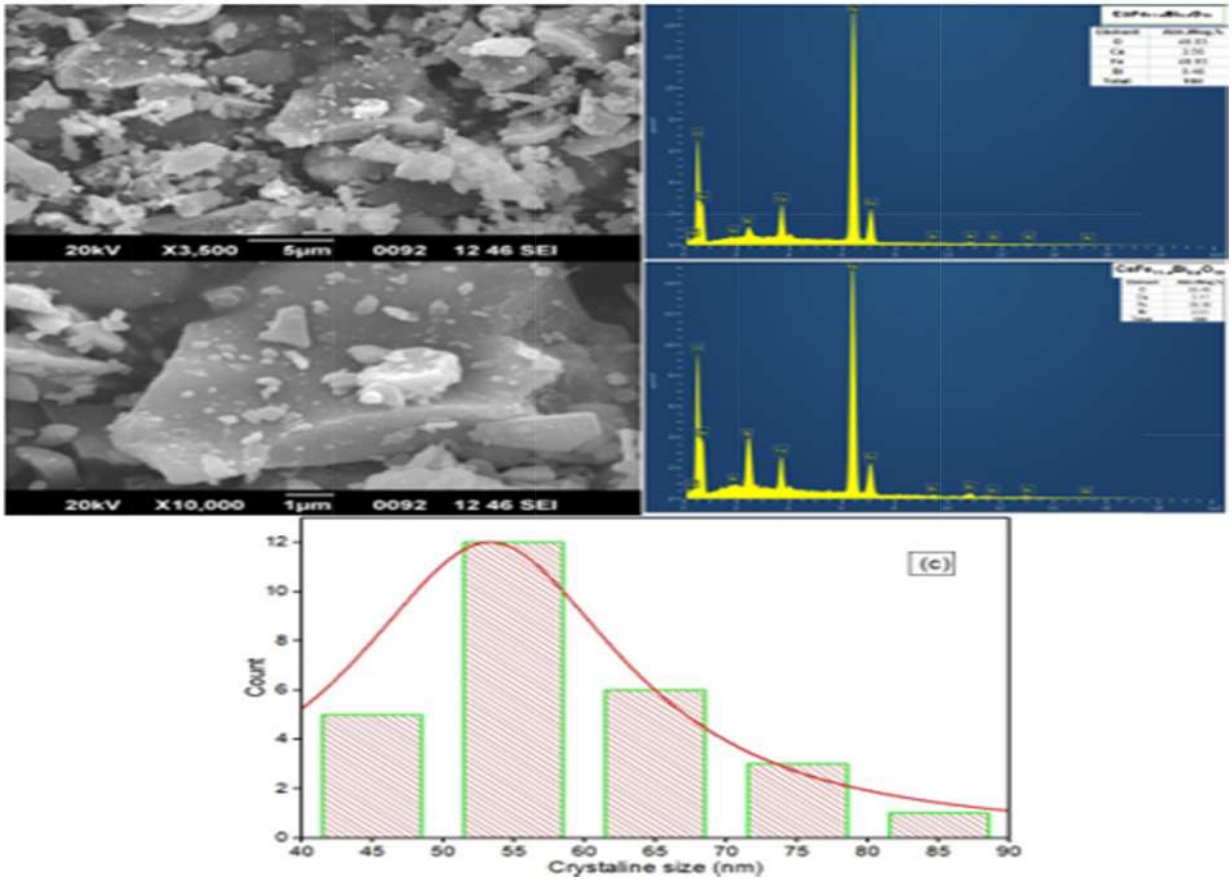


Fig. 5. FE-SEM and EDX images of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, and 0.6) and (c) histogram image of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2) hexaferrite.

images of the synthesized nanocomposite. These results indicated that the produced nanocomposite has non-uniform morphologies and has agglomerated into bigger molecules [21]. The non-uniform and fluffy texture of the resulting material might be a result of the combustion process, as a substantial volume of gas is emitted during the methodology from the self-propagating burning [22]. This resulted in a fluffy structure with voids between nanoparticles and specific nanomaterials scattered more densely. The "Image J" application could examine and approximate particle size distribution bar chart [23]. The histogram was then matched using a Gaussian distribution function to determine the average size distribution of the nanocomposite. The nanocomposite particle size was assessed to be 50 nm (with a range of 40–60 nm), corresponding to the calculated crystalline value from the diffraction data [24].

The EDX examination of Ca-Bi nanomaterials was performed to validate the replacement of trivalent Fe^{3+} ions by Bi^{3+} cations and to analyze the Bi^{3+} substitution in Calcium hexaferrite [25]. The EDX spectrums of Ca-Bi hexaferrite has shown in Fig. 5. Ca, Bi, Fe, and O are the most abundant elements found. EDX analysis demonstrated that the generated hexaferrite has perfect phases and formation, indicating that the Bi^{3+} substitution was reliable [26]. High-resolution transmission electron microscopy (HRTEM) has been preferred to analyze particle shape, micro-structural, as well as crystal structure.

The nanoscale existence of the hexaferrite particles that have been generated is demonstrated in the photographs. The HR-TEM picture and SAED trims of the synthesized Ca nano hexaferrite are shown in Fig. 6. TEM pictures reveal the prevalence of nanoparticles that seem hexagonal formed crystallites with sizes ranging from 40 to 60 nm and decrease as the Bi^{3+} ion substitution increases [27]. This corresponds to the XRD data achieved using scherer's formula. The photos of the sample show agglomerated as well as unpopulated nanoparticles. The materials' natural propensity to build globules is caused by the samples' permanent magnetic moment. The SAED ornament shown in Fig. 6 supports the produced sample's crystalline composition [28]. The SAED pattern clearly shows diffraction rings. It has been established that crystallographic planes with a specific (107) are contained within a material [29].

3.3. VSM study of Ca-Bi hexaferrite

The hysteresis loop of $CaFe_{12-x}Bi_xO_{19}$ (x = 0.2–0.8) samples has depicted in Fig. 7, these hysteresis loops have revealed the ferromagnetic character of synthesized samples. These curves have been used to calculate magnetic characteristics such as saturation magnetization (Ms), coercivity (Hc), and remanence (Mr); these parameters are affected by several various influences, such as the technique of synthesis, the temperature, and duration of processing as well as the proportion of crystalline solids used. Table 2 shows that the Hc ranges from 169 to 2696 Oe. It was observed that Hc and D change inversely, with more significant numbers of D corresponding to the lowest values of Hc and converse [27]. As followed, some of the materials had Hc values that were much higher than 1200 Oe, making them suitable for high-density perpendicular magnetic recording media. Ms and Mr values have been found to decline unwaveringly as Bi^{3+} concentration increased. Ms changes from 0.8 to 0.4 emu/g, while Mr ranges from 0.145, falling to 0.10 emu/g [30]. This reduction could be understood by the

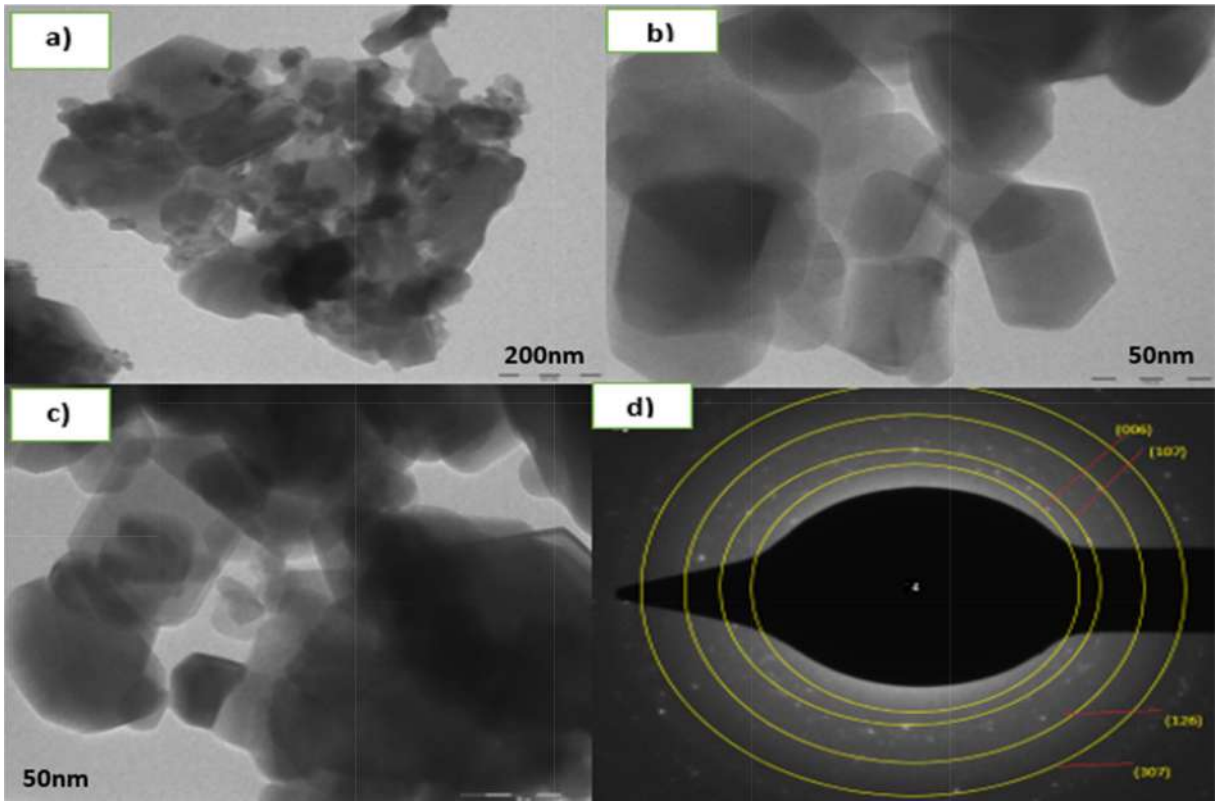


Fig. 6. (a), (b) and (c)HR-TEM micrograph, (d) SAED micrograph of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2) hexaferrite.

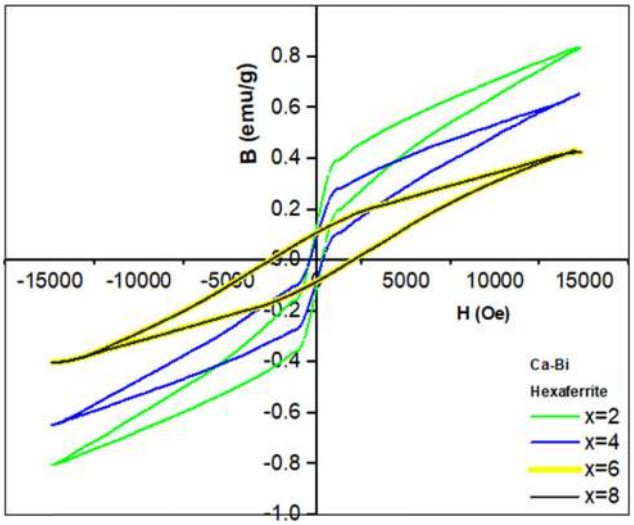


Fig. 7. VSM image of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

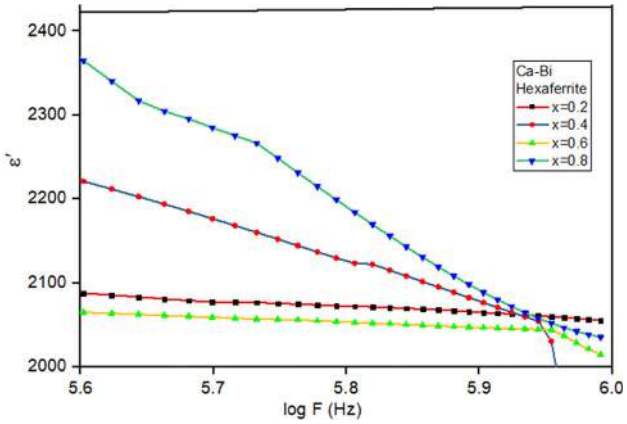


Fig. 8. Dielectric constant vs Frequency of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

placement of Bi^{3+} ions in the Fe^{3+} ions in five crystallographic sublattices, which include one tetrahedral sublattice ($4f_1$), one bipyramidal sublattice (2b), and three octahedral sublattices (12k, 2a, and $4f_2$). Spin-up sites in the hexagonal lattice are 12k, 2a, and 2b, whereas spin-down sites are $4f_1$ and $4f_2$ [10]. The magnetic moment of Bi^{3+} ions is zero, making them diamagnetic. As a result of the occupation of the Bi^{3+} ion, minimal significant contributions to magnetic characteristics have been found. However, the contri-

Table 2
Ms, Mr, Hc of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Conc.x	Saturation magnetizationMs (emu/g)	Retentivity Mr (emu/g)	Coercivity(Hc) (Oe)	Bohr magneton $\mu_B \times 10^{-1}$	SQR ratio (Mr/Ms)
0.2	0.82383	0.14569	169.75	1.54	0.1768
0.4	0.65385	0.11929	222.73	1.25	0.1824
0.6	0.42603	0.10945	2415.9	0.84	0.2569
0.8	0.40991	0.10423	2696.4	0.83	0.2543

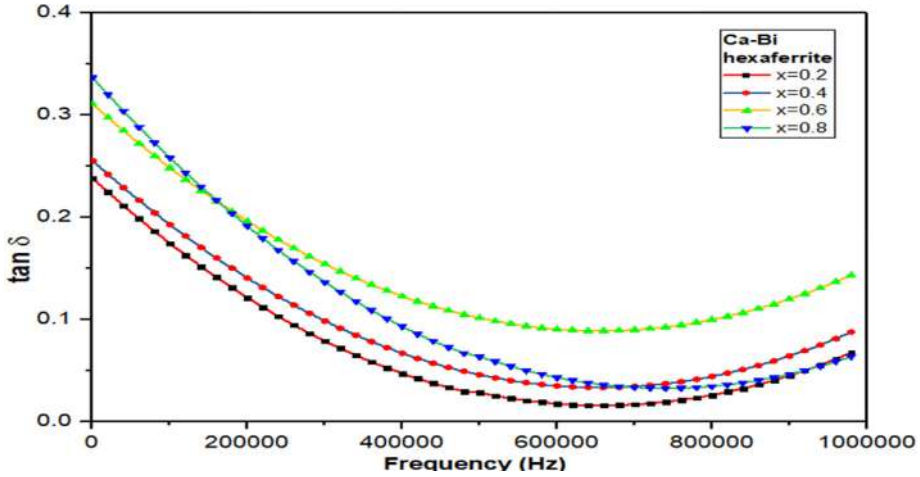


Fig. 9. Tangential loss vs frequency of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

bution of Bi^{3+} ions to the decline in Ms and Mr values is such that throughout the thermal treatment phase, Bi^{3+} ions predominantly occupied Spin up locations. The Mr/Ms proportion is between 0.17 and 0.25, indicating that all generated materials are multi magnetic domain in nature [11].

3.4. Impedance study

The behavior of electrical charge carriers can be predicted using dielectric properties. As the name implies, it's the substance's inborn potential to resist structural damage or conversion to electrical conductivity in the presence of an applied voltage. Much energy lost throughout each cycle is measured by the dielectric loss tangent. Because of their high resistivity, M-type hexaferrite has low dielectric strengths [31]. To figure out the dielectric constant, dielectric tangent loss factor, and dielectric loss, the respective relationships were used:

$$\varepsilon\prime = cd/\varepsilon_0 A$$

$$\tan\delta = 1/2\pi R_p C_p$$

The letter d represents pellet width, the cross-sectional region of the horizontal surface of the pellet has denoted by the letter A, and ε_0 is the permittivity of space, C values represent the capacitance of the pellet, Rp indicates the parallel resistance. We examined the dielectric constant and tan δ in the frequency range of 20 Hz to 1 MHz, as shown in Figs. 8 and 9 respectively [32]. The high dielectric constant results could be attributed to structural variations in bismuth-doped M-type calcium hexaferrite. The variation in the extrinsic dielectric constant is caused by an alteration in the mass of the dopant [33]. Every sampling unit has its unique structure, so these anomalies are to be expected. The bismuth ions, which primarily possess the octahedral site, may be responsible for the declining behavior of dielectric constant and tangent loss. As a result of this occupancy, the maximum count of ferric ions at that same site effects due to the hopping among Fe^{+3} and Fe^{+2}. As a result, both the dielectric constant and the tangent loss are reduced [34]. Fig. 10 depicts the ln σ as a function of 1000/T. When the temperature rises, the dc electrical resistivity decreases proportionately. This is predicated on the possibility that the electrons' kinetic energy increases when the temperature rises. The migration of an electron from one octahedral site to the next increases the electron's drift mobility, resulting in a drop in resistivity. The porous structure, grain size, and cation distribution on the octahedral surface contribute significantly to ferrites' electrical resistivity. Increased porosity and smaller particle size result in increased electrical resistance [35] (Fig. 11).

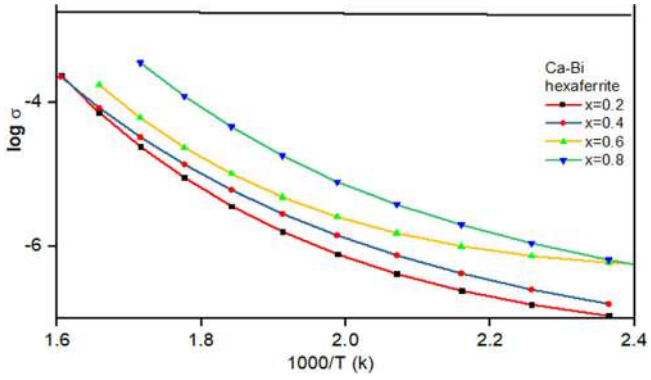


Fig. 10. Conductivity vs temperature of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

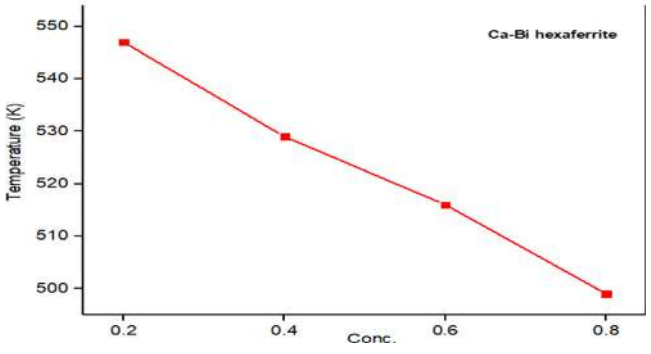


Fig. 11. Curie temperature vs concentration of $CaBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Electrical resistance is strongly influenced by the concentration of Fe^{2+} ions at the octahedral location. As the concentration increased, the number of charge carriers available for conduction increased, and the resistance decreased. Additionally, the graph demonstrates that as the concentration of Bi^{3+} grows, the resistivity gradually decreases. This is due to the differential in Fe^{2+} concentrations at the octahedral 12 K site [26,36].

4. Conclusion

$CaFe_{12-x}Bi_xO_{19}$ (x = 0.2–0.8) nanoparticles have effectively synthesized through the microwave-induced sol–gel auto combustion process. X-ray examination validated the existence of a single crystalline phase in materials with the space group P63/mmc. The vibrational bands of hexaferrite can be seen in the FTIR spectrum, which ranges between 400 and 650 cm^{-1} in wavelength. Because Bi^{3+} ions conquer $4f_1$ sites (tetrahedral sites), Ms and Mr have been shown to fall with Bi^{3+} concentration. The high coercivity (Hc) value indicates that the generated samples are suitable for recording media applications. The dielectric properties (ε' and tan δ) were reported to reduce as the applied field frequency increased, while the conductivity raised with increasing temperature. According to electrical resistivity measurements, the Curie temperature lowers with a rise in bismuth concentration, and it falls within the limit of values recorded.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] C.h. Mamatha, M. Krishnaiah, B. Sreedhar, Enhancement of magnetic properties of calcium hexaferrites with aluminium substitution, Proc. Eng. 215 (2017) 130–135.
[2] M.A. Almessiere, Y. Slimani, H. Güngüneş, S. Ali, A. Baykal, I. Ercan, AC susceptibility and hyperfine interactions of Mg-Ca ions co-substituted BaFe $_{12}$ O $_{19}$ nanohexaferrites, Ceram. Int. 45 (8) (2019) 10048–10055.
[3] U. Topal, H. Ozkan, H. Sozeri, Synthesis and characterization of nanocrystalline BaFe12O 19 obtained at 850°C by using ammonium nitrate melt, J. Magn. Magn. Mater. 284 (2004) 416–422.
[4] C. Mamatha, M. Krishnaiah, C.S. Prakash, Structural, Electrical and Magnetic properties of Aluminum Substituted Nanocalcium Hexaferrites 6 (2014) 2165–2167.
[5] G.R. Gordani, A. Ghasemi, A. saidi, High frequency electromagnetic reflection loss performance of substituted Sr-hexaferrite nanoparticles/SWCNTs/epoxy nanocomposite, J. Magn. Magn. Mater. 391 (2015) 184–190.
[6] J.N. Christy, K.G. Rewatkar, P.S. Sawadh, Structural and dielectric properties of substituted calcium hexaferrites, Int. J. Eng. Res. Technol. 8 (2019) 178–182.
[7] A.S. Kakde, B.A. Shingade, N.S. Meshram, K.G. Rewatkar, structural and magnetic properties of sn-zr substituted calcium nano-hexaferrite 1 (2014) 60–63.
[8] D.M. Borikar, M.A. Borikar, A.S. Kakde, K.G. Rewatkar, Nano copper spinel ferrite: Synthesis & characterization by sol-gel auto combustion technique 5 (n.d.), 7–10.
[9] Z. Mosleh, P. Kameli, A. Poorbaferani, M. Ranjbar, H. Salamati, Structural, magnetic and microwave absorption properties of Ce-doped barium hexaferrite, J. Magn. Magn. Mater. 397 (2016) 101–107.
[10] N.N. Sarkar, D.J. Roy, S.M. Butte, W.S. Barde, K.G. Rewatkar, Synthesis and Magnetic studies of Co-Sn doped Nanoscale Calcium Hexaferrites, 25 (2020) 57–67.
[11] M.A. Borikar, D.M. Borikar, N.S. Meshram, K.G. Rewatkar, Characterization of nanostructured spinel NiCrxFe2-xO4obtained by sol gel auto combustion method, J. Phys. Conf. Ser. 1913 (1) (2021) 012079, https://doi.org/10.1088/1742-6596/1913/1/012079.
[12] D.A. Mahajan, S.R. Choubey, B.T. Borkar, L.P. Damodare, A.B. Borkar, G.C. Vandile, X-ray Diffraction Studies of Synthesized M-type Compound 4 (2019) 25–30.
[13] V. Dixit, C.N. Nandadasa, S.-G. Kim, S. Kim, J. Park, Y.-K. Hong, L.S.I. Liyanage, A. Moitra, Site occupancy and magnetic properties of Al-substituted M-type strontium hexaferrite, J. Appl. Phys. 117 (24) (2015) 243904, https://doi.org/10.1063/1.4922867.
[14] S. Güner, I.A. Auwal, A. Baykal, H. Sözeri, Synthesis, characterization and magneto optical properties of BaBixLaxYxFe12-3xO19 (0.0≤x≤0.33) hexaferrites, J. Magn. Magn. Mater. 416 (2016) 261–268.
[15] V.S. Shinde, S.G. Dahotre, L.N. Singh, Synthesis and characterization of aluminium substituted calcium hexaferrite, Heliyon 6 (1) (2020) e03186, https://doi.org/10.1016/j.heliyon.2020.e03186.
[16] S.V. Blazhevich, L.P. Ol'khovik, A.S. Kamzin, S.V. Chernikov, T.G. Kuzmicheva, N. V. Tkachenko, Synthesis of fine-grained calcium hexaferrite and investigation of its structural and magnetic parameters, Prot. Met. Phys. Chem. Surfaces. 47 (5) (2011) 638–644.
[17] D. Basandrai, Magnetic properties of bismuth substituted strontium ferrite nanoparticles, Eur. J. Mol. Clin. Med. 7 (2020) 3432–3437.
[18] A.S. Kakde, R.M. Belekar, G.C. Wakde, M.A. Borikar, K.G. Rewatkar, B.A. Shingade, Evidence of magnetic dilution due to unusual occupancy of zinc on B-site in $NiFe_2O_4$ spinel nano-ferrite, J. Solid State Chem. 300 (2021) 122279.
[19] L. Shlyk, D.A. Vinnik, D.A. Zherebtsov, Z. Hu, C.-Y. Kuo, C.-F. Chang, H.-J. Lin, L.-Y. Yang, A.S. Semisalova, N.S. Perov, T. Langer, R. Pöttgen, S. Nemrava, R. Niewa, Single crystal growth, structural characteristics and magnetic properties of chromium substituted M -type ferrites, Solid State Sci. 50 (2015) 23–31.
[20] S. Bindra Narang, P. Kaur, S. Bahel, C. Singh, Microwave characterization of Co-Ti substituted barium hexagonal ferrites in X-band, J. Magn. Magn. Mater. 405 (2016) 17–21.
[21] H. Dubey, C. Verma, U. Rai, A. Kumar, P. Lahiri, Synthesis, characterization and properties of nickel based zinc ferrite nanoparticles, Indian J. Chem. –Sect. A. 58 (2019) 454–458.
[22] R.B. Jotania, R.B. Khomane, C.C. Chauhan, S.K. Menon, B.D. Kulkarni, Synthesis and magnetic properties of barium-calcium hexaferrite particles prepared by sol-gel and microemulsion techniques, J. Magn. Magn. Mater. 320 (6) (2008) 1095–1101.
[23] M.R. Sahoo, S. Kuila, K. Sweta, A. Barik, P.N. Vishwakarma, Effect of bismuth substitution in strontium hexaferrite, AIP Conf. Proc. 1953 (2018).
[24] S. Mukherjee, K. Sarkar, S. Mukherjee, Effect of nickel and cobalt doping on nano bismuth ferrite prepared by the chemical route, InterCeram Int. Ceram. Rev. 64 (1-2) (2015) 38–43.
[25] S.A. Pawade, K.G. Rewatkar, V.M. Nanoti, effect of transition metal ion substitution on magnetic structure and properties of la-sr hexaferrites at nanoscale, Int. J. 3 (2012) 31–35.
[26] B. Unal, M. Almessiere, Y. Slimani, A. Baykal, A.V. Trukhanov, I. Ercan, The conductivity and dielectric properties of neobium substituted Sr-hexaferrites, Nanomaterials 9 (8) (2019) 1168, https://doi.org/10.3390/nano9081168.
[27] S. Deepapriya, P.A. Vinosha, J.D. Rodney, S. Krishnan, J.E. Jose, S.J. Das, Effect of lanthanum substitution on magnetic and structural properties of nickel ferrite, J. Nanosci. Nanotechnol. 18 (10) (2018) 6987–6994.
[28] P. Chaware, A. Nande, S.J. Dhoble, K.G. Rewatkar, Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu3+ doped strontium hexa-aluminate nanophosphors for lighting application, Opt. Mater. (Amst). 121 (2021) 111542.
[29] F. Ebrahimi, S.R. Bakhshi, F. Ashrafizadeh, A. Ghasemi, Synthesis and optimization of the magnetic properties of aligned strontium ferrite nanowires, Mater. Res. Bull. 76 (2016) 240–246.
[30] G.B. Teh, N. Saravanan, D.A. Jefferson, A study of magnetoplumbite-type (M-type) cobalt-titanium-substituted barium ferrite, $BaCo_xTi_xFe_{12-2x}O_{19}$ (x = 1–6), Mater. Chem. Phys. 105 (2-3) (2007) 253–259.
[31] M. Shandilya, G.A. Kaur, R. Rai, Low temperature consequence on structural and impedance properties of BST ceramics via sol-hydrothermal method, Mater. Chem. Phys. 263 (2021) 124422, https://doi.org/10.1016/j.matchemphys.2021.124422.
[32] A. Katoch, B.K. Borthakur, A. Singh, T. Singh, Dielectric behavior of M-type hexaferrites Sr $_{1-x}$ Dy $_x$ Fe $_{12}$ O $_{19}$, Doped Rare Earth Ions 5 (2013) 53–57.
[33] S.R.G.P.R.M.R.R.K., K.G.R.S.R. Gawali, P.R. Moharkar, R.R. Kherani, K.G. Rewa, Structural and electrical properties of M-type substituted calcium hexaferrites, Int. J. Res. Biosci. Agric. Technol. 3 (2015) 2672–2678.
[34] M. Shandilya, S. Thakur, R. Rai, Study of phase transitional behavior and electrical properties of relaxor $Ba_{0.85}Ca_{0.15}Zr_{0.05}Ti_{0.95}O_3$ lead free ceramic, Ferroelectr. Lett. Sect. 46 (1-3) (2019) 8–18.
[35] M.A. Almessiere, Y. Slimani, H. Gungunes, A. Manikandan, A. Baykal, Investigation of the effects of Tm 3+ on the structural, microstructural, optical, and magnetic properties of Sr hexaferrites, Results Phys. 13 (2019) 102166, https://doi.org/10.1016/j.rinp.2019.102166.
[36] I.A. Auwal, A. Baykal, H. Güngüneş, S.E. Shirsath, Structural investigation and hyperfine interactions of $BaBixLaxFe_{12-2x}O_{19}$ (0.0≤x≤0.5) hexaferrites, Ceram. Int. 42 (2) (2016) 3380–3387.

Optical Materials 133 (2022) 112945

Contents lists available at ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat

Research Article

Photoluminescence and Judd-Ofelt analysis of Eu^{3+} doped akermanite silicate phosphors for solid state lighting

P.J. Chaware [a,*], Y.D. Choudhari [a], D.M. Borikar [a], K.G. Rewatkar [b]

[a] Dr. Ambedkar College, Nagpur, India
[b] Vidya Vikas Arts, Commerce and Science College, Samudrapur, India

ARTICLE INFO

Keywords:
Silicate
Judd-Ofelt
Rietveld refinement
XRD
Photoluminescence
CIE coordinates

ABSTRACT

After aluminates, alkaline-earth silicates are the most researched category of luminescent inorganic phosphors. Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors synthesized by the combustion process. For the as-prepared phosphors, XRD and Rietveld refinement revealed a single phase with akermanite type structure belonging to tetragonal crystallography. UV–Vis spectroscopy was used to calculate the optical bandgap. $Ca_2MgSi_2O_7$:x%Eu and $Sr_2MgSi_2O_7$:x%Eu (x = 0.5 - 2.5) phosphors produced orange-red light with emission peaks at 590 nm, 614 nm, and 702 nm, which corresponded to the Eu^{3+} transitions $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$, respectively. Using a modified Judd-Ofelt technique based on the emission spectrum, the key spectroscopic properties (transition probabilities, radiative lifetimes, and branching ratios) associated with the $^5D_0$ orange-red emitting level were found. $\Omega_2 < \Omega_4$ reveals that Eu^{3+} ions occupy high symmetry locations in the generated sample under the doping level studied in this work. There has also been a decrease in the Ω_4 parameter. It implies that the $^5D_0 \rightarrow {}^7F_2$ transition is more efficient than the $^5D_0 \rightarrow {}^7F_4$. This indicates that the red color emission has been improved. The estimated CIE coordinates corroborated the PL emission in the orange-red region.

1. Introduction

In recent years, due to their remarkable luminous qualities, rare-earth ion-doped inorganic phosphors have been utilized in various applications (e.g.- illumination, displays, the electronics sector, sensing technologies, biomedical application, and detection) [1–3]. As a solid-state lighting technology, white-light-emitting diodes (wLEDs) have many applications due to their energy efficiency, eco-friendliness, and durability. Upon receiving excitation from an external energy source, inorganic phosphors serve as photoluminescent materials, generating light through the host lattice or the added dopant ions. Dopant ions are the most common source of emission. As a result, a single host lattice might have a distinct color emission based on the type of dopant utilized [4,5]. The majority of commercially available phosphor materials are host lattices such as oxides, silicates, aluminates, sulfides, oxy-sulfides, nitrides, etc. Due to their excellent photoluminescence qualities, good chemical stability, and comparative ease of synthesis compared to other matrices, silicate matrices have attracted considerable interest in producing effective luminous materials [6–8]. Silica-based materials can be studied under standard synthetic conditions, and their constitution, shape, and size can be easily modified to increase the photoluminescence efficiency of phosphor materials. The silicate compounds doped with alkaline earth ions have broad uses in solid-state lasers and nonlinear optical systems. Impurity elements play a vital role in the optical properties of transition metals in solids for laser applications, as they can change the host material's properties. In recent years, alkaline earth-based silicate phosphors have garnered considerable interest due to their resistance to acid, alkali, and oxygen [9,10]. Today, trivalent rare-earth (RE) elements are widely used as dopants in producing luminous materials that any excitation radiation can activate. These materials are produced by doping various host matrices with Re^{3+} ions. Many scientists have studied RE-doped phosphors over the years. The element europium is unique among lanthanides in that its valence fluctuates. In addition to their shared characteristics, their luminescence properties recognize the various valences of rare earth elements. Because of its red-light emission property, Eu^{3+} ion has been utilized extensively in color television, panel displays, crts, and fluorescent powders of three primary colors. Therefore, it is crucial to develop more efficient red-emitting phosphors suitable for the production of white LEDs [11,12]. There has been substantial research into silicate-based

* Corresponding author.
E-mail addresses: pritichaware@gmail.com (P.J. Chaware), yograjchoudhari476@gmail.com (Y.D. Choudhari), drdmborikar@gmail.com (D.M. Borikar), kgrewatkar@gmail.com (K.G. Rewatkar).

https://doi.org/10.1016/j.optmat.2022.112945
Received 21 July 2022; Received in revised form 25 August 2022; Accepted 26 August 2022
0925-3467/© 2022 Elsevier B.V. All rights reserved.

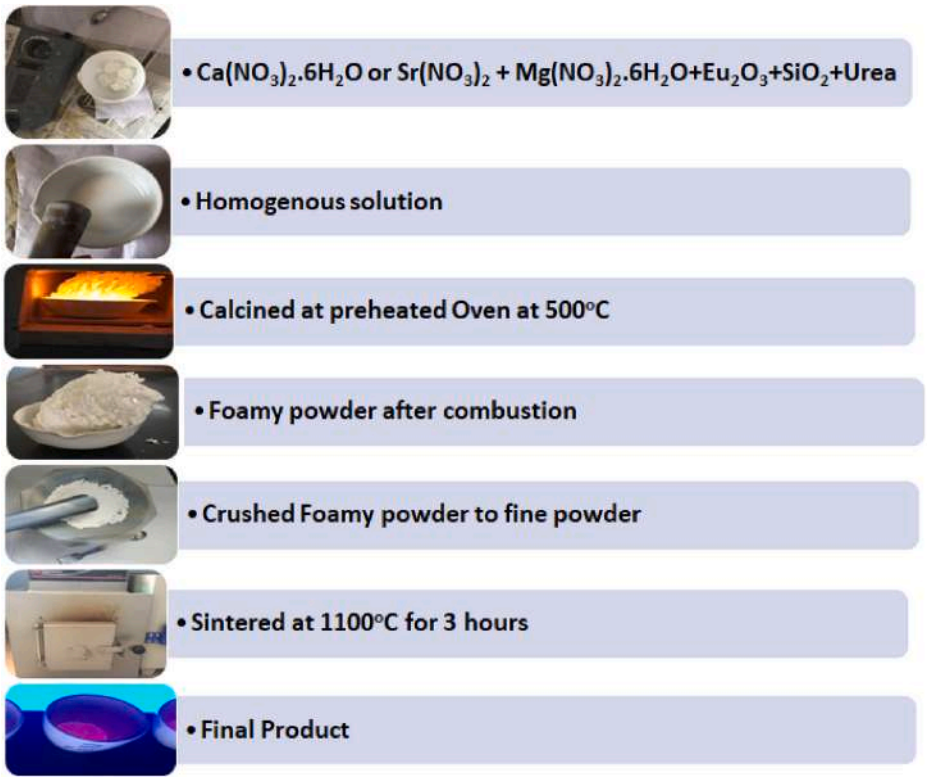


Fig. 1. Flow chart of the synthesis process for Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors.

materials due to their high quantum efficiency, water resistance, low cost, and great chemical and thermal stability. Materials such as Eu^{3+} are the most intriguing subject for red phosphors, which are commonly employed as a red-emitting activator through the $^5D_0 \rightarrow {}^7F_2$ transition at around 614 nm.

Despite extensive experimental and theoretical research, there are no precise descriptions of absorption and emission spectra for Eu^{3+}-activated silicate phosphor to compute the Judd–Ofelt (J-O) parameters. On Eu^{3+} ions in silicate akermanite systems, data on the radiative transition rates, emission branching ratios, and critical distance are not yet available. Important spectroscopic features are required to quantitatively assess the luminescence performance of Eu^{3+} ion in various hosts and design materials for specific optical devices.

In the present work, we report examining the spectroscopic characteristics of Eu^{3+}-doped calcium magnesium silicates and strontium magnesium phosphors synthesized by the combustion process, which enabled absorption measurements. Since activator ion concentration is one of the critical parameters that substantially impact the luminous behavior of phosphors, we explored the photoluminescence characteristics to determine the optimal activator ion concentration. The Judd–Ofelt (J-O) analysis of emission data of Eu^{3+} ions in silicates was done using photoluminescence data, allowing us to determine the intensity parameters. This technique enabled us to calculate the spontaneous transition probabilities (A_R), luminescence branching ratio (β_R), and radiative lifetime (τ_R).

2. Experimental

Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors prepared by combustion method and sintered at 1100 °C. The total oxidizing and reducing valencies of the ingredients were used to calculate the stoichiometry of the redox mixture used for the combustion process as the stoichiometric balance that requires numerical co-efficient is provided by this so that the energy released by the combustion is maximum and the equivalence ratio is unity. Phosphor powders were made using analytical grade calcium nitrate ($Ca(NO_3)_2{\cdot}6H_2O$), Strontium nitrate ($Sr(NO_3)_2$), silica powder (SiO_2), magnesium nitrate ($Mg(NO_3)_2{\cdot}6H_2O$), and Europium oxide (Eu_2O_3). In the first step, a mole of silica powder was dissolved in a concentrated nitric acid solution in a round-bottom flask (RBF). The contents of the RBF were then stirred on a magnetic stirrer for the creation of silica gel, which took around 10 min. Then Eu_2O_3 was dissolved in HNO_3. In contrast, a stoichiometric quantity of europium nitrate and comparable metal nitrates of Sr, Ca, and Mg were homogenously combined in a silica crucible with distilled water. The silica crucible nitrate mixture was then gently added to the flask containing gel, and this combined solution was agitated for roughly 30 min. To achieve consistent mixing of the predecessors, stirring was used. To achieve consistent mixing of the predecessors, stirring was used. The flask's precursors were put back into the silica crucible, which was then warmed on a heating plate to produce a semi-solid paste. At 400–500 °C, the gaseous compounds generated by the breakdown of metal nitrates are hypergolic. When heated to 500 °C, the redox combination boils, froths, and ultimately dehydrates, generating a gel that ignites to produce a massive powder. The entire combustion process was finished in a short period, say 5–10 min. After the combustion, the dish was immediately removed from the furnace, and the resultant voluminous and fluffy powder was crushed using a mortar and pestle in a fine powder; this calcinated phosphor powder was then sintered at 1100 °C for 3 h. The prepared powder was used for further characterization. The detailed flow chart of the combustion process is shown in Fig. 1.

3. Result and discussion

3.0.1. Structural analysis and morphological

The phase and size of the sintered specimen were determined using the XRD technique. The Rietveld refinement method and the FullProf suite—2000 software was used to compute the structural parameters. The morphology and shape of the nanocrystals were studied using scanning electron microscopy.

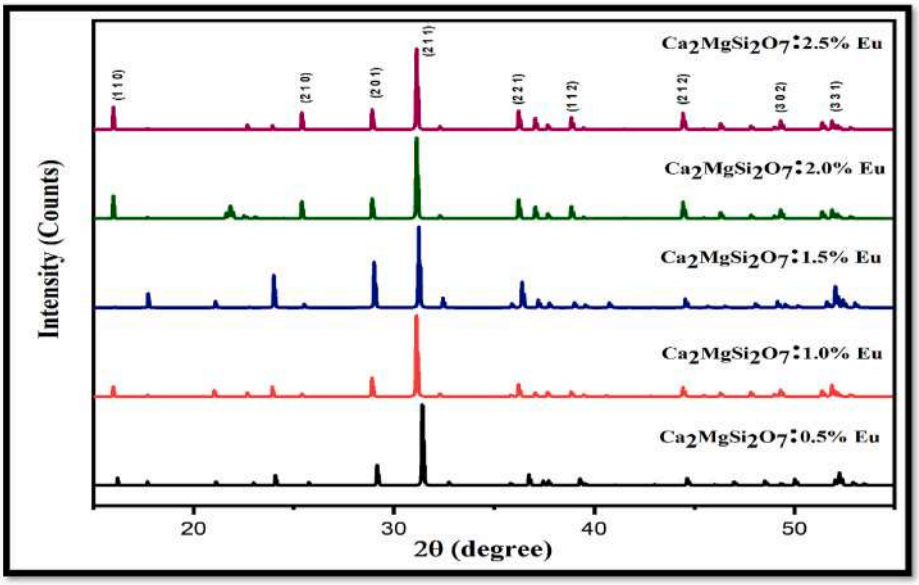


Fig. 2. XRD patterns of $Ca_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5,1.0,1.5, 2.0, and 2.5) phosphors.

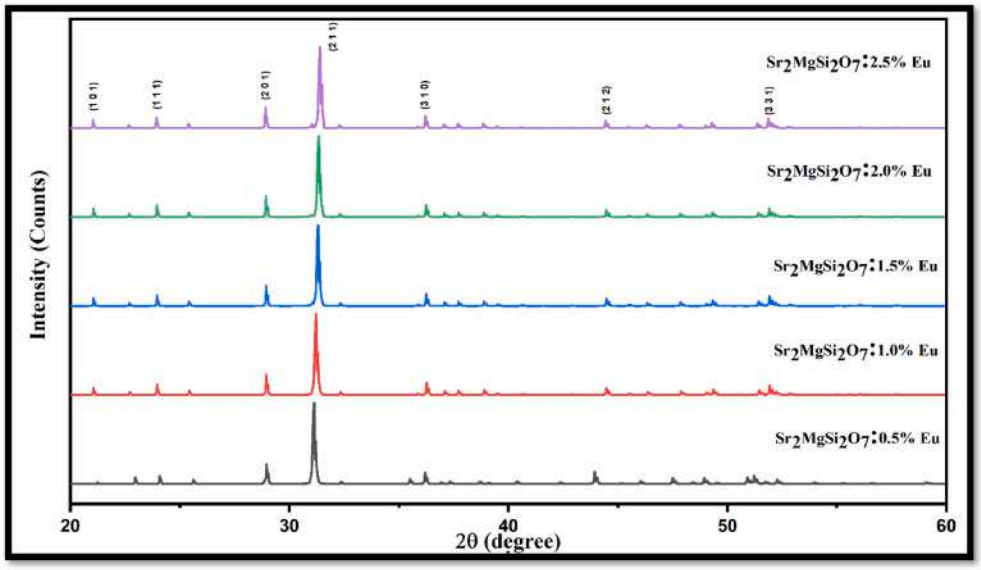


Fig. 3. XRD patterns of $Sr_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5,1.0,1.5, 2.0, and 2.5) phosphors.

3.0.2. X-ray diffraction analysis

The XRD patterns of Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors prepared by combustion method and sintered at 1100 °C are shown in Fig. 2 and Fig. 3 respectively. The position and intensity of diffraction peaks of the synthesized phosphors are well-matched with the Joint Committee Powder Diffraction Standard file (JCPDS: 75–1736) [13–15]. The prepared phosphors have an akermanite-type structure that belongs to tetragonal crystallography and has the space group $P42_1m$. This structure is a member of the melilite group and forms a layered compound. It is colorless and optically clear to translucent. $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ both have an akermanite structure. This structure has one calcium or strontium site that is coordinated by eight oxygen ions. Doped rare-earth ions (Eu^{3+}) have almost no influence on the phase structure of pure $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors. There were no further crystalline phases found. The average crystallite size was calculated from the XRD pattern using the Debye Scherrer relation $D = 0.9\lambda/\beta \cos\theta$, where λ is the wavelength of the incident X-ray radiation (0.154 nm), β is the full width at half maximum in radiation, and θ is the Bragg's angle.

Further, the diffraction data of synthesized silicate powder were examined using the Rietveld refinement (software FULLPROF) and the pseudo-Voigt function for profiling to get descriptions of structural and microstructural parameters. Fig. 4 and Fig. 5 show the Rietveld refinement of XRD patterns for $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors calcined powder respectively. Scale factor, zero correction, displacement, lattice constant, atomic coordinates, and ion occupancy are all updated during refining. During the research, no breach of space-group symmetry was discovered in the meta-stable condition. The lattice has three crystallographically independent cationic lattice sites: M^{2+} (where M = Ca and Sr), Mg^{2+}, and Si^{4+}. M_1 and M_2 atoms are connected to 8 Oxygen and 6 Oxygen atoms, respectively, to form 8-coordinated M_1O_8 and 6-coordinated M_2O_6 polyhedra; the average M − O distance is 2.573 Å. Furthermore, Si and O are joined to create SiO_4 tetrahedra, Mg and O

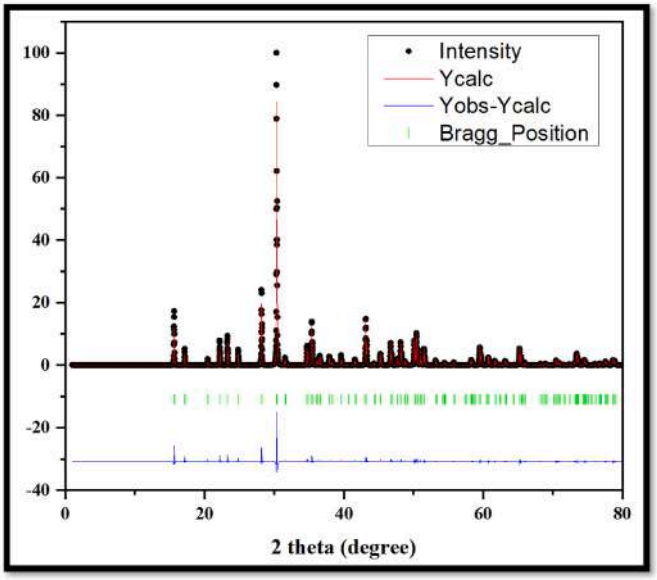


Fig. 4. Rietveld refinement of the $Ca_2MgSi_2O_7$:x%Eu^{3+}.

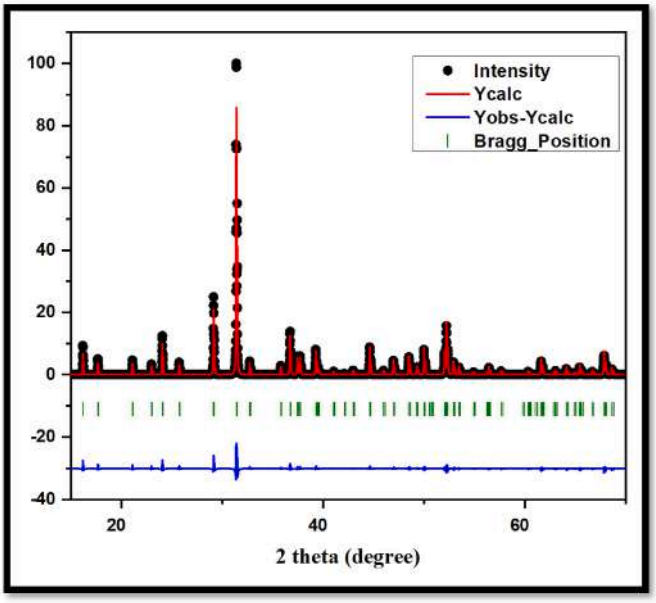


Fig. 5. Rietveld refinement of the $Sr_2MgSi_2O_7$:x%Eu^{3+}.

are connected to produce MgO_4 tetrahedra, and the two tetrahedra are connected to form the (Si/Mg) O_7 group by sharing an O atom; the average Mi-O distances are 1.916 Å (Mi = Mg) and 1.624 Å (Mi = Si), on average. M atoms are interspersed with these groups and closely packed together to produce a thick skeleton. The effective ionic radii of the eight-coordinated Ca^{2+} (r = 1.12 Å), Eu^{3+} (r = 1.06 Å), and Sr^{2+} (r = 1.26 Å) are all identical. In addition, as compared to Eu^{3+}, the effective ionic radii of Mg^{2+} and Si^{4+} in each coordination environment are comparatively modest. Taking the effective ionic radii of cations with various coordination numbers into account, it is possible to determine that the two doped rare-earth ions should occupy M^{2+} rather than Mg^{2+} (r = 0.57) and Si^{4+} (r = 0.26), which have modest ionic radii [16,17]. Fig. 6 depicts the arrangement of the unit cell of $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors, which are a tetragonal structure drawn with the program VESTA [18]. Table 1 and Table 2 provide the estimated average crystallite sizes, lattice parameter *a* and *c* values, and volume of $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors respectively. The average crystallite sizes were calculated using the plane of the most intense peak (211).

3.0.3. Scanning electron microscopy

The luminescence properties of phosphor particles are known to be affected by particle morphology, such as size, shape, size distribution, flaws, and so on. The surface morphology of the $Ca_2MgSi_2O_7$:2%Eu^{3+} and $Sr_2MgSi_2O_7$:2%Eu^{3+} phosphor is seen in Fig. 7 and Fig. 8 respectively. The sample's microstructure reveals the fundamental character of the combustion process. In this case, the form of the particles is irregular spherical, and they are firmly packed together. The agglomeration particles, empty spaces, and pores were caused by gases emitted during the combustion process. When gas escapes under high pressure during the combustion process, pores occur, and microscopic particles form around the pores. The particles are non-uniform and irregular forms can be traced to the non-uniform distribution of temperature and mass flow in the combustion flame [19,20].

3.0.4. Energy dispersive X-ray techniques (EDX)

EDX spectra were used to determine the chemical makeup of the powder sample. The elemental composition of a sample region as tiny as a few nanometers may be identified and quantified using EDX. The energy dispersive X-ray analysis plots for synthesized $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor calcined at 1100 °C are shown in Fig. 9 and Fig. 10 respectively. Table 3 and Table 4 show the chemical composition of $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor. For all the samples EDXA result shows almost the same ratio of chemicals was taken through stoichiometry. The presence of europium (Eu) may be seen in the EDX spectra. There was no additional emission other than calcium (Ca), magnesium (Mg), silicon (Si), and oxygen (O) in the phosphor's $Ca_2MgSi_2O_7$:2.0%Eu EDX spectra. In the presence of Ca, Mg, Si, O, and Eu, strong peaks are seen in the EDX spectra, indicating the production of $Ca_2MgSi_2O_7$:2.0%Eu phosphor. Similar results found in $Sr_2MgSi_2O_7$:2.0%Eu, strontium (Sr), magnesium (Mg), silicon (Si), and oxygen (O) are clearly shown in the EDX spectra and no additional emission seemed. In the spectrum, intense peaks are present which confirm the formation of $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor.

3.1. Optical and photoluminescence study

Optical absorption spectroscopy is a valuable tool for studying metals, semiconductors, and insulators in bulk, colloidal, thin-film, and nanostructure forms. The absorbed intensity as a function of wavelength, from ultraviolet to near-infrared, is important for understanding the electrical structure and transitions between the valence and conduction bands of materials. Luminescence studies are valuable for determining the electrical structure of a substance. It reveals not only the transitions between the conduction and valence bands but also the localized states caused by impurities or doping.

We examined the photoluminescence characteristics to determine the optimum concentration of the dopant ion since it is one of the most significant aspects that substantially impacts the luminous behavior of phosphors. The Judd-Ofelt (J-O) hypothesis was applied to rare-earth ions in several possible host materials. The intensity parameters were calculated using a J-O analysis of both absorption and emission data of Eu^{3+} ions in synthesized samples. The CIE 1931 chromaticity diagram was used to understand the distinct color-tunable characteristic of the produced nanophosphors.

3.1.1. UV–visible spectroscopy

The energy difference between the conduction band and the valence band is determined by the bandgap. Electrons are typically jumped from

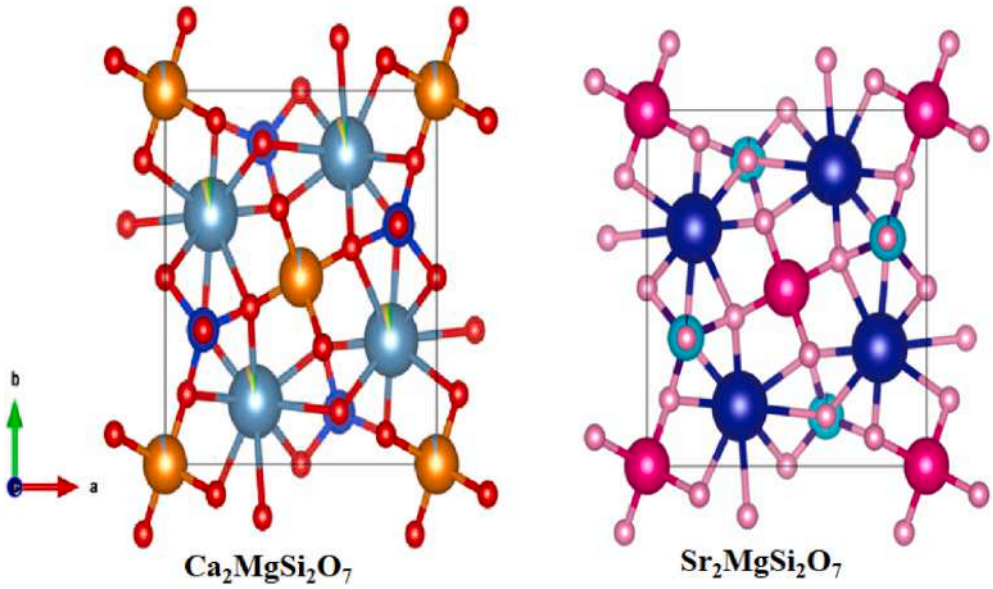


Fig. 6. Unit cells structures of silicates.

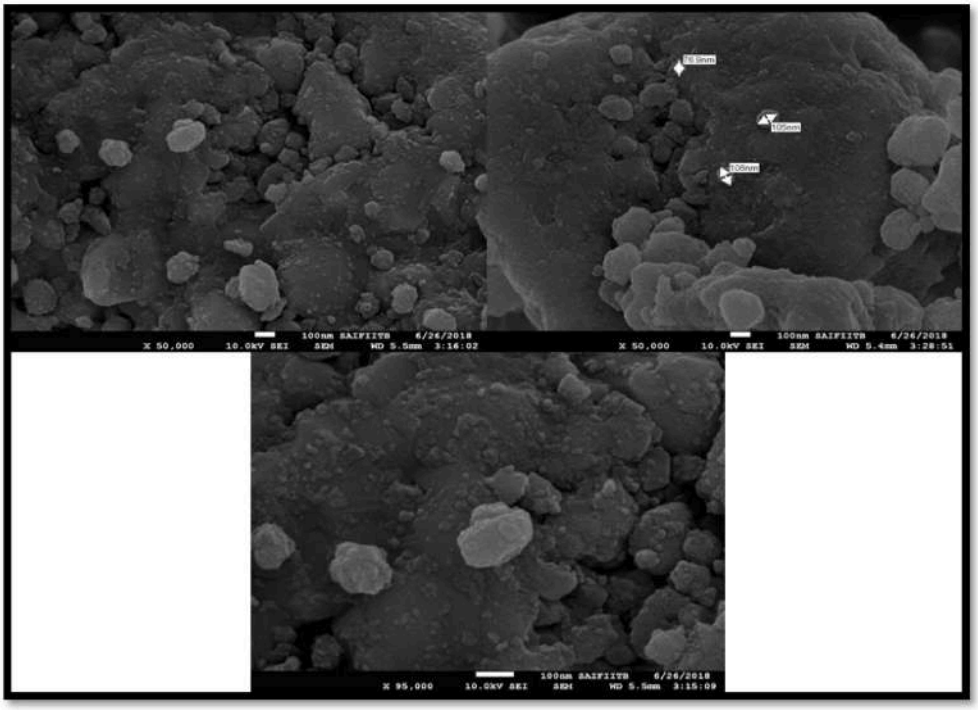


Fig. 7. SEM image of the $Ca_2MgSi_2O_7$:2%Eu^{3+} phosphor.

one band to another as long as a required minimum quantity of energy is given for the transition. The optical band gap was computed from absorption spectra using absorption edge values (edge, in nm). The wavelength range in absorption spectra is 200 nm–500 nm.

The Tauc relation is used to compute the bandgap energy [21]. According to the Tauc equation (6.2.1), the absorption coefficient and incident photon energy hν are related by the following:

$$(\alpha h\nu)^m = h\nu - Eg \quad (1)$$

where a = absorption coefficient, hν = photon energy, Eg = bandgap energy, m = 1/2 or 3/2 for indirect permitted and indirect forbidden transitions, and m = 2 or 3 for direct allowed and direct forbidden transitions [11,22].

Fig. 11 and Fig. 12 show the Tauc plot of $[(\alpha h\nu)^2]$ vs energy (eV) using equations (6.2.1), to construct a straight line with the energy intercept of the direct bandgap. The bandgap of $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphor is 4.67 eV, and 4.79 eV, respectively.

3.1.2. Photoluminescence spectroscopy

The PLE and PL spectra of $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x% Eu^{3+} phosphor are displayed in Fig. 13 and Fig. 14 respectively. The PLE spectra shows series of sharp peak between 350 and 500 nm which were attributed to f-f transitions: $^7F_0 \rightarrow {}^5D_4$ (362 nm), $^7F_0 \rightarrow {}^5L_7$ (383 nm), $^7F_0 \rightarrow {}^5L_6$ (394 nm), $^7F_0 \rightarrow {}^5D_3$ (416 nm), and $^7F_0 \rightarrow {}^5D_2$ (467 nm) [23]. The

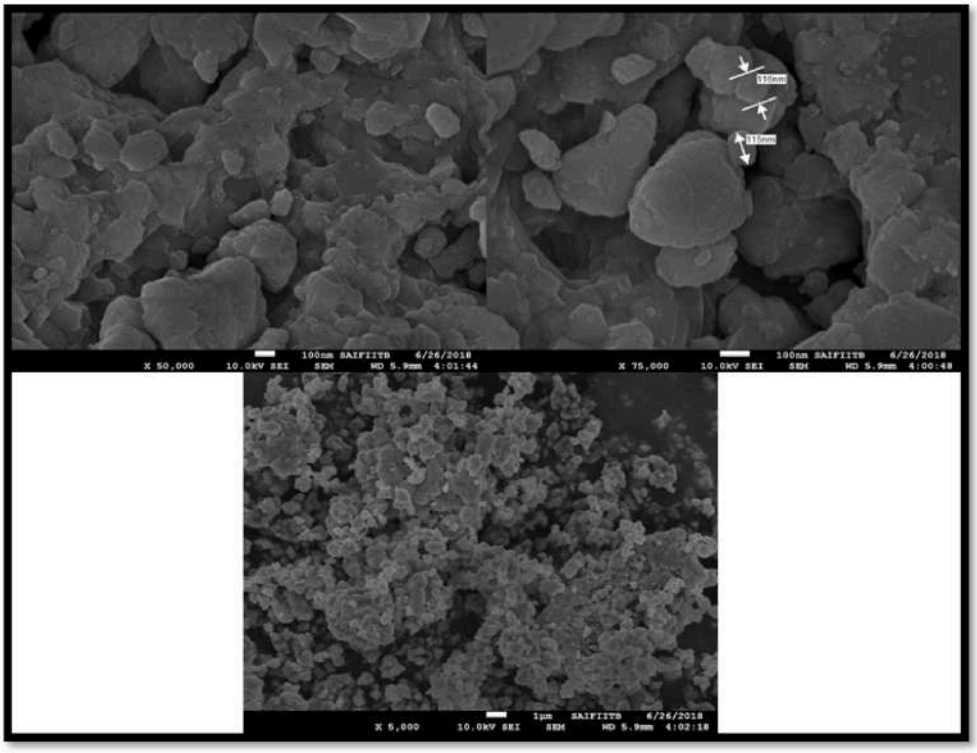


Fig. 8. SEM image of the $Sr_2MgSi_2O_7$:2%Eu^{3+} phosphor.

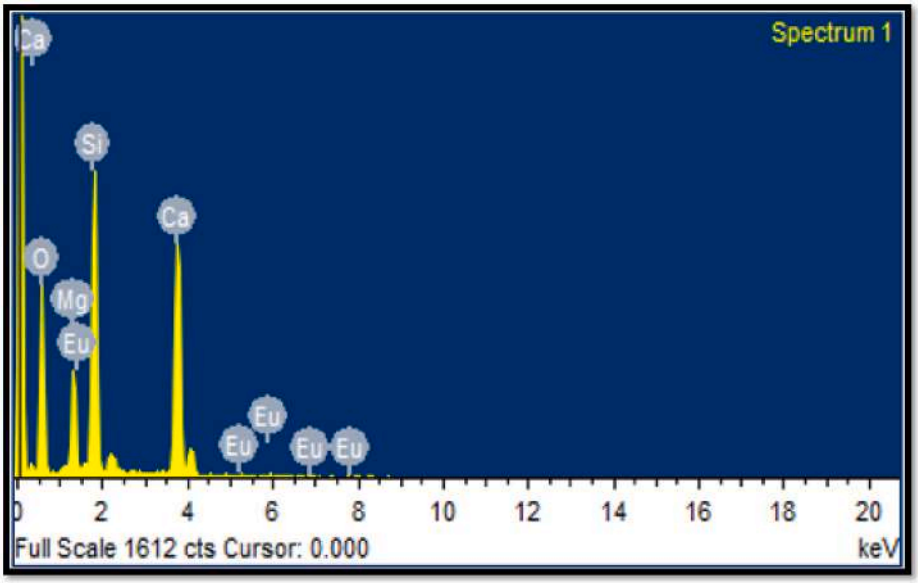


Fig. 9. The energy dispersive X-ray analysis plots for synthesized $Ca_2MgSi_2O_7$:2%Eu^{3+}phosphor.

highest powerful excitation peak (467 nm) coincided with the $^7F_0 \rightarrow {}^5D_2$ transition. One higher exciting peak at 394 nm suggests that an n-UV chip may efficiently excite the phosphor. The emission spectra showed three groups of emission lines 590 nm, 614 nm, and 702 nm, which are attributed to the $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$ transition of Eu^{3+} ions at the excitation wavelength of 467 nm, respectively. The transition $^5D_0 \rightarrow {}^7F_1$ is a magnetic-dipole transition is enabled by the parity selection rule when the Eu^{3+} ions are placed at a location with an inversion symmetric center, resulting in orange-red emission of about 590 nm. Whereas the transition $^5D_0 \rightarrow {}^7F_2$ is an electric-dipole transition that is hypersensitive to the crystal field and its intensity is sensitive to the crystal field. Fundamentally, if the Eu^{3+} ions are located at a site without an inversion symmetric center, the parity selection rule can be lifted because the opposite parity 5d configuration is mixed into the 4f configuration, and the f→f forbidden transition is partially allowed, the hypersensitive $^5D_0 \rightarrow {}^7F_2$ electric dipole transition will be permitted, resulting in red emission around 612 nm. The highest emission at the transition $^5D_0 \rightarrow {}^7F_2$ suggests that the Eu^{3+} ions occurred in the host lattice at low symmetry locations without an inversion center [13,24,25].

The doping concentration affects the performance of a luminescent material, therefore determining the optimum concentration for

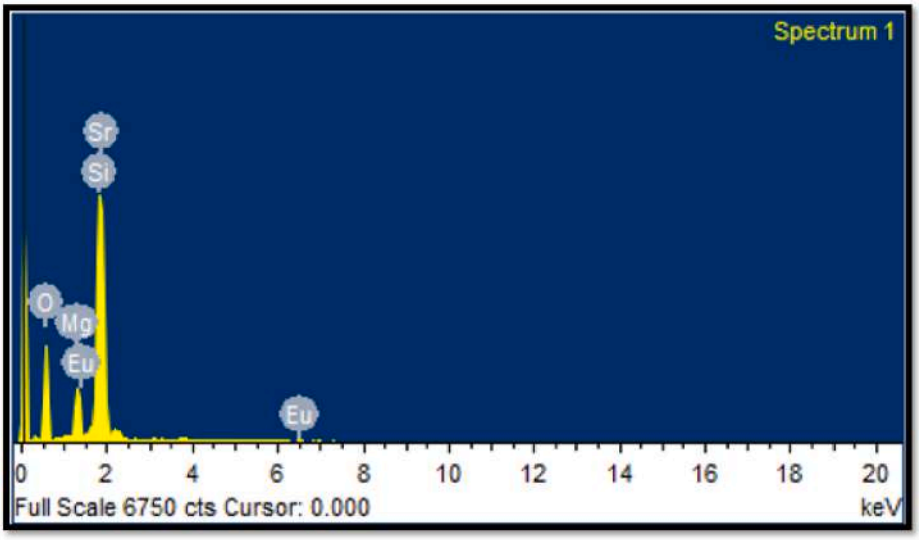


Fig. 10. The energy dispersive X-ray analysis plots for synthesized $Sr_2MgSi_2O_7$:2%Eu^{3+}phosphor.

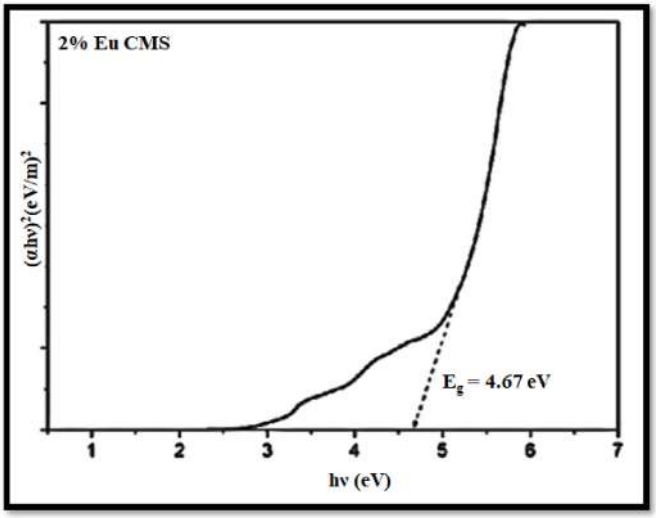


Fig. 11. The Tauc Plot of $Ca_2MgSi_2O_7$:2.0%Eu^{3+} phosphor.

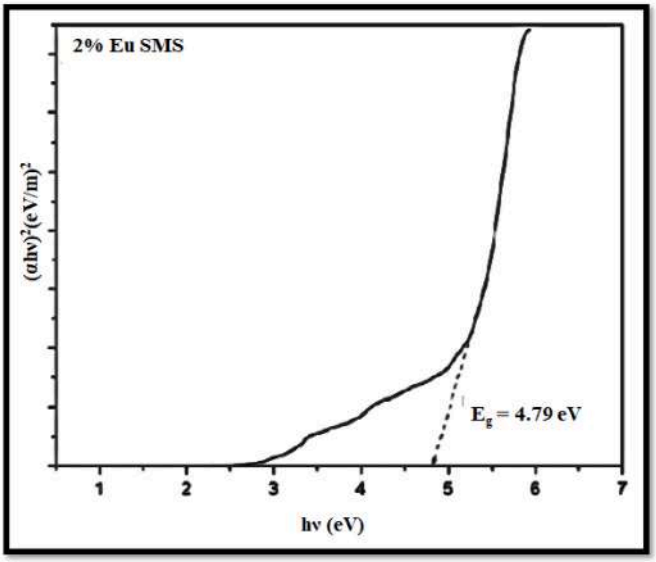


Fig. 12. The Tauc Plot of $Sr_2MgSi_2O_7$:2%Eu^{3+} phosphor.

luminescence is essential. As the Eu^{3+} doping concentration increases, the PL intensity increases up to 2 mol percent and then decreases shown in Fig. 15. The concentration quenching mechanism is mainly caused by the increase in non-radiative relaxation between nearby Eu^{3+} ions.

According to Blasse [26,27], if the activator is solely administered to Z ion sites, where x_c is the critical concentration, N is the number of Z ions in the unit cell, and V is the unit cell volume. The critical transfer distance (Rc) is calculated using the following equation:

$$R_c = 2\left(\frac{3V}{4\pi xN}\right)^{1/3} \quad (2)$$

R_c are computed as 19.422 and 19.425 for $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} respectively using V = 307.2688 for $Ca_2MgSi_2O_7$ and V = 306.8913 for $Sr_2MgSi_2O_7$, Z = 4, and $x_c = 0.02$. As R_c is found at more than 5, the exchange interaction does not affect the energy migration between Eu^{3+} ions in prepared phosphor, because the exchange interaction is generally dominant only for short distances in a forbidden transition [28–30], and the mechanism of radiation re-absorption is only effective when the fluorescence spectra are broadly overlapping. As a result, radiation reabsorption does not occur. Consequently, the process of energy transfer is caused by electric multipolar interactions such as dipole-dipole, dipole-quadrupole, and quadrupole-quadrupole [31]. If energy transfer happens between the same types of activators, the strength of the multipole-multipole interactions may be inferred from the change in emission intensity [28].

According to Dexter's theory, the relationship between luminescent intensity (I) and activator concentration (x) can be expressed by the following equation.

$$\frac{I}{x} = k\left[1 + \beta(x)^{\theta/3}\right]^{-1} \quad (3)$$

where I denote emission intensity; x denotes activator concentration; k and β are constants for the same interaction for a given host crystal; θ = 3 represents energy transfer among nearest-neighbor ions [31], while θ = 6, 8, and 10 represent dipole-dipole, dipole-quadrupole, and quadrupole-quadrupole interactions, respectively [32]. The slope of the relationship between log (I/x) and log (x) for $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} are −0.947 and −1.013 respectively, as illustrated in Fig. 16. Using Eq. (6), the value of is determined to be 2.841 and 3.039

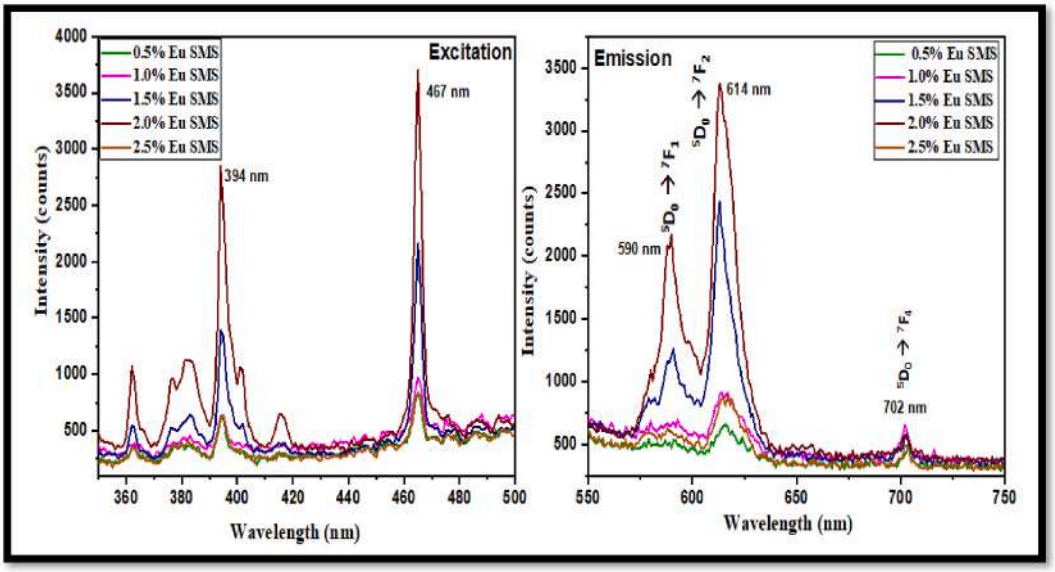


Fig. 13. The excitation and emission spectra of $Ca_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5) Phosphors.

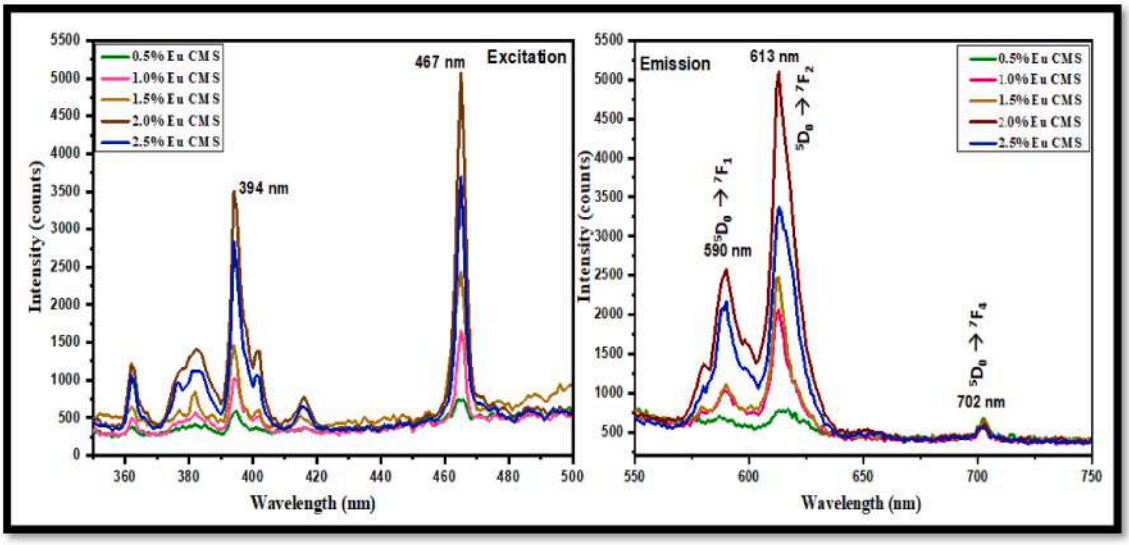


Fig. 14. The excitation and emission spectra of $Sr_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5) Phosphors.

respectively for $Ca_2MgSi_2O_7$:x%$Eu^{3+}$and $Sr_2MgSi_2O_7$:x%Eu^{3+}, which are nearly equal to 3. This finding suggests that the major mechanism of concentration quenching of $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x% Eu^{3+} is energy transfer among nearest neighbor ions.

3.1.3. Judd-Ofelt analysis

The notion of Judd-Ofelt theory is utilized to determine the nature of luminescence behavior and the site symmetry of Eu ions in the host lattice. J-O theory is used to characterize the strength of the f-f transition in rare-earth ions. The J-O intensity parameters Ω_2 and Ω_4 can provide information on the local structure and bonding in the vicinity of rare-earth ions. J-O theory is used to predict radiative characteristics such as radiative lifespan (τ_{rad}), radiative transition rates (A_T), and branching ratios (β_R) for different levels of Eu^{3+} ions.

The JO intensity parameters are estimated using the following equation (Eq. (4)) [33–36]:

$$\Omega_\lambda = \frac{D_{MD}\nu_1{}^3}{e^2\nu_\lambda{}^3U^\lambda}\frac{9n^3}{n(n^2+2)^2}\frac{J_\lambda}{J_1} \quad (4)$$

According to the J-O [14,15] hypothesis, the structural change surrounding rare-earth ions and the covalency of the rare earth sites impact the Ω_J parameters and spontaneous emission probability. In J-O characteristics, Ω_2 is sensitive to the environment and is connected to the covalency of the Eu^{3+} ion, whereas Ω_4 is related to the rigidity of the medium [33,37,38].

The asymmetric ratio is the ratio of the integral intensity of the electric dipole transition (EDT), $^5D_0 \rightarrow {}^7F_2$, to the magnetic dipole transition (MDT), $^5D_0 \rightarrow {}^7F_1$. In a matrix, the asymmetric ratio measures the degree of distortion near the surroundings of the Eu^{3+} ion [39,40]. Depending on the precise crystallographic site symmetry of Eu^{3+}, it might be very small or very large. The asymmetric ratio R [41,42],:

$$R = I_{EDT}/I_{MDT} \quad (5)$$

where I_{EDT} represents the intensity of EDT $^5D_0 \rightarrow {}^7F_2$, and I_{MDT} represents the intensity MDT $^5D_0$-$^7F_1$. The radiative transition A_λ can be expressed using the intensity parameter Ω_J, which is related to electric-dipole transitions, and can be calculated as [43,44],

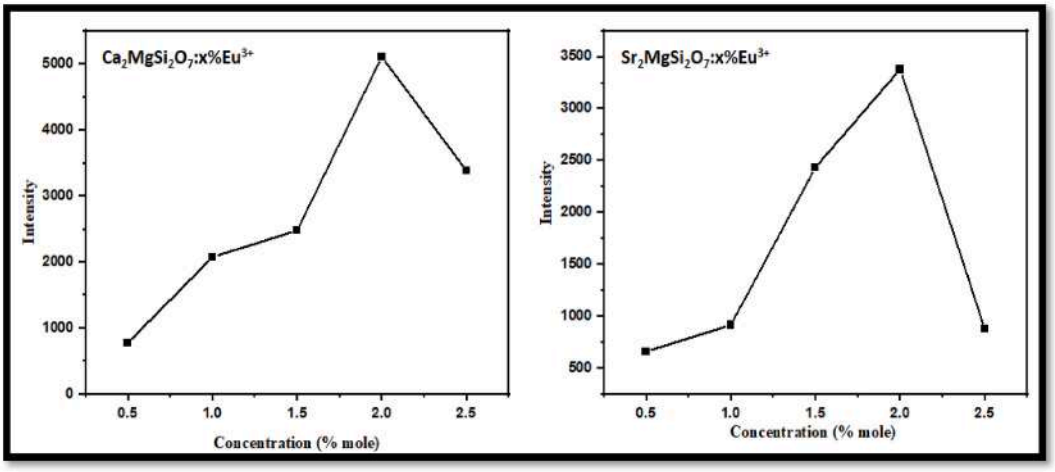


Fig. 15. Variation of PL emission (613 nm) Eu^{3+} Intensity for different concentration.

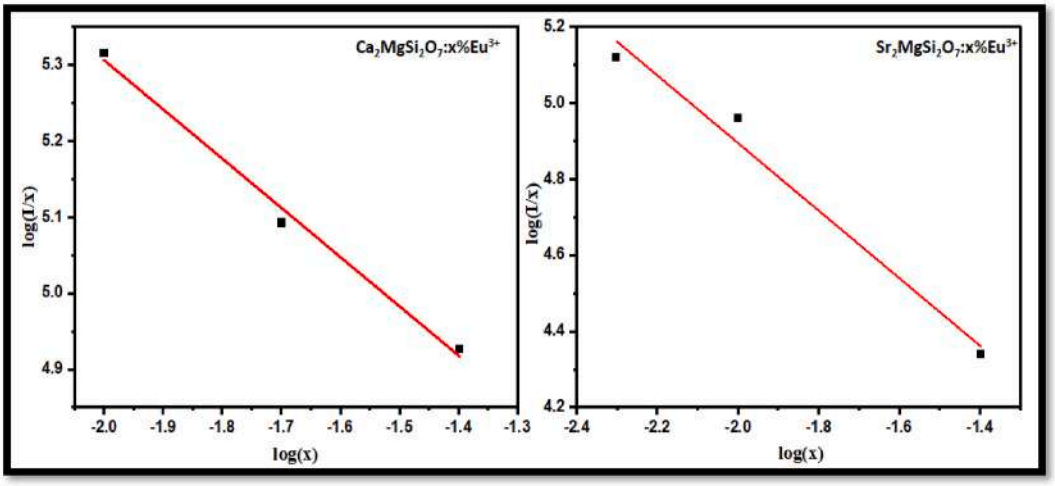


Fig. 16. The linear fitted curve of log (I/x) on log (x) of synthesized samples.

$$A_\lambda = \frac{64\pi^4 \nu_\lambda{}^3}{3h} \frac{n(n^2+2)^2}{9} D_{ED}{}^\lambda, \; as \; D_{ED}{}^\lambda = e^2 \Omega_\lambda U^\lambda \tag{6}$$

where, D_{ED} = dipole strength for ET), $h = 6.63x10^{-27}$ erg s. In Eq. (6), U^λ is abbreviation for $|J|U^\lambda|J|^2$ square reduced matrix elements which are independent of the chemical environment of dopant-Eu^{3+} ion [45]. The radiative time of the $^5D_0$ transition estimate using the sum of all radiative transition A_λ:

$$\tau = \frac{1}{\sum A_\lambda} \tag{7}$$

The branching ratio is the ratio of each transition to the total radiative transition given by, $\beta = \frac{A_\lambda}{\sum A_\lambda}$.

The values of J-O intensity parameters, radiative emission rates, lifetime, branching, and asymmetry ratios for different concentrations of Eu^{3+} in $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} are given in Table 5 and Table 6 respectively. The estimated intensity parameters for prepared phosphors show that the Ω_2 value gradually increases with increasing Eu^{3+} ion, indicating that the covalence degree of the Eu^{3+} site in both materials rises monotonically with doping level. Within the doping level investigated in this study, $\Omega_2 < \Omega_4$ demonstrates that Eu^{3+} ions occupy high symmetry positions in the synthesized sample. There is also a drop in the Ω_4 parameter. It suggests that the $^5D_0 \rightarrow {}^7F_2$ transition is more efficient than the $^5D_0 \rightarrow {}^7F_4$ transition. This implies that the red color emission has been enhanced [46].

The asymmetric ratio R is used to determine the quality of the host material by providing symmetry information around the Eu^{3+} covalency. If R < 1.0 is often considered to be for symmetric surroundings, R > 1.0 is considered to be for asymmetric surroundings. As a result of the high asymmetric ratio, the Eu^{3+} ion is found at sites with poor symmetry and no inversion center [47]. The predicted values of R for all Eu^{3+} concentrations are more than one, demonstrating symmetry distortion around the Eu^{3+} ion in the host lattice. This increased the relative strength of the hypersensitive dipole transition.

Also from the table, it is found that there is an increase in the overall radiative transition probability with an increase in Eu^{3+} concentration. This increase in transition probability might be attributed to the increase in lattice distortion, suggesting a loss in the local symmetry of Eu^{3+} ions. It is observed also from this study that the branching ratios (β) are considerably higher for the $^5D_0 \rightarrow {}^7F_2$ transition [48].

3.1.4. CIE

The CIE chromaticity coordinates are critical in determining the luminous properties of phosphors. The chromaticity coordinate calculation technique based on the CIE 1931 system - color calculator software is used to estimate the color coordinates from the emission spectrum [49].

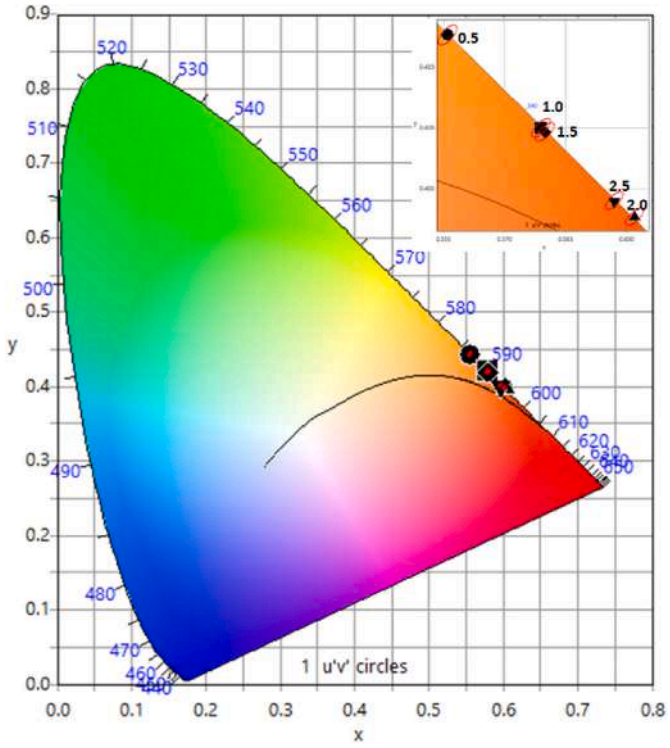


Fig. 17. The chromaticity coordinate diagram for $Ca_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5).

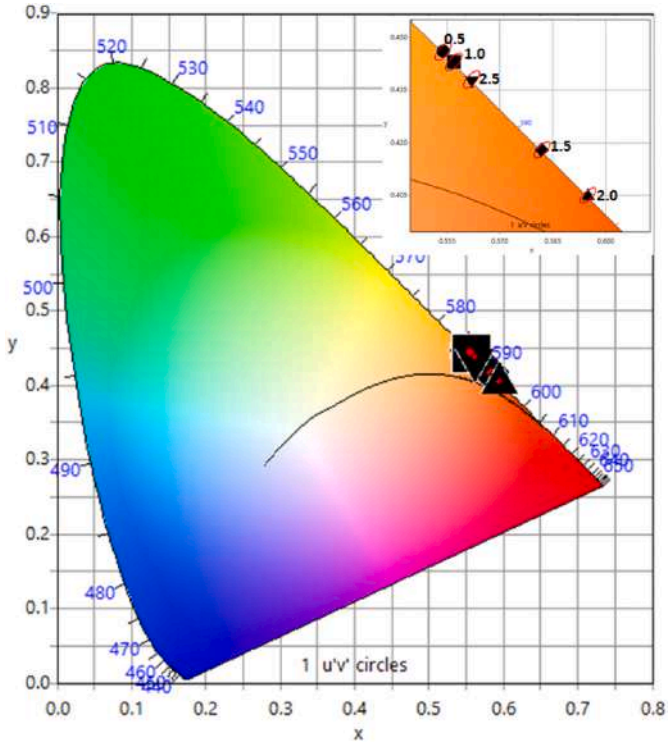


Fig. 18. The chromaticity coordinate diagram for $Sr_2MgSi_2O_7$:x%Eu^{3+} (x = 0.5–2.5).

The CIE chromaticity diagram of $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} phosphors are shown in Fig. 17 and Fig. 18 respectively. The CIE chromaticity coordinates of $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors (which were measured at excitation wavelength

Table 1
the estimated crystallite sizes, lattice parameter, and volume of $Ca_2MgSi_2O_7$ phosphors.

Symbol	Lattice parameter		Volume ($Å^3$)	X-ray density (g/cm^3)	Crystalline size (nm)
	a = b (Å)	c (Å)			
CMS 1	7.7903	5.0262	305.0339	7.761784	57.43
CMS 2	7.8102	5.0245	306.4906	7.724894	57.41
CMS 3	7.8362	5.0087	307.5644	7.697925	46.34
CMS 4	7.8306	5.0071	307.0268	7.711402	54.71
CMS 5	7.8228	5.027	307.6333	7.6962	58.56

Table 2
the estimated average crystallite sizes, lattice parameter a and c values, and volume of $Sr_2MgSi_2O_7$ phosphors.

Symbol	Lattice parameter		Volume ($Å^3$)	X-ray density (g/cm^3)	Crystalline size (nm)
	a = b (Å)	c (Å)			
SMS 1	7.818	5.0051	305.9173	7.73937	57.49
SMS 2	7.826	5.0045	306.507	7.724481	56.66
SMS 3	7.83	5.0019	306.661	7.720602	57.28
SMS 4	7.832	5.0031	306.8913	7.714809	53.47
SMS 5	7.838	5.0062	307.5521	7.698232	54.76

Table 3
The atomic weight percentages of cations Ca2MgSi2O7:2.0%Eu3+.

Element	Weight %	Atomic %
O K	33.84	63.58
Mg K	4.29	5.24
Si K	13.58	14.55
Ca K	47.03	16.18
Eu L	1.25	0.44
Totals	99.99	

Table 4
The atomic weight percentages of cations Sr2MgSi2O7:2.0%Eu3+.

Element	Weight %	Atomic %
O K	42.40	64.55
Mg K	5.92	5.34
Si K	15.81	13.88
Sr K	34.88	15.02
Eu L	1.13	1.21
Totals	99.99	

λex = 397 nm) with varying Eu^{3+} concentrations were presented in Table 7 and Table 8 respectively.

The correlated color temperature (CCT) is usually used to identify the quality of emitted light for the glasses and can be calculated from the McCamy empirical equation [49]:

$$CCT = 437n^3 + 3601n^2 + 6861n + 5517 \quad (9)$$

Where n is the inverse of the slope and is equal to $(x - x_e)/(y_e - y)$; the epicenter points are $x_e = 0.332$ and $y_e = 0.186$. The estimated values for different Eu^{3+} concentrations for the $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors are presented in Table 7 and Table 8 respectively.

It is noticeable in the CIE chromaticity coordinate diagram that $Ca_2MgSi_2O_7$:x%Eu^{3+} and $Sr_2MgSi_2O_7$:x%Eu^{3+} phosphors excited at 397 nm shift to a pure red region with the increasing Eu^{3+} content. Hence the synthesized red color nanophosphors can be used to supplement other available red color phosphors, as well as with other suitable phosphors to compensate for any lack of red color. These color and spectrum data suggest that synthesized phosphors with more pure red chromaticity and

Table 5
The J–O intensity parameters and radiative parameter of $Ca_2MgSi_2O_7$:x%Eu^{3+}.

Concentration (mol%)	J–O intensity parameters (cm^{-2})		*Transition*	A (s^{-1})	β %	$\tau(s)$	Asymmetric ratio (R)
	Ω_2(x10^{-20})	Ω_4(x10^{-20})					
0.5	**2.1962**	**5.0064**	$^5D_0$-$^7F_1$	**14.488**	**23.91**	**0.0165**	**1.461**
			$^5D_0$-$^7F_2$	**21.384**	**35.28**		
			$^5D_0$-$^7F_4$	**24.733**	**40.81**		
1.0	**2.5325**	**4.0224**	$^5D_0$-$^7F_1$	**14.487**	**24.49**	**0.0169**	**1.608**
			$^5D_0$-$^7F_2$	**24.774**	**40.89**		
			$^5D_0$-$^7F_4$	**19.879**	**33.61**		
1.5	**2.7015**	**3.8074**	$^5D_0$-$^7F_1$	**14.486**	**24.23**	**0.01672**	**1.692**
			$^5D_0$-$^7F_2$	**26.473**	**44.28**		
			$^5D_0$-$^7F_4$	**18.821**	**31.48**		
2.0	**2.8045**	**2.7729**	$^5D_0$-$^7F_1$	**14.491**	**26.01**	**0.01794**	**1.763**
			$^5D_0$-$^7F_2$	**27.511**	**49.38**		
			$^5D_0$-$^7F_4$	**13.710**	**24.61**		
2.5	**2.7623**	**2.5209**	$^5D_0$-$^7F_1$	**14.493**	**26.81**	**0.0185**	**1.78**
			$^5D_0$-$^7F_2$	**27.095**	**50.13**		
			$^5D_0$-$^7F_4$	**12.464**	**23.06**		

Table 6
The J–O intensity parameters and radiative parameter of $Sr_2MgSi_2O_7$:x%Eu^{3+}.

Concentration (mol%)	J–O intensity parameters (cm^{-2})		*Transition*	A (s^{-1})	β %	$\tau(s)$	Asymmetric ratio (R)
	Ω_2(x10^{-20})	Ω_4(x10^{-20})					
0.5	**2.2813**	**4.8646**	$^5D_0$-$^7F_1$	**14.481**	**21.61**	**0.0165**	**1.458**
			$^5D_0$-$^7F_2$	**21.228**	**30.29**		
			$^5D_0$-$^7F_4$	**20.503**	**26.01**		
1.0	**2.3656**	**4.7353**	$^5D_0$-$^7F_1$	**14.482**	**21.63**	**0.0164**	**1.513**
			$^5D_0$-$^7F_2$	**22.650**	**32.35**		
			$^5D_0$-$^7F_4$	**19.503**	**24.81**		
1.5	**2.6084**	**3.7808**	$^5D_0$-$^7F_1$	**14.486**	**23.78**	**0.0170**	**1.65**
			$^5D_0$-$^7F_2$	**27.007**	**42.50**		
			$^5D_0$-$^7F_4$	**11.517**	**16.11**		
2.0	**2.625**	**2.9433**	$^5D_0$-$^7F_1$	**14.502**	**27.39**	**0.0182**	**1.653**
			$^5D_0$-$^7F_2$	**24.87**	**45.03**		
			$^5D_0$-$^7F_4$	**7.718**	**12.415**		
2.5	**2.6151**	**3.1148**	$^5D_0$-$^7F_1$	**14.486**	**21.69**	**0.0180**	**1.651**
			$^5D_0$-$^7F_2$	**23.749**	**34.02**		
			$^5D_0$-$^7F_4$	**17.89**	**22.84**		

Table 7
CIE chromaticity coordinates of the $Ca_2MgSi_2O_7$:x%Eu^{3+}.

Concentration	C_x	C_y	CCT
0.5	0.556	0.443	1948
1	0.579	0.42	1672
1.5	0.58	0.419	1661
2	0.602	0.398	1440
2.5	0.597	0.402	1484

Table 8
CIE chromaticity coordinates of the $Sr_2MgSi_2O_7$:x%Eu^{3+}.

Concentration	C_x	C_y	CCT
0.5	0.554	0.446	1979
1	0.557	0.443	1940
1.5	0.582	0.418	1645
2	0.595	0.405	1509
2.5	0.562	0.438	1877

gain are a superior choice for luminescence applications.

4. Conclusion

In this work, Eu^{3+} doped $Ca_2MgSi_2O_7$ and $Sr_2MgSi_2O_7$ phosphors were sintered at 1100 °C after being synthesized by the combustion process. For the as-prepared phosphors, XRD and Rietveld refinement revealed a single phase with akermanite type structure belonging to tetragonal crystallography. UV–Vis spectroscopy was used to calculate the optical bandgap. $Ca_2MgSi_2O_7$:2.0%Eu and $Sr_2MgSi_2O_7$:2.0%Eu phosphors have band gaps of 4.67 eV and 4.79 eV, respectively. $Ca_2MgSi_2O_7$:x%Eu and $Sr_2MgSi_2O_7$:x%Eu phosphors produced orange-red light with emission peaks at 590 nm, 613 nm, and 702 nm, which corresponded to the Eu3+ transitions $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$, respectively. The main spectroscopic features (transition probabilities, radiative lifetimes, and branching ratios) associated with the $^5D_0$ orange-red emitting level were determined using a modified Judd-Ofelt approach based on the emission spectrum. $\Omega_2 < \Omega_4$ reveals that Eu^{3+} ions occupy high symmetry locations in the generated sample under the doping level studied in this work. There has also been a decrease in the Ω_4 parameter. It implies that the $^5D_0 \rightarrow {}^7F_2$ transition is more efficient than the $^5D_0 \rightarrow {}^7F_4$. This indicates that the red color emission has been improved. The estimated CIE coordinates corroborated the PL emission in the orange-red region.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

References

[1] R. Shukla, S.K. Gupta, H. Yadav, P. Ranjane, R.M. Kadam, S.N. Achary, A.K. Tyagi, A carnegieite type red emitting $NaAlSiO_4:Eu^{3+}$ phosphor: concentration dependent time resolved photoluminescence and Judd-Ofelt analysis, J. Lumin. 209 (2019) 283–290, https://doi.org/10.1016/j.jlumin.2019.02.002.

[2] Z. Shi, J. Wang, H. Jiang, X. Guan, Y. Lu, J. Shi, Photoluminescence characteristics and energy transfer mechanism of Eu^{3+}:$NaY(WO_4)_2$ microparticles, J. Mater. Sci. Mater. Electron. 30 (2019) 3169–3176, https://doi.org/10.1007/s10854-018-00597-y.

[3] P. Chaware, K.G. Rewatkar, Structural, and photoluminescence study of $SrAl_2O_4$: Eu^{3+} phosphors synthesized by combustion method, Int. J. Chem. Math. Phys. (IJCMP). 5 (2021) 1–6, https://doi.org/10.22161/ijcmp.5.6.1.

[4] I. Prasad Sahu, D.P. Bisen, N. Brahme, Structural characterization and optical properties of $Ca_2MgSi_2O_7:Eu^{2+}$, Dy^{3+} phosphor by solid-state reaction method, Luminescence 30 (2015) 526–532, https://doi.org/10.1002/bio.2771.

[5] L. Fernández-Rodríguez, A. Durán, M.J. Pascual, Silicate-based persistent phosphors, Open. Ceram. 7 (2021), 100150, https://doi.org/10.1016/j.oceram.2021.100150.

[6] D. Singh, S. Sheoran, V. Tanwar, S. Bhagwan, Optical characteristics of Eu(III) doped MSiO3 (M = Mg, Ca, Sr and Ba) nanomaterials for white light-emitting applications, J. Mater. Sci. Mater. Electron. 28 (2017) 3243–3253, https://doi.org/10.1007/s10854-016-5914-2.

[7] D. Pandey, Comparison study of the thermo- luminescent property of the long after glow phosphors $Ca_2MgSi_2O_7$:Eu with different concentration, (n.d.) 119–123.

[8] D. Singh, S. Sheoran, S. Bhagwan, S. Kadyan, Optical characteristics of sol-gel derived M3SiO5:Eu3+ (M = Sr, Ca and Mg) nanophosphors for display device technology, Cogent Phys. (2016) 1–12, https://doi.org/10.1080/23311940.2016.1262573, 0.

[9] M.M.S. Sanad, D.A. Rayan, M.M. Rashad, Optical and photoluminesce properties of Eu2+-activated strontium magnesium silicate phosphors using different rare earth co-activators, Opt. Quant. Electron. 51 (2019) 1–14, https://doi.org/10.1007/s11082-019-1913-x.

[10] G. Tiwari, N. Brahme, R. Sharma, D.P. Bisen, S.K. Sao, S.J. Dhoble, A study on the luminescence properties of gamma-ray-irradiated white light emitting Ca2Al2SiO7:Dy3+ phosphors fabricated using a combustion-assisted method, RSC Adv. 6 (2016) 49317–49327, https://doi.org/10.1039/c6ra04913c.

[11] R.E.M. Khaidir, Y.W. Fen, M.H.M. Zaid, K.A. Matori, N.A.S. Omar, M.F. Anuar, S.A. A. Wahab, A.Z.K. Azman, Optical band gap and photoluminescence studies of Eu 3 + -doped zinc silicate derived from waste rice husks, Optik 182 (2019) 486–495, https://doi.org/10.1016/j.ijleo.2019.01.061.

[12] V. Singh, MdM. Haque, D.-K. Kim, ChemInform abstract: investigation of a new red-emitting, Eu 3+ -activated MgAl 2 O 4 phosphor, ChemInform 39 (2008) 47–49, https://doi.org/10.1002/chin.200812009.

[13] T.T. Hao Tam, N.D. Hung, N.T.K. Lien, N.D. Trung Kien, P.T. Huy, Synthesis and optical properties of red/blue-emitting $Sr_2MgSi_2O_7:Eu^{3+}/Eu^{2+}$ phosphors for white LED, J. Sci.: Adv. Mater. Dev. 1 (2016) 204–208, https://doi.org/10.1016/j.jsamd.2016.06.009.

[14] M. Li, L. Wang, W. Ran, Z. Deng, J. Shi, C. Ren, Tunable luminescence in Sr2MgSi2O7: Tb3+, Eu3+phosphors based on energy transfer, Materials 10 (2017), https://doi.org/10.3390/ma10030227.

[15] R. Shrivastava, J. Kaur, Characterization and studies on long-lasting properties of Ca2MgSi2O7: Eu2+, Dy3+ phosphors, Ferroelectrics 494 (2016) 52–60, https://doi.org/10.1080/00150193.2016.1135537.

[16] G. Tiwari, N. Brahme, R. Sharma, D.P. Bisen, S.K. Sao, S. Tigga, Luminescence properties of dysprosium doped di-calcium di-aluminum silicate phosphors, Opt. Mater. 58 (2016) 234–242, https://doi.org/10.1016/j.optmat.2016.05.033.

[17] T.T. Hao Tam, N.D. Hung, N.T.K. Lien, N.D. Trung Kien, P.T. Huy, Synthesis and optical properties of red/blue-emitting $Sr_2MgSi_2O_7:Eu^{3+}/Eu^{2+}$ phosphors for white LED, J. Sci.: Adv. Mater. Dev. 1 (2016) 204–208, https://doi.org/10.1016/j.jsamd.2016.06.009.

[18] K. Momma, F. Izumi, VESTA 3 for three-dimensional visualization of crystal, volumetric and morphology data, J. Appl. Crystallogr. 44 (2011) 1272–1276, https://doi.org/10.1107/S0021889811038970.

[19] D. Pandey, N. Brahme, R. Sharma, A. Pandey, Synthesis photoluminescence study of Ca2MgSi 2 O7 : Ce, Adv. Phys. Lett. 3 (2016) 18.

[20] I.P. Sahu, D.P. Bisen, N. Brahme, Europium doped di-calcium magnesium di-silicate orange–red emitting phosphor by solid state reaction method, J. Radiat. Res. Appl. Sci. 8 (2015) 381–388, https://doi.org/10.1016/j.jrras.2015.02.007.

[21] J. Tauc, Optical properties of amorphous semiconductors, in: J. Tauc (Ed.), Amorphous and Liquid Semiconductors, Springer US, Boston, MA, 1974, pp. 159–220, https://doi.org/10.1007/978-1-4615-8705-7_4.

[22] R. Neema, M. Saleem, P.K. Sharma, M. Mittal, Structure, Optical Bandgap and Luminescence Studies of SrAl2O4: Eu3+, Dy3+ Nanophosphor, 3Rd International Conference on Condensed Matter and Applied Physics, vol. 2220, 2020, 020159, https://doi.org/10.1063/5.0002749. Icc-2019.

[23] J. Cheng, J. Zhang, X. Bian, Z. Zhai, J. Shi, Spectrochimica Acta Part A : Molecular and Biomolecular Spectroscopy Photoluminescence Properties , Judd-Ofelt Analysis , and Optical Luminescent Materials, 2020, p. 230.

[24] K. Mondal, J. Manam, Enhancement of photoluminescence in Eu3+ co-activated $Ca_2MgSi_2O_7:Dy^{3+}$ phosphors for solid state lighting application, J. Mol. Struct. 1125 (2016) 503–513, https://doi.org/10.1016/j.molstruc.2016.07.028.

[25] S. Stojadinović, N. Tadić, A. Ćirić, R. Vasilić, Photoluminescence properties of Eu3 + doped HfO2 coatings formed by plasma electrolytic oxidation of hafnium, Opt. Mater. 77 (2018) 19–24, https://doi.org/10.1016/j.optmat.2018.01.014.

[26] G. Blasse, B.C. Grabmaier, Luminescent Materials, Springer Berlin Heidelberg, 1994, https://doi.org/10.1007/978-3-642-79017-1.

[27] G. Blasse, Energy transfer in oxidic phosphors, Phys. Lett. 28 (1968) 444–445, https://doi.org/10.1016/0375-9601(68)90486-6.

[28] D. Deng, H. Yu, Y. Li, Y. Hua, G. Jia, S. Zhao, H. Wang, L. Huang, Y. Li, C. Li, S. Xu, Ca<sub4$(PO_4)_2$O:Eu^{2+} red-emitting phosphor for solid-state lighting: structure{,} luminescent properties and white light emitting diode application, J. Mater. Chem. C 1 (2013) 3194–3199, https://doi.org/10.1039/C3TC30148F.

[29] Q. Zhang, X. Ding, Y. Wang, Novel highly efficient blue-emitting $SrHfSi_2O_7:Eu^{2+}$ phosphor: a potential color converter for WLEDs and FEDs, Dyes Pigments 163 (2019) 168–175, https://doi.org/10.1016/j.dyepig.2018.11.052.

[30] S. Ray, P. Tadge, S. Dutta, T.M. Chen, G.B. Nair, S.J. Dhoble, Synthesis, luminescence and application of $BaKYSi_2O_7:Eu^{2+}$: a new blue-emitting phosphor for near-UV white-light LED, Ceram. Int. 44 (2018) 8334–8343, https://doi.org/10.1016/j.ceramint.2018.02.022.

[31] D.L. Dexter, J.H. Schulman, Theory of concentration quenching in inorganic phosphors, J. Chem. Phys. 22 (1954) 1063–1070, https://doi.org/10.1063/1.1740265.

[32] L. Ozawa, P.M. Jaffe, The mechanism of the emission color shift with activator concentration in $\mathplus$3, Activ. Phosphors. 118 (1971) 1678, https://doi.org/10.1149/1.2407810.

[33] Ž. Antić, R. Krsmanović, V. Dor ević, T. Dramićanin, M.D. Dramićanin, Optical properties of $Y_2O_3:Eu^{3+}$ red emitting phosphor obtained via spray pyrolysis, Acta Phys. Pol., A (2009) 622–624, https://doi.org/10.12693/APhysPolA.116.622.

[34] A. Ćirić, S. Stojadinović, M. Sekulić, M.D. Dramićanin, JOES: an application software for Judd-Ofelt analysis from Eu^{3+} emission spectra, J. Lumin. 205 (2019) 351–356, https://doi.org/10.1016/j.jlumin.2018.09.048.

[35] K. Binnemans, Interpretation of europium(III) spectra, Coord. Chem. Rev. 295 (2015) 1–45, https://doi.org/10.1016/j.ccr.2015.02.015.

[36] P. Chaware, A. Nande, S.J. Dhoble, K.G. Rewatkar, Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu^{3+} doped strontium hexa-aluminate nanophosphors for lighting application, Opt. Mater. 121 (2021), 111542, https://doi.org/10.1016/j.optmat.2021.111542.

[37] M. Kumar, T.K. Seshagiri, S.v Godbole, Fluorescence lifetime and Judd-Ofelt parameters of Eu^{3+} doped $SrBPO_5$, Phys. B Condens. Matter 410 (2013) 141–146, https://doi.org/10.1016/j.physb.2012.10.040.

[38] K. Vuković, S. Čulubrk, M. Sekulić, M.D. Dramićanin, Analysis of luminescence of Eu^{3+} doped $Lu_2Ti_2O_7$ powders with Judd-Ofelt theory, J. Res. Phys. 38–39 (2016) 23–32, https://doi.org/10.1515/jrp-2015-0003.

[39] P.A. Tanner, Some misconceptions concerning the electronic spectra of tri-positive europium and cerium, Chem. Soc. Rev. 42 (2013), https://doi.org/10.1039/c3cs60033e.

[40] H.Q. Liu, L.L. Wang, S.G. Chen, B.S. Zou, Optical properties of nanocrystal and bulk ZrO_2: Eu^{3+}, J. Alloys Compd. 448 (2008) 336–339, https://doi.org/10.1016/j.jallcom.2006.11.171.

[41] S.Y. Zheng, J.W. Chiou, Y.H. Li, Correlation among photoluminescence and the electronic and atomic structures of $Sr_2SiO_4:xEu^{3+}$ phosphors: X-ray absorption and emission studies, Sci. Rep. 10 (2020) 1–12, https://doi.org/10.1038/s41598-020-69428-7.

[42] I.E. Kolesnikov, E.v. Golyeva, E.v. Borisov, E.Y. Kolesnikov, E. Lähderanta, A. v. Kurochkin, M.D. Mikhailov, Photoluminescence properties of Eu^{3+}-doped $MgAl_2O_4$ nanoparticles in various surrounding media, J. Rare Earths 37 (2019) 806–811, https://doi.org/10.1016/j.jre.2018.10.019.

[43] S.S. Babu, P. Babu, C.K. Jayasankar, W. Sievers, T. Tröster, G. Wortmann, Optical absorption and photoluminescence studies of Eu^{3+}-doped phosphate and fluorophosphate glasses, J. Lumin. 126 (2007) 109–120, https://doi.org/10.1016/j.jlumin.2006.05.010.

[44] D.K. Singh, J. Manam, Structural and photoluminescence studies of red emitting $CaTiO_3:Eu^{3+}$ perovskite nanophosphors for lighting applications, J. Mater. Sci. Mater. Electron. 27 (2016) 10371–10381, https://doi.org/10.1007/s10854-016-5123-z.

[45] W.T. Carnall, G.L. Goodman, K. Rajnak, R.S. Rana, A systematic analysis of the spectra of the lanthanides doped into single crystal LaF_3, J. Chem. Phys. 90 (1989) 3443–3457, https://doi.org/10.1063/1.455853.

[46] E. Cantelar, J.A. Sanz-garcía, J. Enrique, Structural , Photoluminescent Properties and Judd-Ofelt Analysis of Eu 3 þ -activated CaF 2 Nanocubes, 2020, p. 813.

[47] W.F. Krupke, Optical absorption and fluorescence intensities in several rare-earth-doped Y_2O_3 and LaF_3 single crystals, Phys. Rev. 145 (1966) 325–337, https://doi.org/10.1103/PhysRev.145.325.

[48] M. Ferhi, C. Bouzidi, K. Horchani-Naifer, H. Elhouichet, M. Ferid, Judd-Ofelt analysis of spectroscopic properties of Eu^{3+} doped $KLa(PO_3)_4$, J. Lumin. 157 (2015) 21–27, https://doi.org/10.1016/j.jlumin.2014.08.017.

[49] C.S. McCamy, Correlated color temperature as an explicit function of chromaticity coordinates, Color Res. Appl. 17 (1992) 142–144, https://doi.org/10.1002/col.5080170211.

Journal of Magnetism and Magnetic Materials 551 (2022) 169162

Contents lists available at ScienceDirect

Journal of Magnetism and Magnetic Materials

journal homepage: www.elsevier.com/locate/jmmm

Influence of Bi^{3+} ions substitution on structural, magnetic, and electrical properties of lead hexaferrite

Y.D. Choudhari *, K.G. Rewatkar

Department of Physics, Dr. Ambedkar College, DeekshaBhoomi, Nagpur 10, India

ARTICLE INFO

Keywords:
Hexaferrite
XRD
SEM
VSM
Electrical conductivity

ABSTRACT

The Microwave induced sol-gel auto-combustion process was used to make lead hexaferrite, $PbFe_{12-x}Bi_xO_{19}$ ($x = 0.2$ to 0.8), with Bi^{3+} as a replacement. X-ray powder diffractometer (XRD), scanning electron microscopy (SEM), vibrating sample Magnetometry (VSM), Fourier transform infrared spectroscopy (FT-IR), and Impedance analysis was used to test the impact of added Bi^{3+} ions on the structure, morphology, magnetic, and dielectric properties of lead hexaferrite. Single-phase hexagonal ferrite nanoparticles with average crystalline sizes of 43 to 59 nm were achieved with the space group of P63/mmc. The magnetic analysis revealed that when the Bi^{3+} ion is supplemented in the Pb ferrite, the coercive and saturation magnetization of the material was amplified. The substance's dielectric constant, electric conductivity, and loss tangent were calculated for frequencies of 20 Hz to 10 MHz, indicating that it is appropriate for wide applications like permanent magnets, high-density magnetic recording media.

1. Introduction

Ferrite materials offer unique electrical and magnetic properties, with a substantial link between spin, charge, and degrees of freedom. All these materials reveal a link between magneto-electric features and have been universally referred to as potential materials for usage in various memory gadgets [1]. More than 80% of permanent magnetic materials used globally are made from this chemically inert and cost-effective substances. A study has spotted that hexaferrite, particularly Sr, Ca and Ba is capable of significant attenuation of electromagnetic waves due to its lower magnetic loss and wider frequency range. Hexaferrite materials with uniaxial magneto-plumbites structure have reasonably large saturation magnetization (Ms), tunable coercive force (Hc), high electrical resistivity(ρ), and low eddy current [2].

M-type hexaferrite has the most significant form of hexaferrite that has a lot of value in the electronics industry. Because of their high magnetization, magnetic anisotropy, and outstanding stability, those are preferable over other ferrites [3]. An M-type hexaferrite contains a set of Pb-M molecular units, units subdivided into layers of cubic S and hexagonal R, with the frame of SRS*R*, have further separated each of the molecular units, in the unit cell, there are $38O^{2-}$ ions, $2Pb^{2+}$ ions, while $24Fe^{3+}$ ions in 5 crystallographic sites (1 trigonal-bi-pyramidal site, 1 tetrahedral site, and 3 octahedral sites). The exchange of Fe^{3+} ions with alternative ions can modify the magnetic characteristic depending on the dopant's magnetic moment, concentration, and proclivity to occupy Fe^{3+} ion sites [4]. Numerous writers have replaced divalent ions for Fe^{3+} and Ba^{2+}, Sr^{2+}, ions, or a mixture of both to change the characteristics of M-type hexagonal ferrite.

Researchers led by Fatima Sehar used the powder metallurgy route to synthesize Bi^{3+} substituted barium ferrite. When the substitution concentration rises in the Ba ferrite, the coercivity and net magnetic moment increase from 1844 to 2466 Oe and 45.39 to 79.12 emu/g. The optical band gap of Ba ferrite also altered at room temperature [5]. T. Osotochan prepared Bi^{3+} ion substituted Ba^{2+} ferrite, coercivity, and net magnetic moment decreases. Bi^{3+} ions would take the place of Fe ions in either the 4e or $4f_n$ sites. By substituting non-magnetic ions at sites such as 4e, a spin-up layer, Ms should be reduced, while at sites such as $4f_n$, a spin-down layer, an increase in Ms should be observed [6]. Deepak Basandrai synthesized Bi^{3+} ion substituted Sr ferrite, the squareness ratio, coercivity, and net magnetic moment improve in the material when the Bi^{3+} concentration increase, making it the optimal material for magnetic applications [7].

An almost large number of hexaferrite research has concentrated on barium and strontium, with minimal research on lead hexaferrite. And there is no research on the effect of Bi^{3+} doping on the structural and magnetic properties of M-type lead hexaferrite. The temperature at

* Corresponding author.
E-mail address: yograjchoudhari476@gmail.com (Y.D. Choudhari).

https://doi.org/10.1016/j.jmmm.2022.169162
Received 5 November 2021; Received in revised form 31 January 2022; Accepted 9 February 2022
Available online 12 February 2022
0304-8853/© 2022 Elsevier B.V. All rights reserved.

which Pb–M hexaferrite forms is relatively low than the temperature at which Ba and Sr hexaferrite forms. As a result, this investigation has been carried out to determine the specific impact of Bi^{3+} on the magnetic, structural, and electrical properties of lead hexaferrite via microwave-induced sol-gel auto combustion processes.

2. Experimental procedure

The Microwave induced sol-gel auto combustion path is used to synthesize Bi^{3+} substituted M-type lead hexaferrite ($PbBi_xFe_{12-x}O_{19}$) (x = 0.2 to 0.8) powders, because of its many advantages, such as ease of use, low anneal or calcine temperature, energy efficiency, and fast reaction rate, produces ultrafine nanoparticle powder with a greater specimen size distribution excellent chemical uniformity, and a more prominent chance of acquiring a single domain structure, using AR grade chemicals like $Pb(NO_3)_3.6H_2O$ (99.99 percent purity), $Fe(NO_3)_3{\cdot}.9H_2O$ (99.99 percent purity), $Bi(NO_3)_3$ (99.99 percent purity), and urea (99.99 percent purity) [8]. Fig. 1 illustrates the synthesis step, in stoichiometric amounts, iron, and metal salts are dissolved in distilled water, then a mixture is made at ambient temperature with continuous stirring. The fuel was urea, which was dissolved into the solution at a 1:1 M ratio of metal ions to urea [9]. The solvent was then evaporated more on a magnetic heating plate at 70–90 °C till it formed a viscous gel. The gel was placed in a specially built microwave oven, this gel is then ignited, producing a homogeneous nanocrystalline powder, resulting in the creation of a large volume of gas. To obtain lead nano-hexaferrite, the resulting precursor powder was sintered at 800 °C for 4 hr. X-ray diffraction was utilized tons examine the structural features of the samples [10]. Fourier Transform Infrared Spectroscopy (FTIR) revealed the occurrence of chemical bonds in the optimum crystal phase. Vibrational sample Magnetometry is also used to investigate the magnetic properties and characteristics of the samples like Saturation magnetization, coercivity, remnant magnetization, and other essential parameters [11], [1,2,4–54]

3. Results and discussion

3.1. XRD data and analysis

Using a Bruker AXS, D8 Advance X-ray diffractometer (STIC Kochi) [λ = 1.5406 Å] for Cu-Kα, structural analysis, and phase identification has performed for the Pb-Bi ferrites', XRD pattern has illustrated in Fig. 2, this pattern consists of a predominantly pure hexagonal phase diffraction pattern (JCPDS No.: 017-0660) with spacing core group P63/mmc [12]. The sample has been found to contain a doped lead hexaferrite phase. Ferrite's peak appears in the same location, but with a different intensity. Reorganized in hexagonal form throughout doped ferrite with various concentrations of Bi^{3+} (x = 0.2, to 0.8). The angle range of scattering (2θ) was preferred from 15° to 65° [13].

The X-ray line's broadening aided in determining crystalline size D. the Debye Scherer's formula is used to calculate the D

$$D = \frac{K\lambda}{\beta \cos\theta} \tag{1.1}$$

In Equation (1.1),

θ is the Bragg angle.
β is the full width at half-maximum expressed in units of 2θ
λ is the X-ray wavelength,
K is the Scherer constant (k = 0.9).

The materials to be amorphous when not calcined, but crystallinity is

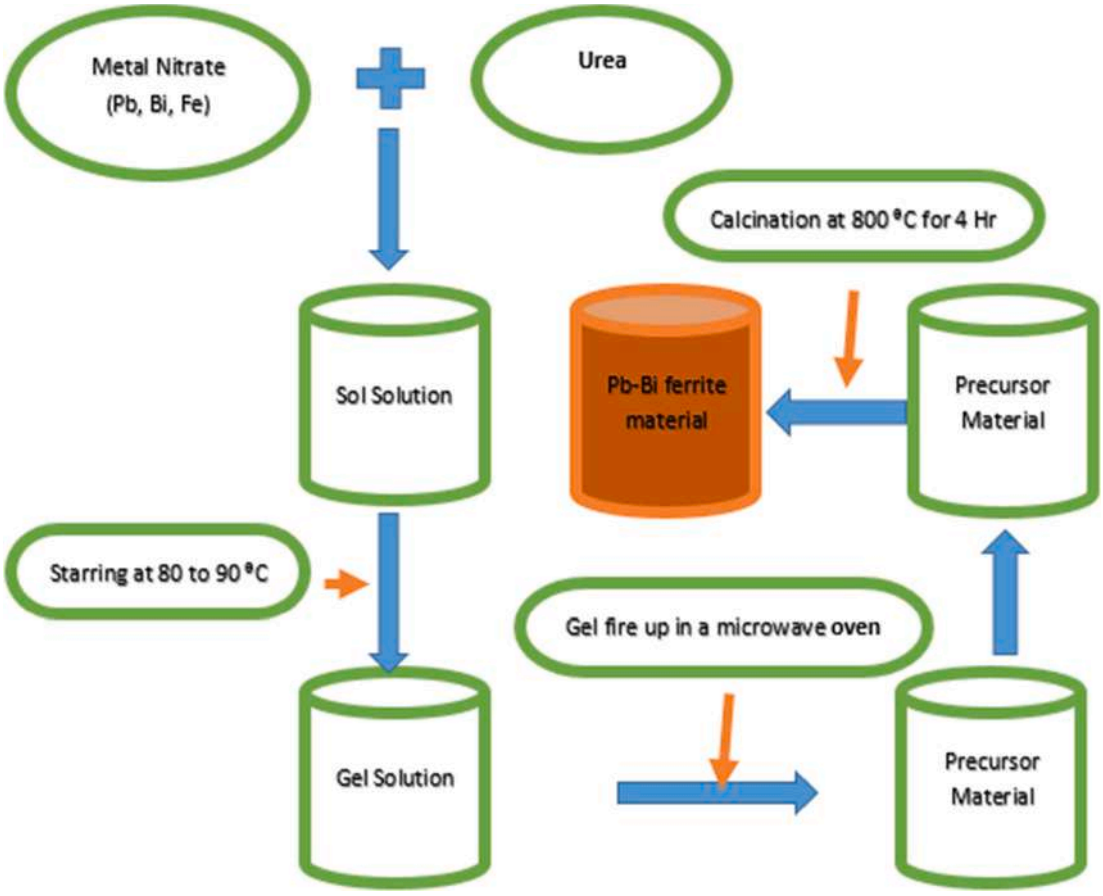


Fig. 1. Flowchart for synthesis of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

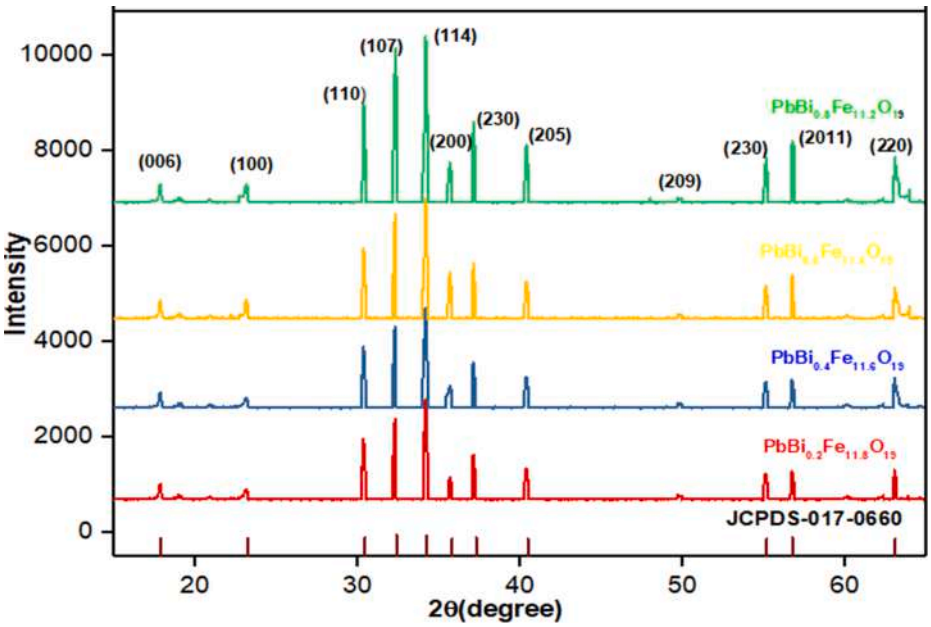


Fig. 2. XRD pattern of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

obtained after calcination, as can be seen in results. While supplementing various concentrations of bismuth in a lead hexaferrite sample, the pattern shows peak formation and broadening. The existence of reflection planes with hkl values of (110), (107), (114), (200), (203), (205), and (2011) for the Pb-Bi hexaferrite proves the formation of hexaferrite as a product and the disappearance of any impurities [14]. According to the Scherer Equation (1.1), the crystalline size for peak intensities is between 43 and 59 nm. The analysis indicates that as the dopant content Bi^{3+} rises, the crystallite size of the extracted ferrite increases. The value of the lattice parameters (a) of the samples decreased, but that of (c) heightened as shown in Fig. 3. This may be due to massive Bi^{3+} (1.03 Å) ions replacing Fe (0.64 Å) cations inside hexagonal block R [15]. It has been reported that hexaferrite with grain sizes less than 60 nm are suitable for a low signal-to-noise ratio and thus be useful for magnetic recording media.

The bulk density (B) was calculated using the Archimedes theorem, and X-ray (Xd) density is determined by the formula

$$X_d = \frac{ZM}{NV}$$

where M is the molecular weight, N is Avogadro's number, Z is the number of molecules for an M-type hexagonal crystal structure, and V is the unit cell's volume, all these outcomes are calculated with the help of various equations and are shown in Table 1 [16]. As the X-ray density has a direct relation with the molecular weight. With an increased amount of substituted Bi^{3+} ions, the value of X-ray density raises this due to the higher molecular weight of substituted samples than that of $PbFe_{12}O_{19}$. The porosity 'P' of all specimens was determined using the formula $P = 1 - \frac{B}{X_d}$ percent. As Bi^{3+} substitution is increased to its full value, the porosity data leads to an increase [17]. The majority of Bismuth atoms enter the hexagonal crystal structure if they are tinier than a value (1.06 Å), and their porosity is improved.

$$S = 6000/D^{*}x_d \tag{1.2}$$

The range of values for porosity and surface area (S) were between 45 and 47 % and 16–23 cm^2/g. The surface area is, as according to equation (1.2), closely correlated with the sample size of crystallites (D), and it was found to vary inversely in S and D: that is to say, the smaller

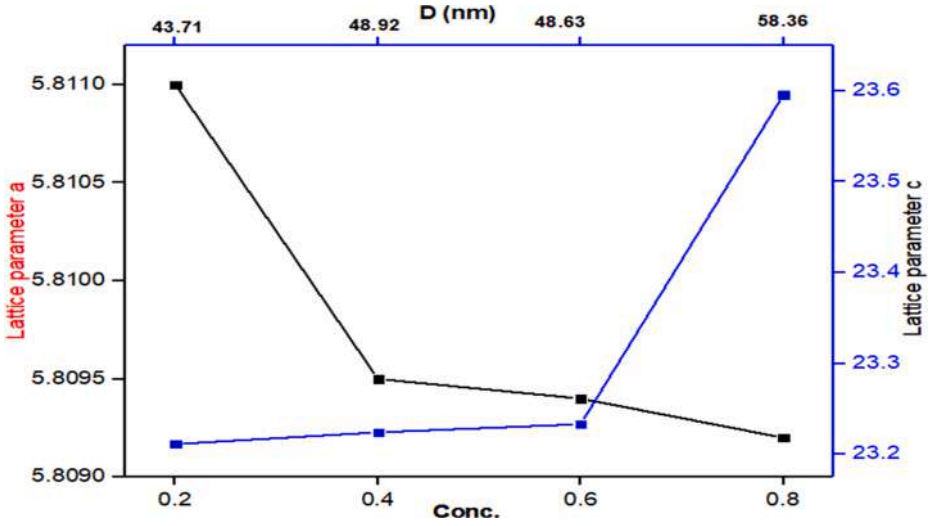


Fig. 3. Concentration vs Lattice parameter and Crystalline size (D) of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Table 1
Lattice parameter, x-ray density bulk density, and particle size of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Compound Name		$PbBi_{0.2}Fe_{11.8}O_{19}$	$PbBi_{0.4}Fe_{11.6}O_{19}$	$PbBi_{0.6}Fe_{11.4}O_{19}$	$PbBi_{0.8}Fe_{11.2}O_{19}$
Lattice parameter	a (Å)	5.8110	5.8095	5.8094	5.8092
	c (Å)	23.2112	23.2242	23.2331	23.5956
Crystalline Size (nm)		43.71	48.92	48.63	58.36
c/a		3.994	3.998	3.999	4.062
Molecular Weight (gm/mol)		1211.967	1242.594	1273.221	1303.848
Volume $(Å)^3$		678.060	678.75	679.771	689.566
X-ray density (gm/mol^3)		5.925	6.078	6.238	6.278
Bulk Density (gm/mol^3)		3.248	3.271	3.327	3.422
Porosity (%)		45.18	46.18	46.66	47.01
Surface area ($*10^7$ cm^2/g)		23.17	20.18	19.78	16.37

the crystallite size, the larger the surface area and the more atoms at the surface, the higher [18].

3.2. FTIR analysis

Infrared scanning is also used to look into the composition of the hexagonal structure in Bi^{3+} mixed lead ferrite. Fig. 4, shows the typical FTIR spectrum of Pb-Bi Ferrite. The IR spectrum of all samples confirms the residence of absorption bands within the 400–600 cm^{-1} range, which is a typical feature of hexaferrite [19]. Fe-O bending vibration in the octahedral site is assigned to the lower frequency absorption band B_1, which lies between 400 and 490 cm^{-1}, and Fe-O stretching vibration in the tetrahedral site is assigned to the higher frequency absorption band B_2, which lies between 500 and 600 $cm^{-1.}$ The B_1 and B_2 bands are constantly increasing, indicating a high degree of crystallinity [14]. There are very few bands visible, implying that a single $PbFe_{12}O_{19}$ phase was obtained, which is consistent with XRD analysis. The impressive maximum absorbance at 545–565 cm^{-1} in pure hexaferrite is tied to the Pb-O stretching vibration band. Since it overlaps with the absorption band (B_1 and B_2) of hexaferrite, this point is less visible in substituted ferrites. Metal-Oxygen-Metal groups are linked with bands in the region of 900–1800 cm^{-1}, while the opaque band about 3400–3500 cm^{-1} is referring to hydroxyl groups [20]. Since the absorbance of the B_1 and B_2 bands are comparable, there is a uniform accumulation of metal ions in the two sites. For substituted hexaferrite, this trend shifts. When Bismuth is substituted, the absorbance of symmetric stretching in the tetrahedral site B_2 is higher than either bending vibrations in the octahedral site; however, for PBM ferrite, the absorbance of B_2 is greater than that of B_1. This efficacy can be explained by the mass of the particles: dense atoms pulsate quicker than smaller ones, so the Me-O bond can jiggle at a lower intensity, resulting in lower sprawling absorption for bismuth as compared to other hexaferrite [21]. However, based on its IR spectrum, it appears to prefer the tetrahedral spot. According to lattice parameters calculated from an XRD analysis, Bi^{3+} with its broad ionic radius tends to populate the octahedral region. As a result, increasing the bismuth, the nodding vibration of this site improved its dimension and thus its absorbance [22].

3.3. SEM analysis

Fig. 5, displays the surface morphology of the specimens taken using a scanning electron microscope (Jeol-6390LA), revealing a nanostructure of Bi^{3+} substituted $PbFe_{12}O_{19}$ sample with sharp grain boundaries. A close examination of SEM may reveal the hexagonal pattern of the grains, which is a feature of the hexagonal crystal formation of $PbFe_{12}O_{19}$ with Bi^{3+} substitutions at Fe sites [18]. The good grain sizes and analogous diversity in the targeted region indicate that the sample is made up of single-phase ferrite. Ferrite structural and magnetic qualities are largely determined by the form and compatibility of their grains. Ferrite platelet-like hexagonal texture has been scrutinized as a possible nominee to a variety of applications, including storage media and microwave absorption coating [23].

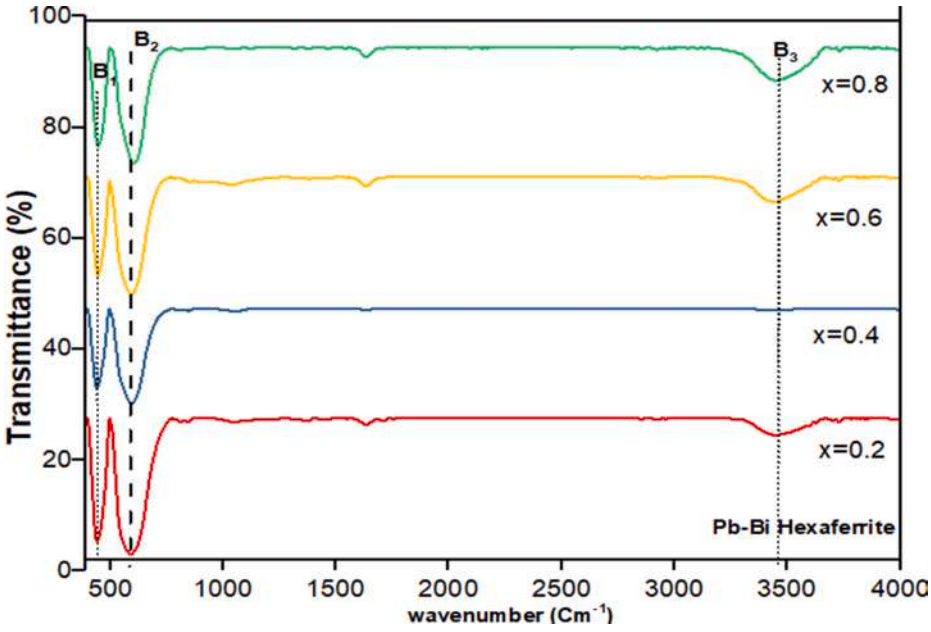


Fig. 4. FTIR image of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

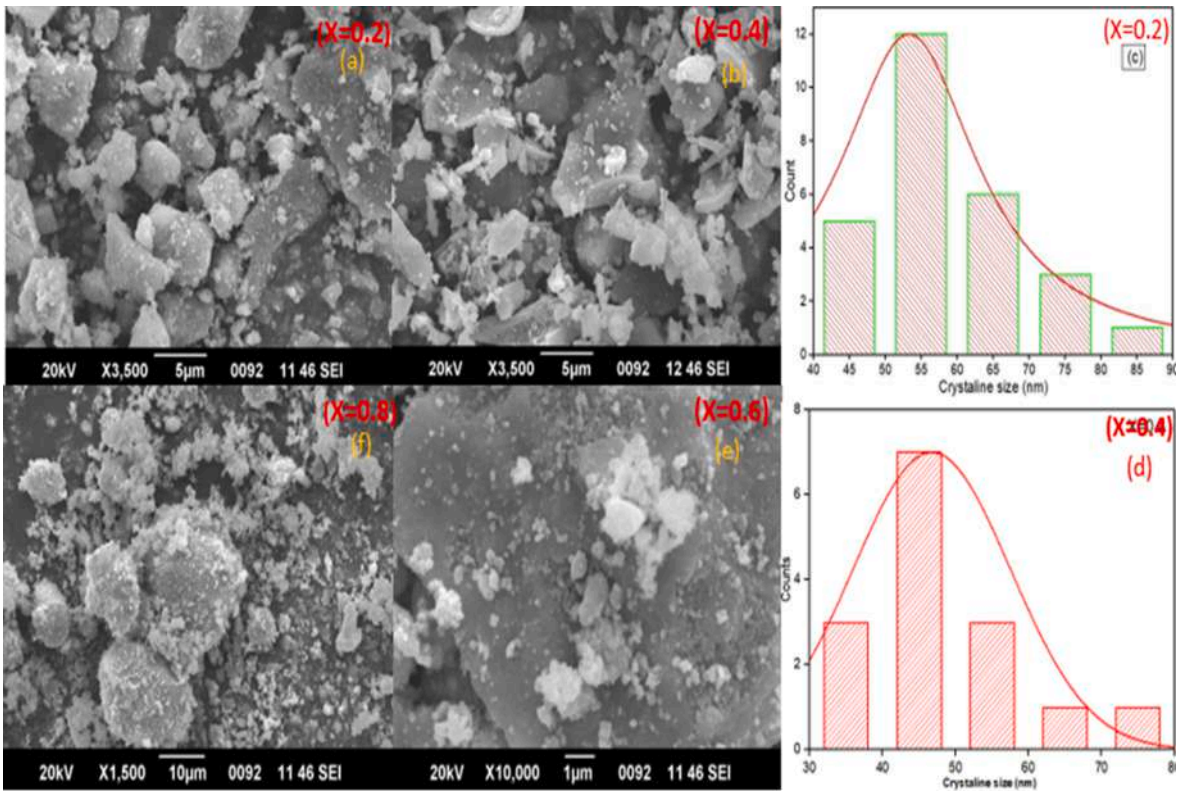


Fig. 5. SEM images of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) and (c), (d) histogram image of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2 and 0.4) hexaferrite.

3.4. HR-TEM analysis

HR-TEM microscopy (**Jeol/JEM 2100**) was used to quantitatively evaluate the particle shape and size of the synthesized nanocomposite. HR-TEM images and a selected area electron diffraction pattern (SAED) for Pb-Bi hexaferrite has shown in Fig. 6 (a) and (b). The $PbBi_xFe_{12-x}O_{19}$ nanoparticles have an approximated average particle size of 40–65 nm based on HR-TEM images [24]. The crystalline particle size obtained from the XRD analysis and SEM pictures has closely paired with the projected average particle size from the HR-TEM images. Furthermore, HR-TEM investigates validated the synthesized nanoparticles non - uniform shape and agglomerated nature [25]. The SAED pattern displayed in Fig. 6 (c) indicates that **$PbBi_xFe_{12-x}O_{19}$ (x = 0.2).** Hexaferrite is polycrystalline, as it has the required number of diffraction rings. The estimated structure from the SAED pattern was also a hexa structure, which was confirmed by the results. Thus, Pb-Bi Hexaferrite nanoparticles possess an M-type hexagonal structure [26].

3.5. VSM analysis

The magnetic theory states that the magnetic behavior in ferrites is caused by the spin-up and down orientation. The distribution of iron ions in the lattice sites is largely responsible for the magnetic properties of ferrites. Lead hexaferrite has a hexagonal structure with 64 ions in varied places in each unit cell [27]. These iron ions have unpaired electrons, and they are all in a unique group. There are five locations, three of which are on 12K, 2a, $4f_2$ (octahedral site), $4f_1$ (tetrahedral site), and 2b (bi-pyramidal site). The overall magnetic moment of lead hexaferrite has been determined by the summation of the magnetic moments of iron ions.

$$\mathbf{M} = \mathbf{M}(2\mathbf{a} + 2\mathbf{b} + 12\mathbf{k}) - \mathbf{M}(4\mathbf{f}_2 + 4\mathbf{f}_1)$$

The total magnetic moment per unit formula for un-doped lead hexaferrite has been calculated to be approximately 20 μ_B due to Fe^{3+} containing a magnetic moment of 5 μ_B. Thus, the unit cell's magnetic moment is 40 μ_B. The magnetic characteristics of $PbFe_{12}O_{19}$ can be altered by replacing other cations [9]. The magnetic characteristics of $PbBi_xFe_{12-x}O_{19}$ hexaferrite were determined and analyzed using a Vibrating Sample Magnetometer (Lakeshore 7410 model, CIF-IITG) with an applied field of 15 KOe. The VSM hysteresis loop reveals the relationship between magnetization (B) and applied field (H) at room temperature [28]. The loop's retrieved parameters include Coercivity (Hc), Saturation Magnetization (Ms), and Remanence (Mr).

The magnetization vs applied magnetic field (B vs H) curve for Pb-Bi hexaferrite samples has shown in Fig. 7. The hysteresis loops are ferromagnetic in Pb-Bi ferrites nanostructures. Increasing the Bi^{3+} content at the A-site and B-site of Fe substantially alters the magnetic properties of the produced nanoparticles. Table 2 displays the values of the Bohr magnetron and another magnetic paramters [29].Fig. 8.

3.5.1. Effect on coercivity, saturation magnetization and retentivity

The material crystallinity, size, topology, porosity, anisotropy constant (K), and other factors play a significant role in the coercivity of nano ferrite material. The coercivity of produced lead hexaferrite has been reported to enhance from 2756.3 to 4386.4 Oe as Bi^{3+} content increased. In this case, the observed rise in coercivity was caused by the crystalline size and anisotropy constant [18]. The relationship between coercivity and crystallite size has simply been explained by the critical diameter of crystallite size and domain structure. SEM and TEM examinations revealed that increasing the Bi^{3+} content boosted coercivity because of the homogeneous shape and minimal crystallite size that were formed. Coercivity was enhanced with smaller crystalline sizes because the single domain crystallite has high magnetic energy, but when it is not split into several domains, the magnetization energy boosts [30]. Table 2 shows the values of anisotropy constants, which were computed using the equation below.

$$\mathbf{K} = \frac{\mathbf{M_s}^{*}\mathbf{H_c}}{\mathbf{0.96}}$$

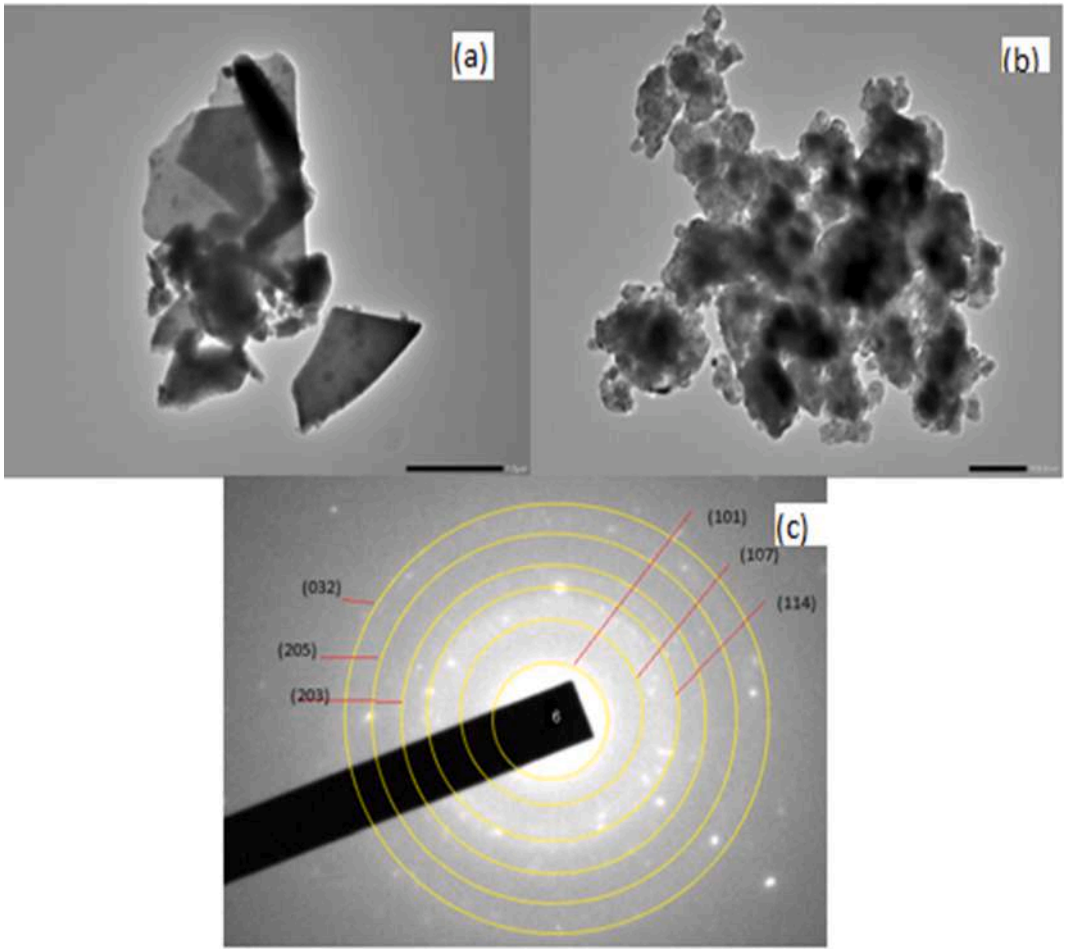


Fig. 6. (a) and (b) HR-TEM micrograph, (c) SAED micrograph of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2) hexaferrite.

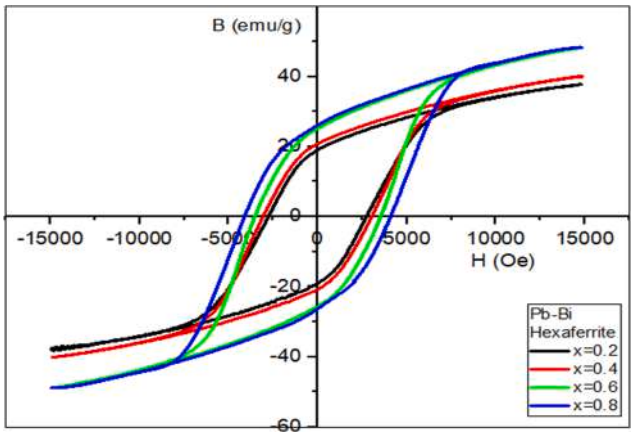


Fig. 7. VSM image of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

The total anisotropy constant for Bi^{3+} substituted lead hexaferrite is the sum of the anisotropy constants of Bi^{3+} and Pb^{2+}. As the concentration of Bi^{3+} increases, the total magnetic anisotropy constant gets

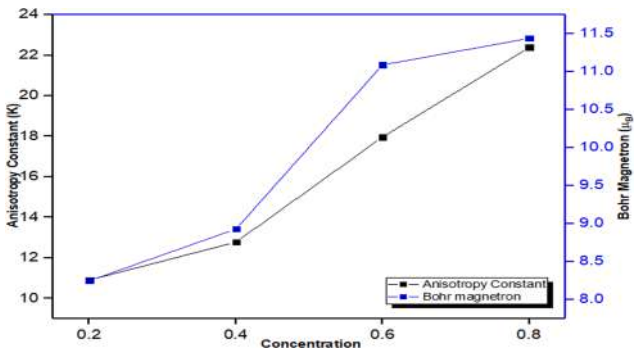


Fig. 8. Concentration vs Bohr magnetron and Anisotropy constant of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Table 2
Ms, Mr, Hc of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Sr no	Conc. x	Saturation Magnetization Ms (emu/g)	Retentivity Mr (emu/g)	Coercivity Hc (Oe)	Bohr magneton μ_B	SQR Ratio (Mr/Ms)	Anisotropy constant (K)*10^4 (HA^2/kg)
1	0.2	38.003	19.037	2756.3	8.25	0.5009	10.91
2	0.4	40.126	20.796	3058.4	8.93	0.5183	12.78
3	0.6	48.661	25.478	3544.6	11.09	0.5235	17.96
4	0.8	49.016	26.590	4386.4	11.44	0.5423	22.39

increases due to a large K value, which in turn increases coercivity. The remanent magnetization Mr, like coercivity, increased as Bi^{3+} content increased. Due to the single domain nature of the nano-sized crystallite [31]. Ms and Mr values in ferrite samples ramped up from 38.003 to 49.016 emu/g and 19.037 to 26.590 emu/g

For the Bohr's magneton, the following equation was used to determine

$$\mu_B = \frac{M_s * M_w}{5585}$$

M_w has the sample's molecular weight, When Bi^{3+} ions are processed, the values of the Bohr magnetron improve, which is related to the enhanced magnetization of the material. Cation distribution was used to explain the overall increase in μ_B. In this scenario, Bi^{3+} ions occupied octahedral sites where they replaced ferromagnetic Fe ions, resulting in an increase in magnetic dipole moments at octahedral sites [22]. However, the presence of a single magnetic domain is indicated by a squareness ratio (Mr/Ms) higher than 0.5, a ratio enhanced from 0.50 to 0.54 in the study as shown in Fig. 9. The crystalline structure has been identified as having a crucial role in influencing the material's magnetic activity. Pb hexaferrite has five non-equivalent sublattices with three octahedral (2a, 12 k, and 4f), one tetrahedral ($4f_1$), and one trigonal bipyramidal (2b) site in its crystal structure. Three of these sites (2a, 12 k, and 2b) have upward spin, while the other two ($4f_1$ and $4f_2$) have downward spin [18]. As a consequence of the upward spins, there is a net magnetic moment, as Bi^{3+} is replaced for any of the iron ions, the net saturation magnetization rises, and it continues to grow as the Bi^{3+} content is increased up to $x = 0.8$ [22]. Since the supplemented ions tend to favor to populate the octahedral 12k site, which has upswing spin, preceded by 2a and $4f_2$, this increase in Ms value could be due to accession in superexchange interactions between certain Fe A 3+-O-Fe B3+.

3.6. Impedance analysis

Impedance spectroscopy may be used to detect the electronic properties of micron-sized compounds, such as their electronics, dielectrics, and the effects of nearly any doping as a pattern and distribution. The impedance of submicron-sized particles extracted with grain boundaries has been further examined using spectrographic analysis [32]. In this approach, the dielectric characteristics were determined using a two-probe method over a frequency spectrum of 20 Hz to 1 MHz at room temperature around 303 K. Each sample mounting was calibrated to operate as an asymmetric platform to evaluate the dielectric constant and loss tangent of doped ferrite, as shown in Fig. 10 and Fig. 11. The substance to be investigated is sandwiched between two circular plates to produce a twin-plate capacitor-like module in this step [33]. In this arrangement, the load value was calculated using an LCR unit. Which is

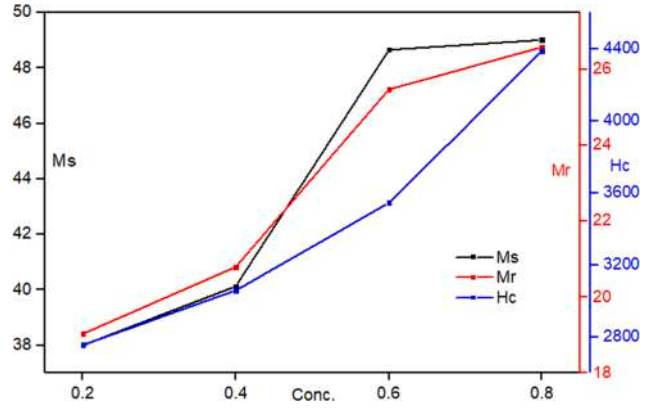


Fig. 9. Concentration vs Ms, Mr and Hc of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

stated mathematically as follows.

$$\tan\ \delta = \varepsilon'' / \varepsilon' \quad (2.1)$$

$$\varepsilon' = C^*d/A^*\varepsilon_0$$

The capacitance of the cell is denoted by C, the cross-sectional area of the pellet's flat surface is A, and its thickness is d of the pallet. The plots inside this figure are based on the theoretical hypothesis that any dielectric material introduced to an electric field experiences a latency as well as a reduction in dielectric reaction with the field [19]. ε′ denotes the amount of energy retained in the dielectric material as a result of the applied field, while ε″ denotes the decline to the ac electric field. As a result, the loss tangent (**tanδ**) is the proportion of the complex relative permittivity's imaginary to real parts shown in Eq. (2.1). The value of loss tangent and dielectric loss for all Bi^{3+} substituted lead hexaferrite ceramics reduces at high frequency [34]. There are fewer total dipoles that may aggregate and polarise themselves in the trajectory of the applied electric field with increasing frequency, so this leads to a plunge in a dielectric loss at high frequencies. The existence of many kinds of polarization, including interfacial, dipolar, atomic, ionic, and electronic, leads to larger dielectric values at lower frequencies [35]. At the increased frequency range, the above polarizations make less influence, which means the value of dielectric goes down. The high dielectric value at low frequencies (less than 100 KHz) can be explained by Maxwell-Wagner polarization, also known as interfacial polarization. The high value of the dielectric is due to heterogeneous conduction in the grain and grain boundary, as well as grain separation by more insulating intergrain barriers [36]. The loss tangent for lead ferrite is almost zero, indicating that it is a non-dielectric absorbing component. In comparing the results to pure Pb ferrite, the loss tangent of Bi^{3+} doped lead ferrite reduces. This validates reports of enhanced dielectric properties based on the concentration of a dopant [23].

With the insertion of dopants, the loss tangent of bismuth drugged lead ferrite strengthened dielectric properties. By hopping through the grain boundary, the electrons enter the grain boundary [33]. If somehow the resistance of the grain boundary seems to be intense, the electrons stay heaped up there, resulting in polarization. A charge carrier must travel in the path of the imposed ac field for a set amount of period. The carrier must match their orientation to the applied ac field more consistently as the frequency of the Pb-Bi hexaferrite material increases. As a result, their chances of reaching the grain boundary are decreased, resulting in declining polarization [37]. The doped lead hexaferrite structure uniformity is also verified by the low dielectric loss tangent value. With the addition of a dopant, the electrical conductivity appears almost consistent. Its linearity proves that polarized form conduction exists [38].

In the range of temperatures 323–650 K, electrical conductance was calculated as a function of temperature. Fig. 12 shows a plot of ln of σ as a function of 1000/T. As the temperature rises, the dc electrical resistivity rises as well. This is based on the possibility that as the heat increases, the kinetic energy of the electrons reduces [10]. The movement of electron skipping from one octahedral site over the next, fall's drift mobility reduces, and thus resistivity rises. The porous structure, grain size, and cation distribution on octahedral all play a significant role in ferrites' electrical resistivity. Increased electrical resistivity is caused by increased porosity and smaller particle size [39]. The electrical resistivity is heavily influenced by the Fe^{2+} ion concentration on the octahedral site. The charge carriers available for conduction would increase as the concentration increased, and the resistivity would decrease. The graph also shows that as the concentration of Bi rises, the resistivity gradually increases as well. The difference in Fe^{2+} concentration on the octahedral 12k site is the reason for this [27].

The dielectric constant of Pb ferrite varies with temperature at the constant frequency of 100 Hz, as shown in Fig. 13. This constant was spotted to be temperature independent up to 300 K, then grows after

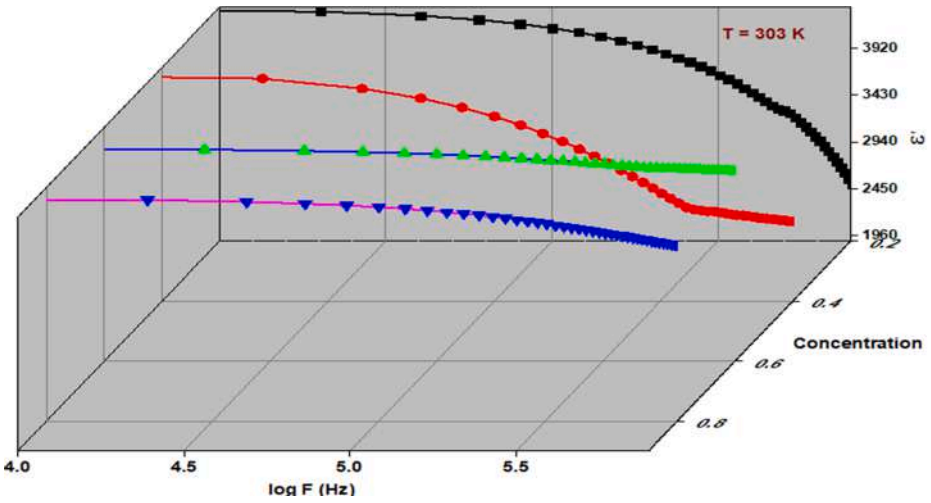


Fig. 10. Frequency Vs Dielectric loss of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

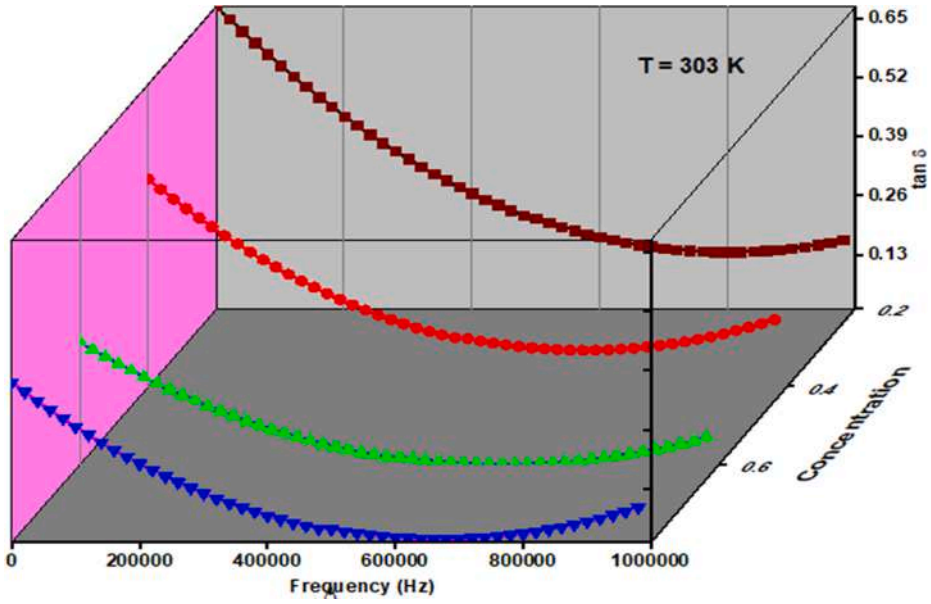


Fig. 11. Frequency Vs Tangential loss of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

that [40]. As can be observed, the dielectric constant increases gradually as the temperature increases and reaches a maximum at 602 K for the composition x = 0.2, 549 K for the composition x = 0.4, 496 K for the composition x = 0.6, and 448 K for the composition x = 0.8. The dielectric constant peak values for lead hexaferrites declined from >10112 at x = 0.2 to >2751 at x = 0.8. Lead hexaferrite compounds have a wide peak, which has considered a diffusive phase transition, and a strong frequency-dependent dielectric constant [41]. On an atomic basis, lead hexaferrite composition has thought to be chemically disordered, meaning that various metal ions are dispersed equally or even randomly across comparable lattice positions [42]. This gives rise to randomly directed polarization, even in the macroscopical phase, these local dipoles and fields exist. Koop's model can be used to describe the polarization of composites. Koop demonstrated the dielectric dispersion by thinking of the ferrite compressed as a multilayer capacitor with specific features [43]. Respectively two identical grains, the grains serve as an insulating medium. Many researchers have looked at how the dielectric constant in ferrites changes with temperature. The conduction mechanisms are based on electron hopping among Fe^{2+} and Fe^{3+} ions, as well as a hole hopping in Bi^{3+} and Pb^{2+} on the octahedral sites in the present ferrite. The electron jumping is triggered by heat. Target deflections in the direction of the externally applied field result from electron hopping [44]. Dielectric polarization in ferrite nanoparticles is an example of this. As the temperature rises, the dielectric polarization and dielectric constant rise with it. Ferrites have an intrinsic ionic polarization due to their existence as ionic solids, in addition to the polarization caused by charge carrier hoping [45]. The dielectric constant started to decline off at a certain higher temperature (T_C) due to non - uniform inclination of dipoles, indicating a phase change through ferromagnetic to the paramagnetic condition. As shown in Fig. 14, T_C also showed a downward tendency with rising Bi^{3+} substrate, which is nearly identical to the other research. In terms of the temperature coefficient of dielectric constant, the present Bi substituted lead hexaferrite material (x = 0.2 to 0.8) displays good thermal stability. Each compound's dielectric properties have been highly influenced by the structural and morphological aspects of its crystalline system [33]. The order-disorder effects, which are caused by reasons like particle size, surface morphology, and lattice defects, are thought to be the most critical aspects. This combination of parameters linked with the results describes the behavior of the Bi^{3+} substituted lead hexaferrite sample

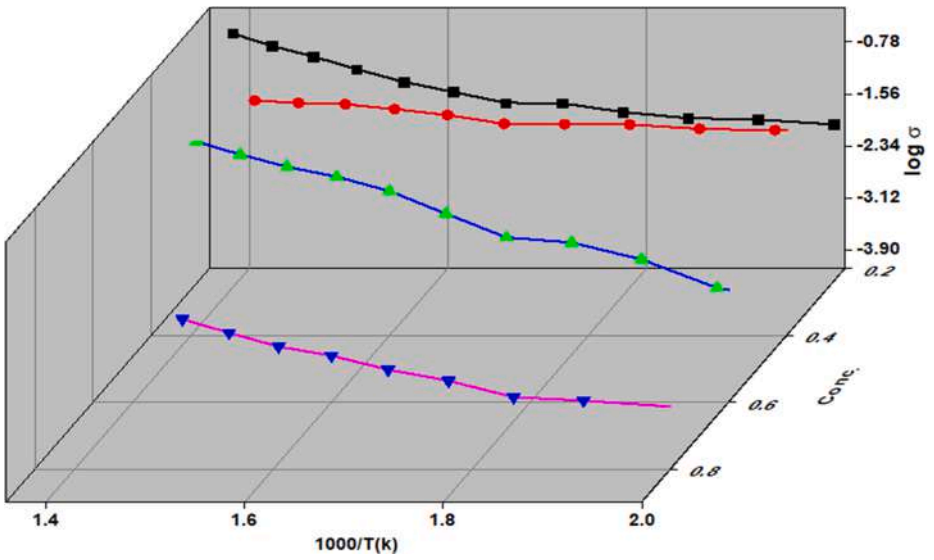


Fig. 12. Conductance vs Temperature of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

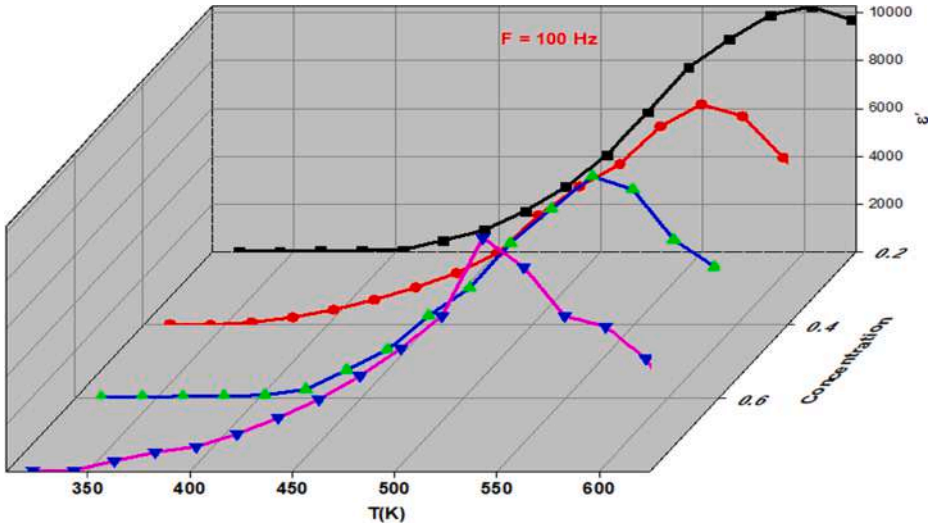


Fig. 13. Dielectric constant vs Temperature of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

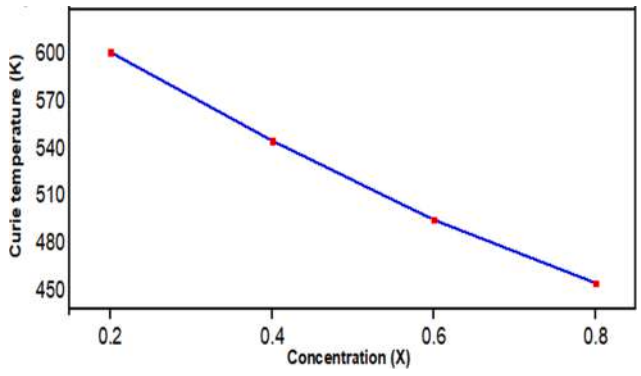


Fig. 14. Curie Temperature Vs Concentration of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

with x = 0.2 to 0.8. The minimal dielectric constant at higher temperatures and frequencies in this investigation implies that the materials are thermally stable at specific frequencies [46].

Using the impedance spectroscopy technique, the role of the grain boundary and grain of ferrites in the electrical resistance process was investigated. The real part of the impedance (Z′) of Bi^{3+} substituted lead hexaferrite nanoparticles is shown in Fig. 15. At lower frequencies, the scattering of the real part with frequency is minimal, whereas it increases with frequency [38]. It could be related to the polarization effect in the samples. This refers to the normal negative temperature coefficient of resistance behavior of ceramics, which is commonly seen in semiconductors [47]. All of the curves intersect at a very minimal value in the high-frequency region, and Z′ appears to be frequency independent. It denotes the possibility of a space charge release [48]. Fig. 16 shows the imaginary part (-Z″) varies with the frequency of lead hexaferrite nanoparticles. The effect of grain boundary has shown as a high-intensity relaxation peak in the lower frequency region [49].

The grains' influence is visible at high frequencies, with a low relaxation peak. Modulus peaks shift to the higher frequency side, indicating a link between the motions of mobile charge carriers [50]. The asymmetry in peak broadening means that relaxation times with different time constants are scattered apart, indicating that the relaxation is not of the Debye type. Low-frequency peaks indicate that ions can go to large regions, but high-frequency peaks indicate that ions have

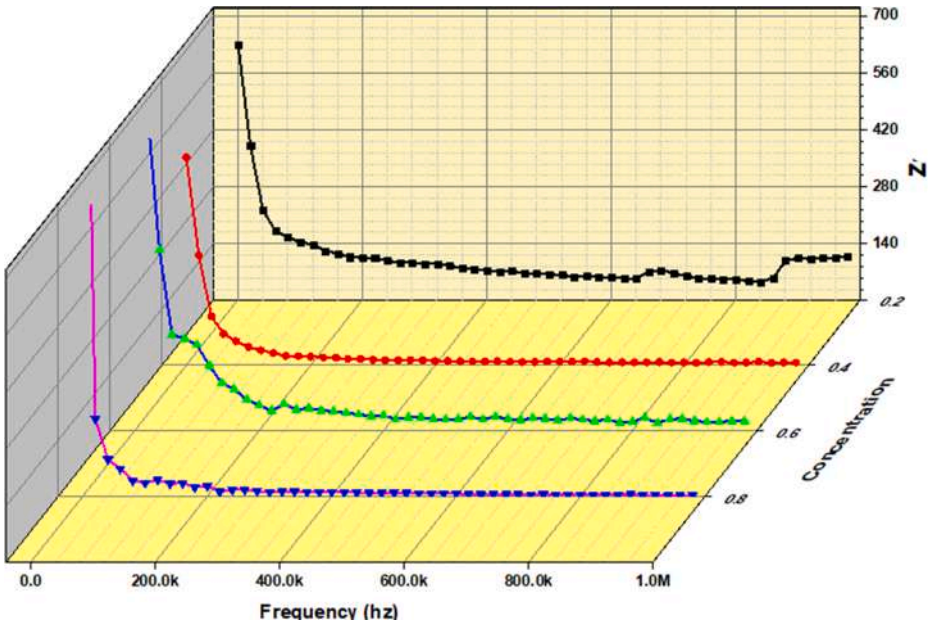


Fig. 15. Variation of real part vs frequency of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

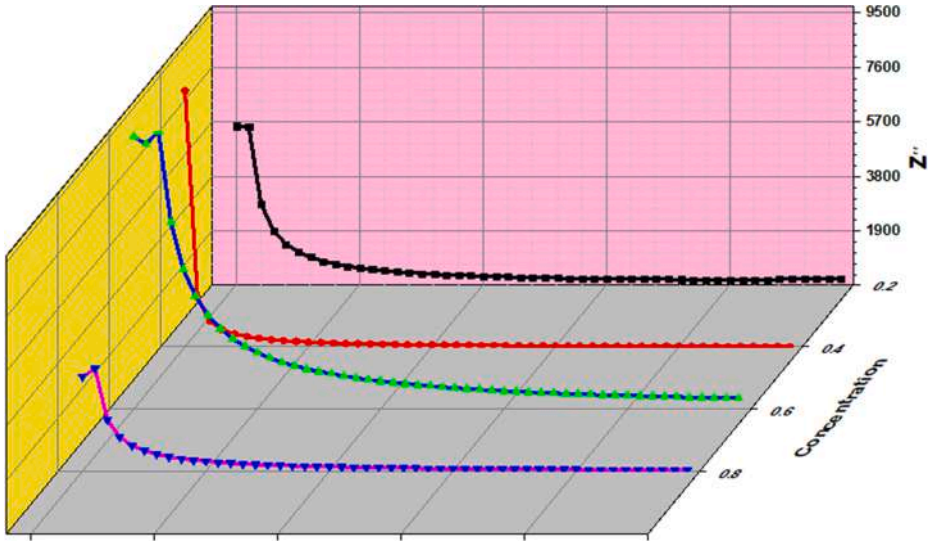


Fig. 16. Variation of imaginary part vs of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

confined within their potential well [51]. The character of modulus spectrums confirms the existence of a hopping process in the electrical conduction of materials.

When Bi^{3+} is substituted in nanocrystalline lead hexaferrite, the peaks have shifted to the lower frequency side [52]. The relaxation processes correspond to the grain boundary, and the Cole-Cole (-Z″ vs. Z′) plot has been used to further study grains. Fig. 17 shows the Cole-Cole plot of Bi^{3+} substituted lead hexaferrite. In the Cole-Cole plot, the impedance measurements at room temperature do not adopt the shape of a half circle, but rather display a straight line with a large slope, indicating insulating behaviour [53].

The presence of such loops suggests that the grain effect has played a significant role in the materials' conduction mechanism [53]. The slope of the lines reduces as the sample frequency increases, and they bend towards the real axis. The conductivity of the sample appears to be increasing in this graph [54]. With increasing frequency, the peak maxima of the plots fall and shift towards low values.

4. Conclusion

$PbFe_{12-x}Bi_xO_{19}$ (x = 0.2 to 0.8) nanoparticles were successfully produced using the microwave-assisted sol-gel auto combustion process. The X-ray investigation of materials with the space group P63/mmc revealed a single crystalline phase with no impurity. The absorption bands of hexaferrite are visible in FTIR spectra between 400 and 600 cm^{-1}. Because of the size and magnetic characteristics, the Pb-Bi hexaferrite nanoparticles clump together in the FE-SEM and HR-TEM studies; doping also altered the morphologies and borders of the grains. Magnetic characteristics (Ms and Mr) improved with Bi^{3+} concentration because Bi^{3+} ions occupy tetrahedral sites. The produced samples were found to have a high value of coercivity (Hc), indicating that they are suitable for recording media. The dielectric properties (ε′ and tan δ) were observed to reduce as the applied field frequency varies, whereas the conductivity improved.

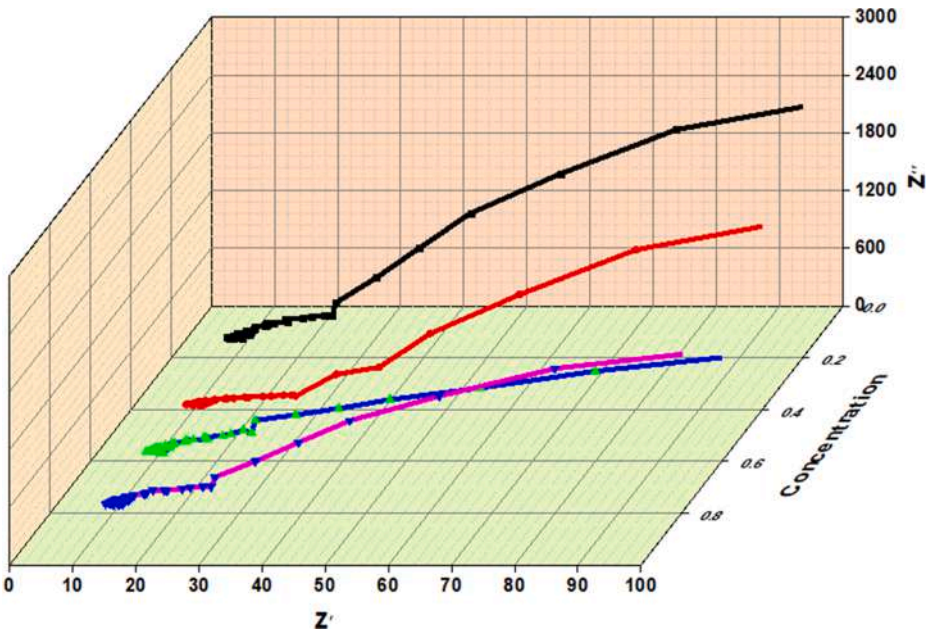


Fig. 17. Variation of real vs imaginary part of $PbBi_xFe_{12-x}O_{19}$ (x = 0.2, 0.4, 0.6, and 0.8) hexaferrite.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

The authors would like to thank the Sophisticated Test and Instrumentation Centre (STIC), Cochin University, Kerala, India, for the XRD and FE-SEM, as well as IIT Guwahati for the VSM instrumentation characterization.

References

[1] S. Güner, I.A. Auwal, A. Baykal, H. Sözeri, Synthesis, characterization and magneto optical properties of BaBixLaxYxFe12-3xO19 (0.0≤x≤0.33) hexaferrites, J. Magn. Magn. Mater. 416 (2016) 261–268, https://doi.org/10.1016/j.jmmm.2016.04.091.

[2] M. Lal, M. Shandilya, R. Rai, A. Ranjan, S. Sharma, M.A. Valente, Study of structural, electrical and magnetic properties of 1–x(Ba0.96Ca0.04TiO3)−x (BiFeO3) ceramics composites, J. Mater. Sci.: Mater. Electron. 29 (16) (2018) 13984–14002, https://doi.org/10.1007/s10854-018-9531-0.

[3] S. Sharma, M. Shandilya, R. Rai, Effect of Tb, Ti co-doping on the electrical and magnetic properties of (Bi, La)FeO3 multiferroic ceramics, J. Mater. Sci.: Mater. Electron. 26 (12) (2015) 9484–9494, https://doi.org/10.1007/s10854-015-3450-0.

[4] I.A. Auwal, A. Baykal, H. Güngüneş, S.E. Shirsath, Structural investigation and hyperfine interactions of BaBixLaxFe12−2xO19 (0.0≤x≤0.5) hexaferrites, Ceram. Int. 42 (2) (2016) 3380–3387, https://doi.org/10.1016/j.ceramint.2015.10.132.

[5] F. Sehar, S. Anjum, Z. Mustafa, S. Atiq, Co-existence of Ferroelectric and Ferromagnetic Properties of Bi+3 Substituted M-type Barium Hexaferrites, J. Supercond. Nov. Magn. 33 (7) (2020) 2073–2086, https://doi.org/10.1007/s10948-020-05452-y.

[6] I.J.S. Tech, T. Osotchan, S. Thongmee, On the Coercivity of the Bi-Doped BaFe t z- * Bi *, O t q 4 (1999) 54–58.

[7] D. Basandrai, Magnetic properties of bismuth substituted strontium ferrite nanoparticles, Eur. J. Mol. Clin. Med. 7 (2020) 3432–3437.

[8] A.S. Kakde, B.A. Shingade, N.S. Meshram, K.G. Rewatkar, Structural and magnetic properties of sn-zr substituted calcium nano-hexaferrite 1 (2014) 60–63.

[9] N.N. Sarkar, D.J. Roy, S.M. Butte, W.S. Barde, K.G. Rewatkar, Synthesis and Magnetic studies of Co-Sn doped Nanoscale Calcium Hexaferrites, 25 (2020) 57–67.

[10] D.M. Borikar, M.A. Borikar, A.S. Kakde, K.G. Rewatkar, Nano copper spinel ferrite : Synthesis & characterization by sol-gel auto combustion technique, 5 (n.d.) 7–10.

[11] M.A. Borikar, D.M. Borikar, N.S. Meshram, K.G. Rewatkar, Characterization of nanostructured spinel NiCrxFe2-xO4obtained by sol gel auto combustion method, J. Phys. Conf. Ser. 1913 (1) (2021) 012079, https://doi.org/10.1088/1742-6596/1913/1/012079.

[12] D.A. Mahajan, S.R. Choubey, B.T. Borkar, L.P. Damodare, A.B. Borkar, G.C. Vandile, X-ray Diffraction Studies of Synthesized M-type Compound, 4 (2019) 25–30.

[13] M.R. Sahoo, S. Kuila, K. Sweta, A. Barik, P.N. Vishwakarma, Effect of bismuth substitution in strontium hexaferrite, AIP Conf. Proc. 1953 (2018), https://doi.org/10.1063/1.5032572.

[14] Z. Mosleh, P. Kameli, A. Poorbaferani, M. Ranjbar, H. Salamati, Structural, magnetic and microwave absorption properties of Ce-doped barium hexaferrite, J. Magn. Magn. Mater. 397 (2016) 101–107, https://doi.org/10.1016/j.jmmm.2015.08.078.

[15] V.G. Kostishyn, L.V. Panina, A.V. Timofeev, L.V. Kozhitov, A.N. Kovalev, A. K. Zyuzin, Dual ferroic properties of hexagonal ferrite ceramics BaFe12O19 and SrFe12O19, J. Magn. Magn. Mater. 400 (2016) 327–332, https://doi.org/10.1016/j.jmmm.2015.09.011.

[16] S.K. Gore, R.S. Mane, M.u. Naushad, S.S. Jadhav, M.K. Zate, Z.A. Alothman, B.K. N. Hui, Influence of Bi3+-doping on the magnetic and Mössbauer properties of spinel cobalt ferrite, Dalt. Trans. 44 (14) (2015) 6384–6390.

[17] M.N. Ashiq, M. Javed Iqbal, I. Hussain Gul, Effect of Al-Cr doping on the structural, magnetic and dielectric properties of strontium hexaferrite nanomaterials, J. Magn. Magn. Mater. 323 (3-4) (2011) 259–263, https://doi.org/10.1016/j.jmmm.2010.08.054.

[18] A.S. Kakde, R.M. Belekar, G.C. Wakde, M.A. Borikar, K.G. Rewatkar, B.A. Shingade, Evidence of magnetic dilution due to unusual occupancy of zinc on B-site in NiFe2O4 spinel nano-ferrite, J. Solid State Chem. 300 (2021), 122279, https://doi.org/10.1016/j.jssc.2021.122279.

[19] S. Malhotra, M. Chitkara, I.S. Sandhu, N. Dawar, J. Singh, Investigation of structural, magnetic and dielectric properties of terbium doped strontium hexaferrite for high frequency applications, Indian, J. Sci. Technol. 9 (2016), https://doi.org/10.17485/ijst/2016/v9i27/96638.

[20] T. Vigneswari, P. Raji, Structural and magnetic properties of calcium doped nickel ferrite nanoparticles by co-precipitation method, J. Mol. Struct. 1127 (2017) 515–521, https://doi.org/10.1016/j.molstruc.2016.07.116.

[21] F. Abdollahi, M. Yousefi, M. Hekmati, A. Khajehnezhad, S.S.S. Afghahi, Magnetic and microwave absorption properties of barium hexaferrite doped with La3+ and Gd3+, J. Nanostruct. 9 (2019) 579–586, https://doi.org/10.22052/JNS.2019.03.019.

[22] M.N. Akhtar, A.B. Sulong, M. Ahmad, M.A. Khan, A. Ali, M.U. Islam, Impacts of Gd-Ce on the structural, morphological and magnetic properties of garnet nanocrystalline ferrites synthesized via sol-gel route, J. Alloy. Compd. 660 (2016) 486–495, https://doi.org/10.1016/j.jallcom.2015.11.146.

[23] M. Shandilya, S. Thakur, R. Rai, Study of phase transitional behavior and electrical properties of relaxor Ba0.85Ca0.15Zr0.05Ti0.95O3 lead free ceramic, Ferroelectr. Lett. Sect. 46 (1-3) (2019) 8–18, https://doi.org/10.1080/07315171.2019.1647705.

[24] P. Chaware, A. Nande, S.J. Dhoble, K.G. Rewatkar, Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu3+ doped strontium hexa-aluminate nanophosphors for lighting application, Opt. Mater. (Amst). 121 (2021), 111542, https://doi.org/10.1016/j.optmat.2021.111542.

[25] J. Jadhav, S. Biswas, A.K. Yadav, S.N. Jha, D. Bhattacharyya, Structural and magnetic properties of nanocrystalline Ni[sbnd]Zn ferrites: In the context of

cationic distribution, J. Alloy. Compd. 696 (2017) 28–41, https://doi.org/10.1016/j.jallcom.2016.11.163.
[26] M.A. Almessiere, Y. Slimani, A.D. Korkmaz, A. Baykal, H. Güngüneş, H. Sözeri, S. E. Shirsath, S. Güner, S. Akhtar, A. Manikandan, Impact of La3+ and Y3+ ion substitutions on structural, magnetic and microwave properties of Ni0.3Cu0.3Zn0.4Fe2O4 nanospinel ferrites synthesized: Via sonochemical route, RSC Adv. 9 (53) (2019) 30671–30684.
[27] M. Shandilya, R. Verma, Impedance modulated dielectric and magnetic properties of BCT-NF multiferroic composite, J. Magn. Magn. Mater. 527 (2021), 167782, https://doi.org/10.1016/j.jmmm.2021.167782.
[28] M. Shandilya, R. Rai, A. Zeb, Structural and dielectric relaxor properties of Ba1-xMgxTiO3 ceramics prepared through a hydrothermal route, Adv. Appl. Ceram. 117 (5) (2018) 255–263, https://doi.org/10.1080/17436753.2017.1405557.
[29] C. Singh, S.B. Narang, I.S. Hudiara, Y. Bai, K. Marina, Hysteresis analysis of Co-Ti substituted M-type Ba-Sr hexagonal ferrite, Mater. Lett. 63 (22) (2009) 1921–1924, https://doi.org/10.1016/j.matlet.2009.06.002.
[30] M.A. Almessiere, Y. Slimani, H. Güngüneş, S. Ali, A. Baykal, I. Ercan, AC susceptibility and hyperfine interactions of Mg-Ca ions co-substituted BaFe 12 O 19 nanohexaferrites, Ceram. Int. 45 (8) (2019) 10048–10055, https://doi.org/10.1016/j.ceramint.2019.02.050.
[31] M. Tahir, S. Riaz, U. Khan, S.S. Hussain, A. Nairan, A. Akbar, M. Saleem, S. Atiq, S. Naseem, Enhanced structural and magnetic ordering in as-synthesized Ca doped bismuth iron oxide nanoceramics, J. Alloy. Compd. 832 (2020), 154725, https://doi.org/10.1016/j.jallcom.2020.154725.
[32] Y. Kang, Y. Huang, R. Yang, C. Zhang, Journal of Magnetism and Magnetic Materials Synthesis and properties of core – shell structured Fe (CO) 5 / SiO 2 composites, J. Magn. Magn. Mater. 399 (2016) 149–154, https://doi.org/10.1016/j.jmmm.2015.09.061.
[33] P. Kumar, A. Gaur, R.K. Kotnala, Magneto-electric response in Pb substituted M-type barium-hexaferrite, Ceram. Int. 43 (1) (2017) 1180–1185, https://doi.org/10.1016/j.ceramint.2016.10.060.
[34] J.N. Christy, K.G. Rewatkar, P.S. Sawadh, Structural and Dielectric Properties of Substituted Calcium Hexaferrites, Int. J. Eng. Res. Technol. 8 (2019) 178–182.
[35] S.R. Gawali, P.R. Moharkar, R.R. Kherani, K.G. Rewatkar, Structural and Electrical Properties of M-Type Substituted Calcium Hexaferrites, Int. J. Res. Biosci. Agric. Technol. 3 (2015) 2672–2678, https://doi.org/10.29369/ijrbat.2015.03.ii.0066.
[36] M. Shandilya, R. Rai, K. Sharma, D. Thakur, Effect of addition of zinc ferrite on dielectric and magnetic properties of (Ba, Ca)TiO3 ceramics, Integr. Ferroelectr. 185 (1) (2017) 147–154, https://doi.org/10.1080/10584587.2017.1370350.
[37] A. Katoch, B.K. Borthakur, A. Singh, T. Singh, Dielectric Behavior of M-Type Hexaferrites Sr 1–x Dy x Fe 12 O 19, Doped with Rare Earth Ions 5 (2013) 53–57.
[38] J.S. Ghodake, R.C. Kambale, T.J. Shinde, P.K. Maskar, S.S. Suryavanshi, Magnetic and microwave absorbing properties of Co2+ substituted nickel-zinc ferrites with the emphasis on initial permeability studies, J. Magn. Magn. Mater. 401 (2016) 938–942, https://doi.org/10.1016/j.jmmm.2015.11.009.
[39] N. Humera, S. Riaz, S. Naseem, Effect of temperature on electrical properties of barium titanate nanoceramics, 5 (n.d.) 153–161.
[40] P. Shepherd, K.K. Mallick, R.J. Green, Dielectric properties of cobalt substituted M-type barium hexaferrite prepared by co-precipitation, J. Mater. Sci.: Mater. Electron. 18 (5) (2007) 527–534, https://doi.org/10.1007/s10854-006-9059-6.
[41] V. Jančárik, A. Grusková, J. Sláma, R. Dosoudil, Study of Sr and Ba hexaferrite prepared by low temperature auto-combustion method, J. Electr. Eng. 57 (2006) 163–166.
[42] R.B. Jotania, R.B. Khomane, A.S. Deshpande, C.C. Chauhan, B.D. Kulkarni, Physical and Magnetic Properties of Barium Calcium Hexaferrite Nano-particles Synthesized by Water-in-oil Reverse Micelle and Co-precipitation Techniques, J. Sci. Res. 1 (2008) 1–13, https://doi.org/10.3329/jsr.v1i1.1684.
[43] M. Javed Iqbal, M. Naeem Ashiq, I. Hussain Gul, Physical, electrical and dielectric properties of Ca-substituted strontium hexaferrite (SrFe 12O 19) nanoparticles synthesized by co-precipitation method, J. Magn. Magn. Mater. 322 (13) (2010) 1720–1726, https://doi.org/10.1016/j.jmmm.2009.12.013.
[44] S. Joshi, M. Kumar, S. Chhoker, G. Srivastava, M. Jewariya, V.N. Singh, Structural, magnetic, dielectric and optical properties of nickel ferrite nanoparticles synthesized by co-precipitation method, J. Mol. Struct. 1076 (2014) 55–62, https://doi.org/10.1016/j.molstruc.2014.07.048.
[45] Y. Bakış, I.A. Auwal, B. Ünal, A. Baykal, Conductivity and dielectric properties of SrLaxBixYxFe12−3xO19 ($0.0 \leq x \leq 0.33$) hexaferrites, Ceram. Int. 42 (10) (2016) 11780–11795, https://doi.org/10.1016/j.ceramint.2016.04.099.
[46] Q. Wen, W. Zhou, J. Su, Y. Qing, F. Luo, D. Zhu, High performance electromagnetic interference shielding of lamellar MoSi2/glass composite coatings by plasma spraying, J. Alloy. Compd. 666 (2016) 359–365, https://doi.org/10.1016/j.jallcom.2016.01.123.
[47] L.M. Ridgway, I. Harrison, High frequency dielectric properties of bismuth substituted barium hexaferrite, Lect. Notes Electr. Eng. 99 (2011) 995–1000, https://doi.org/10.1007/978-3-642-21747-0_129.
[48] P. Kuruva, P. Reddy Matli, B. Mohammad, S. Reddigari, S. Katlakunta, Effect of Ni-Zr codoping on dielectric and magnetic properties of SrFe12O19 via sol-gel route, J. Magn. Magn. Mater. 382 (2015) 172–178, https://doi.org/10.1016/j.jmmm.2015.01.050.
[49] K. Praveena, K. Sadhana, H.L. Liu, N. Maramu, G. Himanandini, Improved microwave absorption properties of TiO2 and Ni0.53Cu0.12Zn0.35Fe2O4 nanocomposites potential for microwave devices, J. Alloy. Compd. 681 (2016) 499–507, https://doi.org/10.1016/j.jallcom.2016.04.190.
[50] Y. Liu, X. Su, X. He, J. Xu, J. Wang, Y. Qu, C. Fu, Y. Wang, Dielectric and microwave absorption properties of ZrB 2 /Al 2 O 3 composite ceramics, J. Mater. Sci.: Mater. Electron. 30 (3) (2019) 2630–2637, https://doi.org/10.1007/s10854-018-0538-3.
[51] A. Tarasov, K. Titov, On the use of the Cole-Cole equations in spectral induced: Polarization, Geophys. J. Int. 195 (2013) 352–356, https://doi.org/10.1093/gji/ggt251.
[52] A.F. Ahmad, S. Ab Aziz, Z. Abbas, S.J. Obaiys, A.M. Khamis, I.R. Hussain, M.H. M. Zaid, Preparation of a chemically reduced graphene oxide reinforced epoxy resin polymer as a composite for electromagnetic interference shielding and microwave-absorbing applications, Polymers (Basel) 10 (2018), https://doi.org/10.3390/polym10111180.
[53] S.T. Assar, H.F. Abosheiasha, A.R. El Sayed, Effect of γ-rays irradiation on the structural, magnetic, and electrical properties of Mg–Cu–Zn and Ni–Cu–Zn ferrites, J. Magn. Magn. Mater. 421 (2017) 355–367, https://doi.org/10.1016/j.jmmm.2016.08.028.
[54] R. Khalil, F. Salman, R. Khalil, H. Hazaa, Dielectric studies and Cole-Cole plot analysis of silver-ion conducting glasses Magnesium Batteries View project Dielectric studies and Cole-Cole plot analysis of silver-ion conducting glasses, 3 (2014) 1–9. http://www.accessinterjournals.org/ajps.

ScienceDirect

Materials Today: Proceedings

Volume 66, Part 4, 2022, Pages 1858-1861

Synthesis and structural characterization of zinc substituted calcium W-type hexagonal ferrite

Smita Tolani [a], Kishorchandra Rewatkar [b]

Show more

Outline | Share Cite

https://doi.org/10.1016/j.matpr.2022.05.289

Get rights and content

Abstract

Calcium hexaferrites are a subject of great interest due to their promising applications and narrow particle size distribution. It has good magnetic and electrical properties with very good chemical stability along with thermal stoutness with cost effectivity. From the technological point of view substitution of different types of ions was found to be an effective way of improving and enhancing the quality of material and their magnetic characteristics which can lead to various potential applications. The sample of calcium W- type hexaferrite with substitution of Zinc having composition $CaZn_2Fe_{16}O_{27}$ was synthesized using Sol-Gel auto combustion route of synthesis. The enhancement in the properties of the Calcium W-type ferrite with substitution of divalent Zn^{2+} is not researched and recorded sufficiently. In this paper, the main cornerstone is on the effects of Zn^{2+} ionic substitution on the structural characteristics of this hexagonal W-type ferrite. The structural modifications of the sample were studied by using XRD and SEM techniques. XRD shows the crystal has the hexagonal structure with lattice parameters a=5.843 A^0 & c=32.18 A^0 belonging to space group $P6_3/mmc$. The surface morphology was studied and particle size was confirmed using Scanning Electron Microscope.

Previous

Next

Keywords

Ca-Hexaferrites; W-type Ferrite; Zn Substitution; Co_2W Hexaferrite; C-axis anisotropy; Sol-Gel Auto Combustion

Special issue articles Recommended articles

Cited by (1)

Impact of Alkaline Earth Metals Doping on Adsorption Properties of Nickel Ferrites for Heavy Metal Removal from Waste Water
2022, SSRN

Copyright © 2022 Elsevier Ltd. All rights reserved. Selection and peer-review under responsibility of the scientific committee of 2022 International Conference on Recent Advances in Engineering Materials.

Copyright © 2023 Elsevier B.V. or its licensors or contributors.
ScienceDirect® is a registered trademark of Elsevier B.V.

ELSEVIER

RELX™

Volume 15, Number 1, 2022. pp. 21-27

Jordan Journal of Physics

ARTICLE

Impact of La on Structural, Morphological and Magnetic Properties of $NiCoFe_2O_4$ Nano Ferrites

P. K. Nagpure[a], **A. K. Nandanwar**[b], **V. M.Nanoti**[c] and **K. G. Rewatkar**[b]

[a] *Department of Physics, D.B. Science College, Gondia-441614, Maharashtra, India.*

[b] *Department of Physics, Dr. Ambedkar College, Deekshabhoomi Nagpur-440010, Maharashtra, India.*

[c] *Department of Physics, PIET, Nagpur-440019, Maharashtra, India.*

Doi: **https://doi.org/10.47011/15.1.3**

Received on: 01/08/2020; *Accepted on: 16/12/2020*

Abstract: $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$ (x = 0.02, 0.06, 0.10) nano ferrites have been synthesized by Sol-gel auto combustion method using urea as a fuel. The sample calcinations have been performed at 800 ^oC for 4 hours. The synthesized samples were subjected to study X-ray diffraction spectroscopy (XRD) for structural investigations. All the samples were found to constitute Face Centered Cubic (FCC) spinel structure belonging to the Fd3m space group. The XRD results show the single cubical phase formation in the heated samples. Energy-dispersive X-ray spectra confirmed the presence of Ni, Co, La Fe and O elements with no existence of any impurity. The average crystallite size was decreased by varying the concentration of La from 10 to 8 nm. The Field Emission Gun Scanning Electron microscopy (FEG-SEM) and Field Emission Gun transmission electron microscopy (FEG-TEM) have given the morphological study of the samples. It is also found that the value of the lattice constant decreases with increases in La concentration. The magnetic properties of the samples were investigated by using a vibrating sample magnetometer (VSM). The results obtained from VSM show that the value of both magnetization (Ms) and coercivity (Hc) decreases with an increase in diamagnetic La concentration.

Keywords: Spinel ferrites, Sol-gel, SEM, TEM, VSM.

Introduction

The physical, electrical and magnetic properties of ferrites enable their use in various types of technologies. Spinel ferrite nanoparticle materials are highly preferred in engineering and technology applications, like biomedecine, pharmaceuticals, sensors, magnetic resonance imaging, drug delivery, microwaves, high-frequency devices, information storage and electronic chips [1, 2, 3, 4]. The structure and electromagnetic properties of nano-spinel ferrites can be modified by the substitution of different cations. Rare earth substitutions are highly valuable for reducing the particle size and intensification of the lattice parameter [5]. In this respect, substituting rare earth (RE) cations into the spinel ferrite structure plays an important role in enhancing the dielectric, magnetic and electric properties due to the Fe–Fe interactions caused by the spin coupling effect of 3d electrons [6]. Therefore, when rare earth and iron interactions (3d–4f coupling) of the spinel ferrites occur, they can vary the structural, electrical, spectral and magnetic properties of spinel ferrites. In our study, structural changes, such as decreases in lattice constant due to the transfer of an equivalent number of Fe^{3+} ions (0.64 Å) from tetrahedral (A) site to octahedral [B] site to relax strain at the octahedral site, are observed. Magnetic parameters, such as

Corresponding Author: Priti K Nagpure **Email**: pritinagpure1979@gmail.com

coercivity (Hc), saturation magnetization (Ms) and retentivity (Mr), decrease with an increase in La concentration. Different RE substitutions have proven to have different results on the ferrite structure [7,8,9]. Some researchers have investigated the effects of La substitution into cobalt-doped nickel ferrite [10-14].

Materials and Methods

Nano-sized ferrite particles with the composition $Ni_{0.2}$ $Co_{0.8}$ $Fe_{2-x}La_xO_4$ (x = 0.02, 0.06, 0.10) were prepared using sol-gel auto combustion method using urea as a fuel. The high-purity AR grade ferric nitrate ($Fe(NO_3)_3.9H_2O$), Nickle nitrate ($Ni(NO_3)_2.6H_2O$), Cobalt nitrate ($Co(NO_3)_2.6H_2O$), Lanthanum nitrate ($La(NO_3)_3.6H_2O$) are dissolved in distilled water. This solution was then heated at 80^0 C for 4 to 5 hrs, to form sol to viscous brown gel. After that, it was kept in a microwave oven (Model IFB 17 PM – MEC1); within 2 to 3 min. auto combustion takes place and yields fine powder of $Ni_{0.2}$ $Co_{0.8}$ $Fe_{2-x}La_xO_4$ ferrite nanoparticles. The powder was sintered at 800^0 C for 4 hrs.

Results and Discussion

X-ray Diffraction Analysis

The X-ray diffraction pattern for $Ni_{0.2}$ $Co_{0.8}$ $Fe_{2-x}La_xO_4$ (x = 0.02, 0.06, 0.10) synthesized by sol-gel auto combustion method is shown in Fig. 1. The XRD pattern confirmed the formation of single-phase cubic spinel with space group Fd3m, which is in agreement with ICSD 174321. Measurements were performed using Cu Kα radiation having a wavelength, λ = 1.5406 Å. Fig. 1 shows that the most intense diffraction peak (311) is slightly shifted towards a higher angle with increasing La substitution. The peak shift towards a higher angle can be attributed to a decrease in lattice parameter the reason behind which is that the lattice parameter is inversely proportional to the diffraction angle $\sin\theta$. When the diffracting angle (θ) increases, lattice constant (a) goes on decreasing.

The broadening of XRD peaks is related to the nano-sized particle and lattice strain. The value of lattice constant 'a' and particle size for each sample are given in (Table 1).

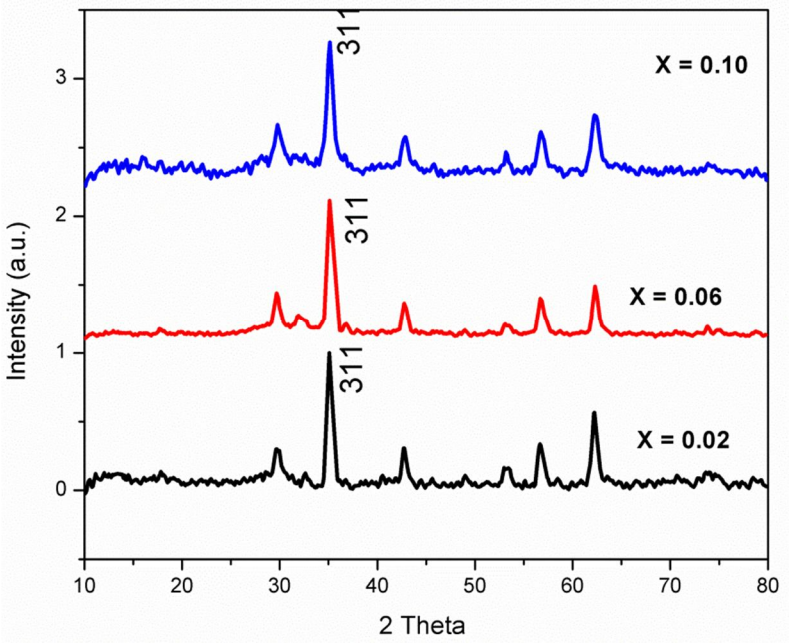


FIG. 1. XRD pattern of $Ni_{0.2}$ $Co_{0.8}$ $Fe_{2-x}La_xO_4$.

TABLE 1. Average particle size (D) and lattice constant (a).

Composition (X)	Average particle size (D) nm	Lattice constant (a) Å
X = 0.02	10.34	8.48024
X = 0.06	11.89	8.47431
X = 0.10	8.56	8.46290

Note: Variation of average particle size (D) and lattice constant (a) of $Ni_{0.2}$ $Co_{0.8}$ $Fe_{2-x}La_xO_4$.

Morphological Analysis

The Field Emission Gun scanning electron microscopy (FEG-SEM) of $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$ (x = 0.02, 0.06, 0.10) nanoparticles is shown in Fig 2. The image exhibits a higher agglomeration cubic shape with an average grain size of 39 nm. The existence of agglomeration may be due to the interaction between the magnetic particles [12].

The EDX spectrum confirmed the existence of Ni, Co, Fe, La and O in composition X = 0.02, 0.06 and 0.10, as shown in Fig 3. The EDX spectra illustrate that La peak intensities increase with an increase in La content. The TEM pattern of $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$ (x = 0.02) nanoparticles is shown in Fig. 4. The image confirms the cubic spinel structure. Fig 5 shows the Selected Area Electron Diffraction (SAED) image which also confirms the formation of poly-nanocrystalline form.

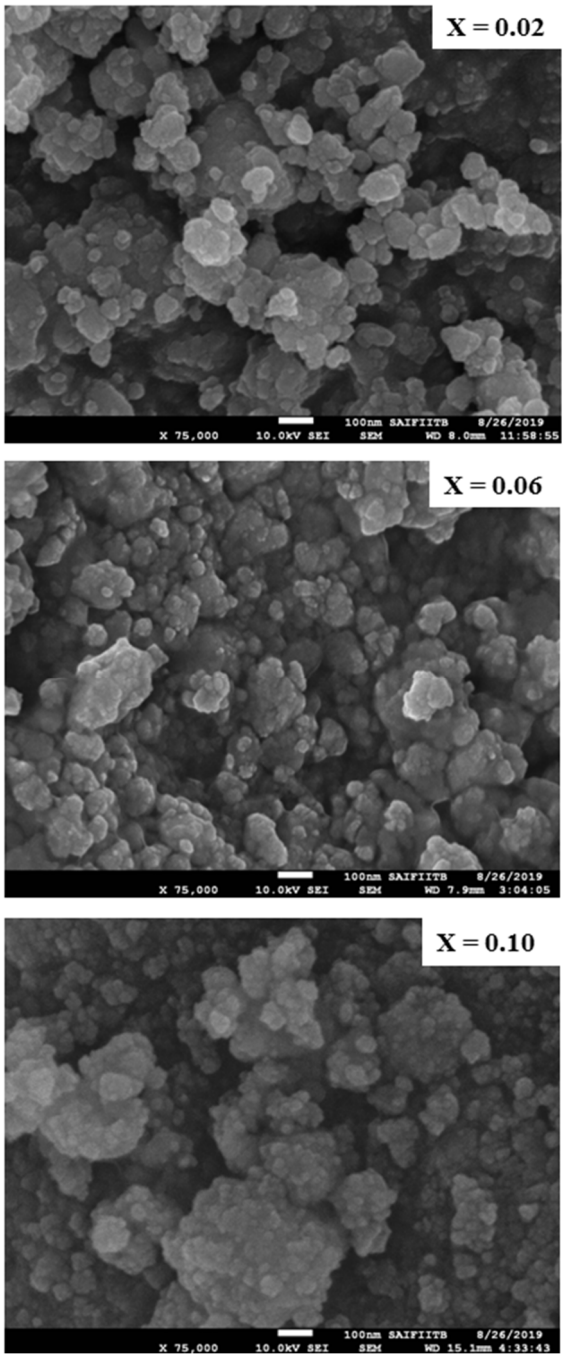


FIG 2. Field emission gun scanning electron microscopy (FEG- SEM) of $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$ for different concentrations of X.

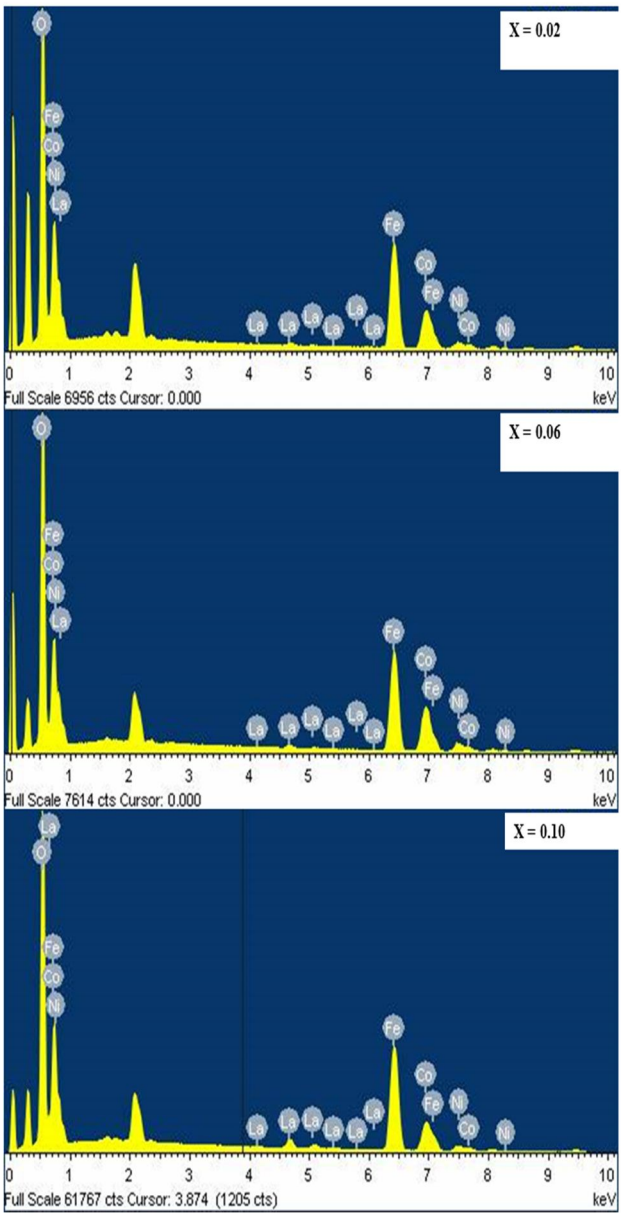


FIG. 3. EDX of $Ni_{0.2}$ $Co_{0.8}$ $Fe_{2-x}La_xO_4$ for different concentrations of X.

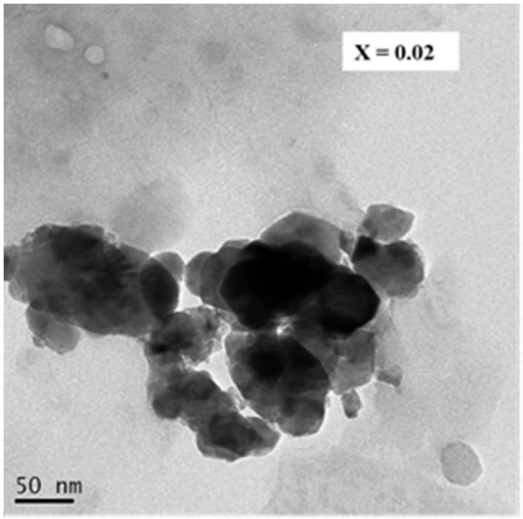


FIG. 4. The field emission gun transmission electron microscopy (FEG- TEM) of $Ni_{0.2}$ $Co_{0.8}$ Fe_{2-x} La_xO_4 for (X = 0.02).

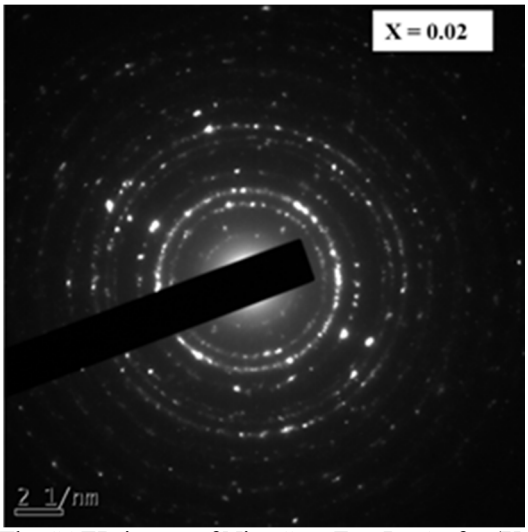


FIG. 5. The SAED image of $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$ for (X = 0.02).

Magnetic Properties

At room temperature, magnetization as a function of the applied magnetic field is shown in Fig. 6 for different samples. All samples show a typical magnetic characteristic of ferrites with a difference in the value of saturation magnetization (Ms). The saturation magnetization value (Ms) and coercivity (Hc) have been found to decrease with the increase in La concentration. In the rare-earth substituted ferrites, the rare-earth ions have a strong preference for the octahedral lattice site (B) of the spinel lattice. Neel has explained the magnetic behavior of these spinels based on the exchange interaction that occurs between metal ions at A & B sites spinel. Fig. 7a and Fig. 7b show tetrahedral A sites and octahedral B sites, respectively. [15-18]. It was expected that a fraction of La ion enters into octahedral sites and creates distortions as well as a decrease in lattice constant. This is in agreement with the findings in this work (Table1). Thus, the observable decreases in coercivity (Hc) and saturation magnetization (Ms) may be attributed to the larger lattice distortion and smaller crystalline size. The values of saturation magnetization (Ms), coercivity (Hc) and retentivity (Mr) for all three samples are tabulated in (Table 2).

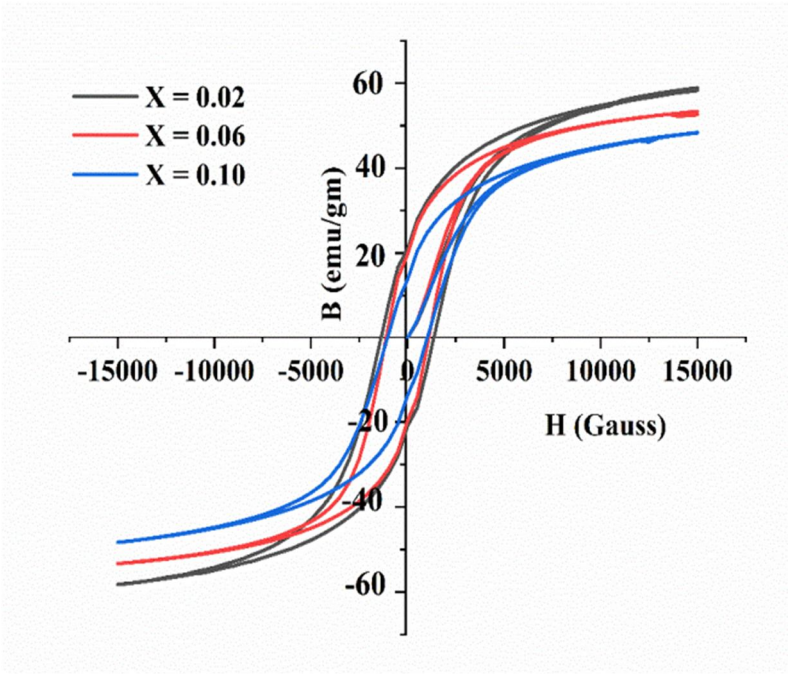


FIG. 6. Hysteresis loop for $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$.

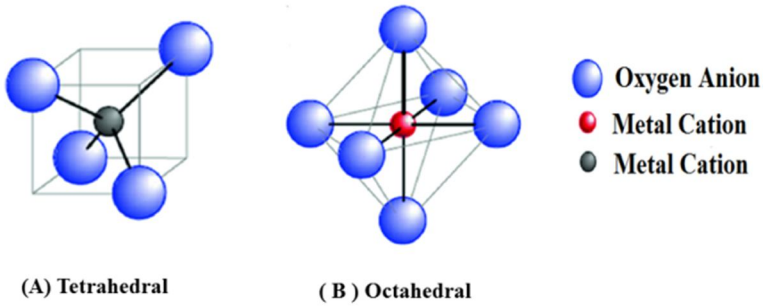


FIG. 7. (a) Tetrahedral (A) sites and (b) Octahedral (B) sites.

TABLE 2. Values of coercivity (H_C), retentivity (Mr) and saturation magnetization (Ms) for $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$.

Composition (X)	H_C (G)	Mr (emu/gm)	Ms (emu/gm)
X = 0.02	1366.2	20.92	58.58
X = 0.06	1105.0	19.67	53.34
X = 0.10	1031.6	13.75	48.36

Conclusion

In this work, a series of $Ni_{0.2}Co_{0.8}Fe_{2-x}La_xO_4$ (X = 0.02, 0.06 and 0.10) powders and sintered samples were successively prepared by sol-gel auto combustion method using oxide as precursor and urea as fuel. The structural properties were investigated by XRD. XRD confirmed the formation of the FCC spinel phase for all the samples. The EDX spectrum shows that no additional impurity is present in the sample. It also shows that the lattice constant 'a' decreases with the increase in La concentration. The particle size calculated from X-ray diffraction is approximately constant. The SAED image also confirms the formation of a poly-nanocrystalline sample. Further, La-substituted $NiCoFe_2O_4$ ferrite shows a definite hysteresis loop at room temperature. The presence of non-magnetic La in $NiC_OFe_2O_4$ ferrite results in a reduction of coercivity (Hc), saturation magnetization (Ms) and retentivity (Mr), which could be due to dilution in the magnetic interaction.

References

[1] Chen, Q. and Zhang, Z.J., Appl. Phys. Lett., 73 (1998) 3156.

[2] Zhao, L., Yang, H., Yu, L., Cui, Y., Zhao, X. and Feng, S.J., Mater. Sci., 42 (2007) 686.

[3] Kumar, E.R., Kamzin, A.S. and Janani, K.J., J. Magn. Magn. Mater., 417 (2016) 122.

[4] Kumar, E.R., Jayaprakash, R. and Patel, R., Superlattices and Microstructures, 62 (2013) 277.

[5] Das Calu, G., Popescu, T., Feder, M. and Caltun, O.F., J. Magn. Magn. Mater., 333 (2013) 69.

[6] Shah, M.S., Ali, K., Ali, I., Mahmood, A., Ramay, S.M. and Farid, M.T., Mater. Res. Bull., 98 (2018) 77.

[7] Junaid, M., Khan, M.A., Iqbal, F., Murtaza, G., Akhtar, M.N., Ahmad, M., Shakir, I. and Warsi, M.F., J. Magn. Magn. Mater., 419 (2016) 338.

[8] Boda, N., Boda, G., Naidu, K.C.B., Srinivas, M., Batoo, K.M., Ravinder, D. and Reddy, A.P., J. Magn. Magn. Mater., 473 (2019) 228.

[9] Kokare, M.K., Jadhav, N.A., Singh, V. and Rathod, S.M., Opt. Laser Technol., 112 (2019) 107.

[10] Kumar, P., Sharma, S.K., Knobel, M., Chand, J. and Singh, M., J. Electroceram., 27 (2011) 51.

[11] Mansour, S.F., Hemeda, O.M., El-Dek, S.I. and Salem, B.I., J. Magn. Magn. Mater., 420 (2016) 7.

[12] Vadivel, M, Ramesh Babu, R., Arivanandhan, M. and Ramamurthi, K., Journal of Superconductivity and Novel Magnetism, 30 (2017) 441.

[13] Yadav, R.S., Kuritka, I., Vilcakova, J., Havlica, J., Kalina, L., Urbánek, P., Machovsky, M., Masar, M. and Holek, M., Journal of Materials Science: Materials in Electronics, 28 (2017) 9139.

[14] Kumar, L. and Kar, M., Ceram. Inter., 38 (2012) 4771.

[15] Karimi, Z., Mohammadifar,Y., Shokrollahi, H., Asl, S.K., Yousefi, G. and Karimi, L., J. Magn. Magn. Mater., 361 (2014) 150.

[16] Ghone, D.M., Mathe, V.L., Patankar, K.K. and Kaushik, S.D., J. Alloys Compd., 739 (2018) 52.

[17] Wu, X., Ding, Z., Song, N., Li, L. and Wang, W., Ceram. Int., 42 (2016) 4246.

[18] Neel, L., Ann. Phy., 3 (1948) 137.

ScienceDirect

Materials Today: Proceedings

Volume 62, Part 8, 2022, Pages 5075-5082

Analysis of structural, electric and magnetic features of Bi^{3+} substituted nanocrystalline calcium hexaferrite

Y.D. Choudhari [a], K.G. Rewatkar [b]

Show more

Outline | Share Cite

https://doi.org/10.1016/j.matpr.2022.02.416

Get rights and content

Abstract

Calcium hexaferrite ($CaFe_{12-x}BixO_{19}$, x=0.2–0.8) was successfully brewed through a microwave-induced sol–gel auto-combustion technique with Bi^{3+} as a substitute. The impact of added Bi^{3+} ions on the structure, morphology, magnetic, and dielectric properties of calcium hexaferrite was analyzed using an X-ray powder diffractometer (XRD), Field emission scanning electron microscopy (FE-SEM), vibrating sample Magnetometry (VSM), Fourier transforms infrared spectroscopy (FT-IR), and impedance study. The peak position in the XRD pattern confirms the development of single-phase hexagonal ferrite nanoparticles with a space group of P63/mmc and an average crystalline size of 46–56 nm. Magnetic analysis revealed that when the Bi^{3+} ion is added to Ca ferrite, the material's coercive force improves, but the saturation magnetization decreases. The dielectric constant, electric conductivity, and loss tangent of the substance were determined for frequencies ranging from 20 Hz to 1 MHz, indicating appropriate for various applications, including permanent magnets and high-density magnetic recording media.

Previous Next

Keywords

Calcium hexaferrite; Bismuth; XRD; FE-SEM; HR-TEM; VSM, etc.

Cited by (0)

Copyright © 2022 Elsevier Ltd. All rights reserved. Selection and peer-review under responsibility of the scientific committee of the International Conference on Emerging Trends in Material Science and Technology – 2022.

Copyright © 2023 Elsevier B.V. or its licensors or contributors.
ScienceDirect® is a registered trademark of Elsevier B.V.

RELX™

Optical Materials xxx (xxxx) 111542

Contents lists available at ScienceDirect

Optical Materials

journal homepage: www.elsevier.com/locate/optmat

Research Article

Structural, photoluminescence and Judd-Ofelt analysis of red-emitting Eu^{3+} doped strontium hexa-aluminate nanophosphors for lighting application

Priti Chaware [a], Amol Nande [b,*], S.J. Dhoble [c], K.G. Rewatkar [a]

[a] Department of Physics, Dr. Ambedkar College, Nagpur, 440010, India
[b] Guru Nanak College of Science, Ballarpur, 442701, India
[c] Department of Physics, R T M Nagpur University, Nagpur, 440001, India

ARTICLE INFO

Keywords:
Nanophosphors
Eu^{3+}
Combustion synthesis
Photoluminescence
Hexa-aluminate
Photometry
Judd-Ofelt analysis

ABSTRACT

In this paper, the structural and luminescence properties of Eu^{3+}- doped $SrAl_{12}O_{19}$ nanophosphors are discussed. A series of $SrAl_{12}O_{19}$:xEu^{3+} (x = 0.5, 1, 1.5, 2 and 2.5 mol %) nanophosphors were prepared using urea assisted-combustion synthesis method. The elemental and phase identification were performed by X-ray diffraction. The peak positions in the X-ray diffraction pattern have confirmed the formation of hexagonal structure. The vibration of oxide bonds and the formation of the molecules were confirmed from FTIR spectra. The surface morphology and particle size distribution are estimated using Field Emission-Scanning Electron Microscopy (FE-SEM), High Resolution-Transmission Electron Microscopy (HR-TEM). The optical properties of prepared nanophosphors series are studied using photoluminescence spectra and UV–visible spectra analysis. The refractive index of the optimized concentration of nanophosphor is estimated using Herve and Vandamme relation. Further, Judd-Ofelt analysis was performed on photoluminescence emission spectra. The potential application of synthesized nanophosphors in light-emitting devices (LED) is verified using photometry analysis on obtained emission spectra. The obtained CCT number confirmed that these phosphors are useful as a red color LED.

1. Introduction

In recent years, luminescent materials have potential applications in the field of color display devices, high-efficiency solid-state lighting, storage devices, biological sensors, optoelectronic and photonic devices [1,2]. The solid-state lightning technology can replace the traditional lighting tools which are eco-friendly and provides elegant quality. In spite of many papers published on solid-state lighting devices the field still has a scope for research in color purity, photoluminescence quantum yield, intensity variation, and persistent luminescence properties.

The properties of phosphor are depending on both host materials and dopant or activator [3]. Thus, selecting an appropriate combination of host and dopant material is very important. Oxides, halides, silicates, aluminates, sulphates, and phosphates are considered good host materials, Out of which alkaline earth aluminates such as strontium-based aluminates ($SrO–Al_2O_3$) are considered promising hosts as it is non-toxic, thermally and chemically stable [4]. Strontium-based aluminate phosphors show extra-ordinary luminescent characteristics such as high quantum yield, efficient photoluminescence, and color purity. These phosphors have been used for solid-state lighting, display, and LED applications [5]. $SrO–Al_2O_3$ systems have been in different forms such as $SrAl_{12}O_{19}$, $SrAl_4O_7$, $Sr_4Al_{14}O_{25}$, $SrAl_2O_4$, and $Sr_3Al_2O_6$ [6] [–] [9]. All these forms are used as a host for nanophosphors.

Rare-earth materials are used as activators in nanophosphors. In most cases, the rare-earth dopant is responsible for a particular color emission such as Er^{3+} ion shows emission in a green region or Eu^{3+} ion has emission in the red region. Trivalent europium doped nano-size phosphor is ideally suited for various applications such as LEDs, WLED's, photovoltaic devices, photocatalysis devices, display panels, and biometric sensors due to their high quantum efficiency. Phosphors stimulated by Eu^{3+} are considered an ideal red source, as these phosphors show sharp emission lines in the red region. However, the emission wavelength and properties of Eu^{3+} and Eu^{2+} dopants depend on the host structure and its lattice [10,11].

Rare-Earth-doped strontium aluminate phosphors are usually prepared using various methods such as combustion, precipitation, sol-gel, and solid-state reaction method [12,13]. However, the synthesis methods for aluminates always required pre or post heating at temperature; thus, non-uniformity in particle size distribution is observed. The combustion method is one of the most efficient and rapid routes to prepare

* Corresponding author.
E-mail address: nande.av@gmail.com (A. Nande).

https://doi.org/10.1016/j.optmat.2021.111542
Received 13 July 2021; Received in revised form 27 August 2021; Accepted 30 August 2021
0925-3467/© 2021

UNCORRECTED PROOF

highly pure and homogeneous oxide nanopowder. Furthermore, this process is fast, cost-effective, energy-saving and gives fine products at the nano-scale [14].

There are only a few papers published in recent years that showed the luminescence studies of Eu^{3+}or Mn^{4+} ions doped $SrAl_{12}O_{19}$ synthesized using a solid-state process and a sol-gel technique [15] [–] [17]. In this paper, a series of Eu^{3+}-doped $SrAl_{12}O_{19}$ nanophosphors were synthesized using urea assisted combustion process. The morphological, structural, optical, and photoluminescence properties of the synthesized nanophosphors are studied in detail. Eu^{3+}-doped $SrAl_{12}O_{19}$ showed red color emission with Eu^{3+} ion as the emission center under ultraviolet excitation. Thus, these phosphors behaved as down-converting phosphors. Further, Judd-Ofelt (JO) parameters were estimated and studied from emission spectra of Eu^{3+} ions in $SrAl_{12}O_{19}$ nanophosphors [18,19]. As per our knowledge, only Bento F. dos Santos Jr. et al. [20] published a brief study of JO analysis for the Eu-doped $SrAl_2O_4$ system (but not on Eu^{3+}-doped $SrAl_{12}O_{19}$ nanophosphors). Thus, in this article, we report a detailed JO analysis of Eu^{3+}-doped $SrAl_{12}O_{19}$ nanophosphors. The JO analysis of emission data of Eu^{3+} ions in $SrAl_{12}O_{19}$ allowed us to calculate the intensity parameters. This analysis helps to understand the luminescence performance of Eu^{3+} into the $SrAl_{12}O_{19}$ host matrix. At the end of the paper, the photometry analysis shows that these nanophosphors can be used in LEDs for red color substituents.

2. Synthesis of nanophosphors

A series of $SrAl_{12}O_{19}$:x%Eu^{3+} (x = 0.5, 1, 1.5, 2, 2.5) nanophosphors were synthesized using a combustion method. Strontium nitrate [$Sr(NO_3)_2$], and aluminium nitrate nonahydrate[$Al(NO_3)_39H_2O$] was used as the oxidizers, while urea (CH_4N_2O) was used as the fuel for the method. Europium oxide (Eu_2O_3) was used as the dopant precursor. All the reagents were obtained A.R. grade and taken according to their stoichiometric ratio.

The schematic of the synthesis process is shown in Fig. 1. The precursor and initial reactant materials were dissolved in double distilled water and mixed in a china dish using porcelain mortar and pestle. Later, the homogeneous solution of the mixture was obtained by heating the mixture at 80 °C for 15–20 min. The mixture was kept in a preheated muffle furnace whose temperature was nearly 525 °C. As soon as the china dish was kept in the preheated furnace, the mixture reached the boiling point, which followed a decomposition process. This led to combustion reaction with the liberation of combustible gases such as nitrogen oxides and ammonium oxides. The combustion process is completed in a short period. The formed sample was foamy, and the foamy powder was removed as soon as the completion of the combustion process. The foamy powder was crushed to a fine powder which was sintered at 800 °C for 4 h. The final obtained product was taken for characterization, and the characterizations were done at room temperature.

The structural and morphological analyses of the nanophosphors were performed from XRD, TEM, SEM, and FTIR data. The UV–visible spectroscopy study was also performed to estimate the band-gap of nanophosphor. However, the photoluminescence properties of the nanophosphors were measured from a fluorescence spectrometer using a Xenon lamp (λ_{exc} = 330 nm) as an excitation source.

3. Result and discussion

3.1. Structural and morphological analysis

3.1.1. X-ray diffraction (XRD)

The measured XRD spectra of synthesized $SrAl_{12}O_{19}$:xEu^{3+}(x = 0.5, 1, 1.5, 2%) nanophosphors are precisely shown in Fig. 2. These spectra had an excellent match with Joint Committee Powder Diffraction Data Standard (JCPDS) file number 80–1195 [17]. The comparison of the experimental spectra with the provided JCPDS file depicted that the as-prepared nanophosphors have a hexagonal shape crystal structure. Fig. 2 also confirmed that the intensity of prominent peaks decreases with increasing Eu^{3+} concentrations. This indicates that the Eu^{3+} atoms are mainly involved in replacing a few prominent atoms of the host materials but not in overall crystal formation, consistent with previous research works [21].

To better understand the structural pattern of $SrAl_{12}O_{19}$, the XRD patterns of all as-synthesized nanophosphors are fitted using the Rietveld refinement function in the Full-Prof Software suite. An example of analyzed data for $SrAl_{12}O_{19}$ is shown in Fig. 3. Hexagonal crystal structure with space group P63/mmc (#194) had been considered for the refinement process; it has to be consistent with the JCPDS data file. Also, in the refinement process, peak shape was modeled as Pseudo-Voigt function. Varying lattice parameters (constants – a, b, c and angles α, β, γ), scale factor value, zero correction, half-width full maxima value, and the position of coordinates of an atom, the refine process car-

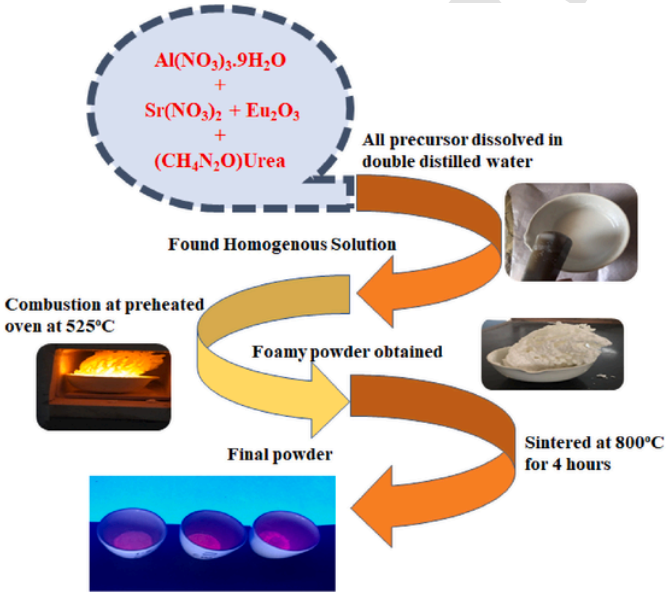


Fig. 1. A schematic for synthesis of $SrAl_{12}O_{19}$:x%Eu^{3+}(x = 0.5, 1.0, 1.5, and 2.0) nanophosphors.

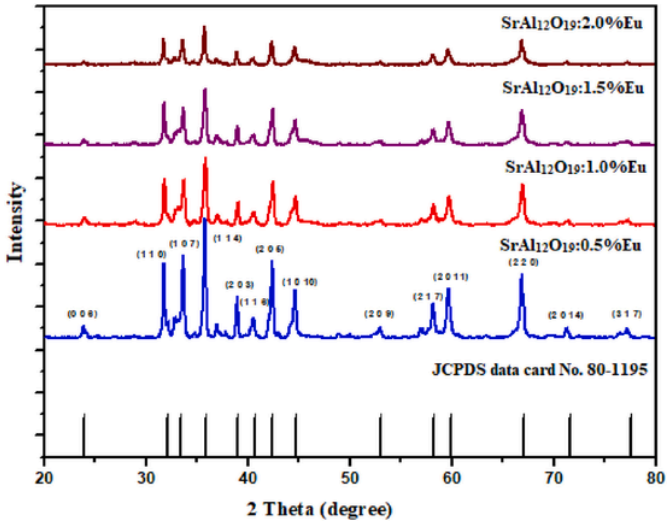


Fig. 2. X-ray diffraction patterns of $SrAl_{12}O_{19}$:x%Eu^{3+}(x = 0.5,1.0,1.5, and 2.0) nanophosphors with different concentration of Eu^{3+}.

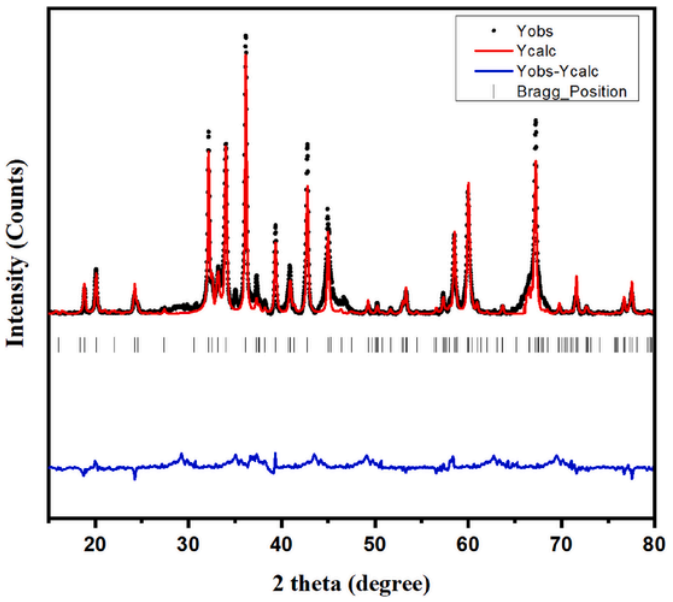


Fig. 3. X-ray Rietveld refinement pattern of the $SrAl_{12}O_{19}$.

ries out. Table 1 depicts the synthesized series's estimated parameters, which were matched with the reference data [22,23].

For all synthesized nanophosphors average crystallite size was calculated from Debye–Scherrer equation,

$$d = \frac{0.9\lambda}{\beta cos\theta} \quad (1)$$

here, d represents the average grain size of the crystallites, θ represents Bragg angle, λ represents the incident wavelength, and β represents full-width half-maximum (FWHM) of the prominent (114) diffraction peak.

Further, the XRD data were processed using the Rietveld refinement process. Table 2 provides the estimated average crystallite sizes, lattice parameter a and c values. The crystallite size decreases with increasing Eu^{3+} concentration, which further supports the atomic-site doping of Eu^{3+}. Nevertheless, the dopant does not change the complete crystalline structure. The estimated values of crystallite size varied from 30.8 to 39.1 nm. The estimated crystallite size further supports the formation of nanophosphors. The c/a ratio is considered a valuable term to confirm the formation of M-type hexagonal structure, consistent with the previously mentioned results [24,25]. The estimated value of a and c for all nanophosphors are ~5.6 Å (0.56 nm) and 22 Å (2.2 nm). From the estimated a and c values, c/a ratios were found to be constant and equal to ~3.95, which confirmed magneto-plumbite structure, i.e., M-type hexagonal structure (Table 2). From the above discussion, it can be claimed that the synthesized nanophosphors obey Vegard's law [26].

Table 1
Parameters obtained from the refinement of $SrAl_{12}O_{19}$.

Compound	$SrAl_{12}O_{19}$
Space group	P63/mmc (#194)
$a = b$ (Å)	5.57
c (Å)	22.029
V (Å^3)	683.48
Z	6
2θ interval	10–80
No. of reflection	100
χ^2	1.723
R_p	7.99
R_{wp}	8.51
Re	6.48

Table 2
Lattice parameters, FWHM, and Crystalline size of samples.

Concentration (mol%)	Lattice Parameter		c/a	FWHM (degree)	Crystalline size (nm) (nm)
	$a = b$ (Å)	c (Å)			
0.5	5.57	22.03	3.95	0.237	39.1
1	5.56	22.02	3.95	0.251	36.9
1.5	5.56	22.00	3.95	0.288	32.1
2.0	5.55	21.96	3.95	0.3	30.8

The proposed crystal structure of the nanophosphors is shown in Fig. 4. The hexagonal structure of nanophosphors unit cells is obtained by alternating spinel ($S = Al_6O_8^{2+}$) and hexagonal ($R = SrAl_6O_{11}^{2-}$) layers. Also, O^{2-} ions and Sr^{2+} ions are closely packed in the hexagonal layer, and Al^{3+} ions are oriented in the octahedral (12k, 2a, and 4f_2), trigonal-bipyramidal (2b), and tetrahedral (4f_1) sites. However, Al^{3+} ions are bound together with other Al^{3+} ions with super-exchange interactions through the O^{2-} ions via their magnetic moments.

3.1.2. Field Emission-Scanning Electron Microscopy (FE-SEM)

The FE-SEM images of the synthesized nanophosphors are depicted in Fig. 5 (a) and (b). These images suggested the formed nanophosphors are non-uniform shapes and agglomerated to big particles. Also, the images suggested that formed nanophosphors are in foamy nature. The obtained non-uniform and foamy nature could be due to the combustion process as during the process a large amount of gas is released from the self-propagating combustion. This led to a foamy structure with voids in between nanoparticles and some nanoparticles allotted at a smaller volume [27]. The "Image J" software package was used to analyzed and estimate a histogram for particle size distribution. Later the histogram was and fitted with the Gaussian distribution function to obtain the average particle size of the nanophosphors (as shown in Fig. 5 (c)). The estimated particle size of the nanophosphors was ~35 nm (with variation from 30 to 40 nm) which was a good match with the estimated crystalline value from the XRD patterns.

3.1.3. High Resolution-Transmission Electron Microscopy (HR-TEM)

The particle shape and size of synthesized nanophosphor were further confirmed using HR-TEM microscopy. Fig. 6 (a) and (b) show HR-TEM images and selected area electron diffraction pattern (SAED) obtained for $SrAl_{12}O_{19}$ nanophosphors. The estimated average particle

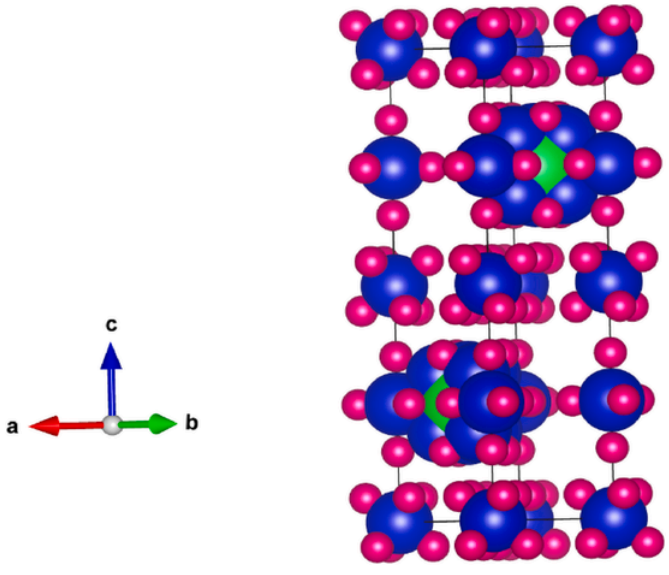


Fig. 4. Unit cells of the parent structures of $SrAl_{12}O_{19}$ (Green = Sr, Pink = O, Blue = Al).

UNCORRECTED PROOF

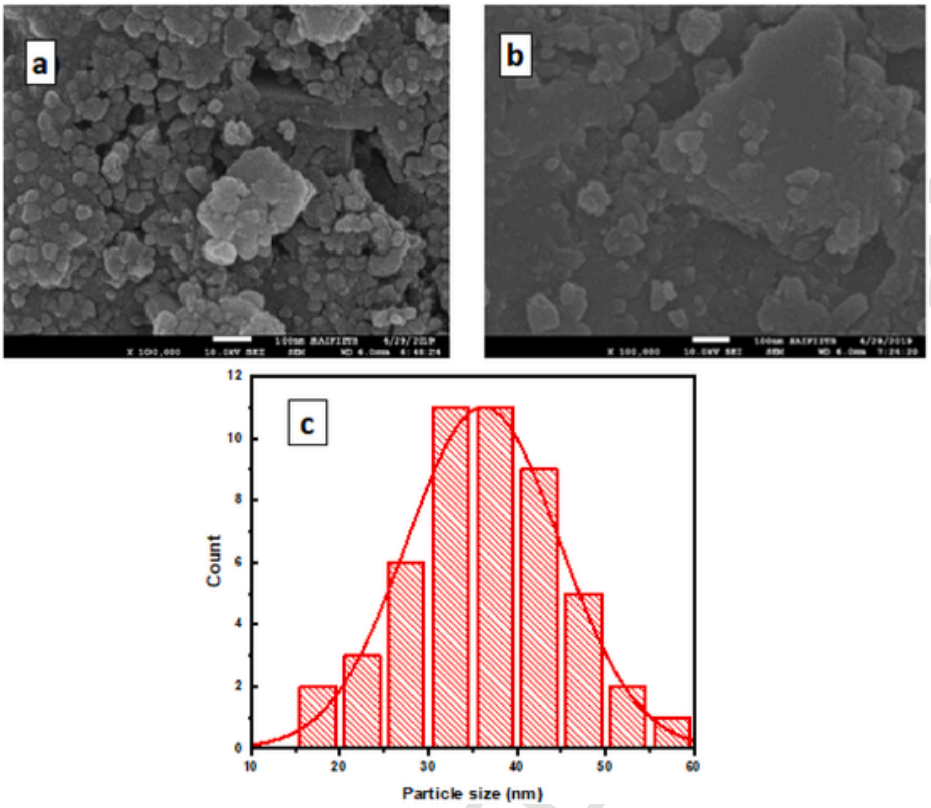


Fig. 5. (a) and (b) FE-SEM images of $SrAl_{12}O_{19}$nanophosphor. (c) Particles size distribution of nanophosphors was estimated using image-j software suit.

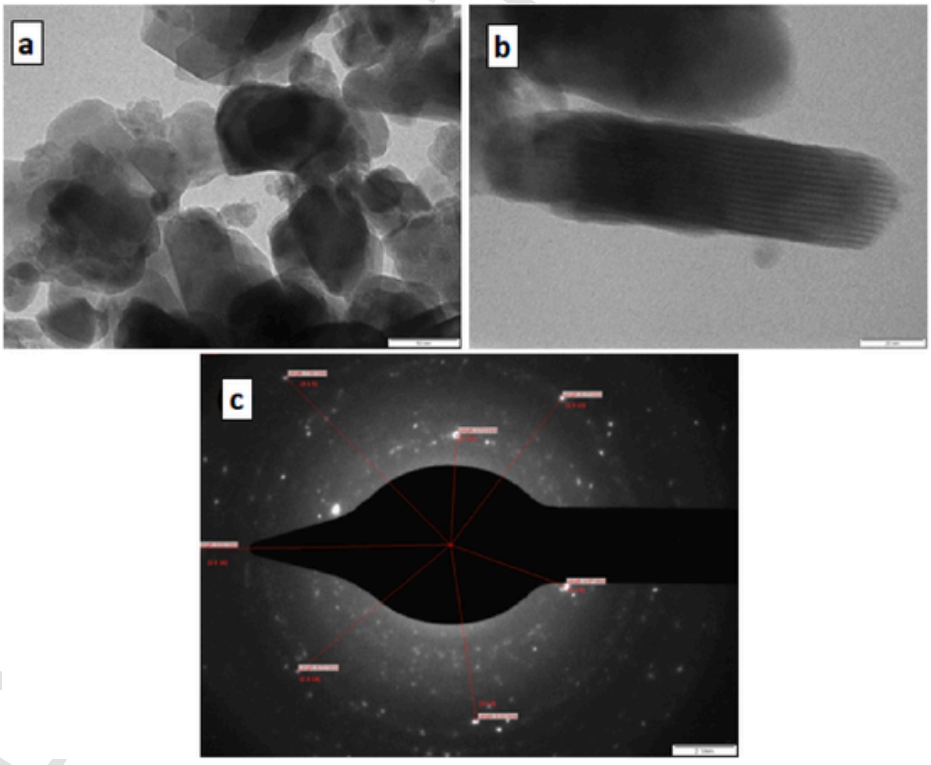


Fig. 6. (a) and (b) TEM micrographs and (c) SAED pattern of $SrAl_{12}O_{19}$nanophosphor.

size from the HR-TEM images is in a range of 35–60 nm (with an average particle size ~ 35 nm) for the $SrAl_{12}O_{19}$ nanoparticles. The estimated average particle size from the HR-TEM images is matched with the crystalline particle size obtained from the XRD analysis and FE-SEM images [28]. Further, HR-TEM images confirmed the irregular shape and agglomerated nature of synthesized nanoparticles.

The SAED pattern [as shown in Fig. 6 (c)] suggests the polycrystalline feature of $SrAl_{12}O_{19}$ nanophosphors, as it contains the number of

diffraction rings. Also, the estimated structure from the SAED pattern was a hexagonal shape which is consistent with the structure obtained from the Rietveld refinement analysis. Thus, we can say that $SrAl_{12}O_{19}$ nanoparticles have an M-type Hexa-aluminates structure.

3.1.4. Fourier transformation infrared spectroscopy (FTIR)

FTIR spectroscopy analysis was done to find out the functional group present in the compound. The FTIR spectrum of nanophosphor $SrAl_{12}O_{19}$, sintered at 800 °C, is shown in Fig. 7. The spectrum was noted from 4000 cm^{-1} to 400 cm^{-1} at room temperature. The broadband was observed at ~3461 cm^{-1}; due to the (O-H) stretching vibration of H_2O absorbed by the samples. This peak may be seen in all the spectra. The other peak was observed at 1636 cm^{-1} due to atmospheric water vapor. These bands are attributed to the antisymmetric stretching vibrations of free O-H bonds [29]. The peak detected at 1457 cm^{-1} corresponds to C-O vibrations obtained from residual carbon from the combustion process or by surface absorption of CO_2 molecule [29,30].

Fig. 7 shows that many absorption bands are seen in a range of 830–400 cm^{-1} due to the phonon energy of the metal-oxygen vibrations. These metal-oxygen vibration peaks are due to the $SrAl_{12}O_{19}$ crystals [14]. This also supports the previously mentioned studies.

3.2. Optical and luminescence analysis

3.2.1. Photoluminescence studies

The photoluminescence emission spectra of combustion derived $SrAl_{12}O_{19}$:xEu^{3+} (x = 0.5–2.5% mole) nanophosphors are shown in Fig. 8. The emission spectra were measured at an excitation wavelength of 397 nm. The characteristic emissions transitions of Eu^{3+} ion resulting from the spin forbidden f-f electronic transition were observed for the emission spectra. The emission peaks are observed at 590, 614, 647, 682, and 695 nm, which corresponds to $^5D_0 \rightarrow {}^7F_J$ (J = 1, 2, 3, 4) Eu^{3+} ions transitions. The transitions are - 590 nm belongs to $^5D_0 \rightarrow {}^7F_1$, 614 nm belongs to $^5D_0 \rightarrow {}^7F_2$, 647 nm belongs to $^5D_0 \rightarrow {}^7F_3$, and 682 nm and 695 nm belong to $^5D_0 \rightarrow {}^7F_4$ [10,31]. The dominant transition at 614 nm emits red, corresponds to the electric dipole transition $^5D_0 \rightarrow {}^7F_2$ of Eu^{3+}. The dominant transition due to electric dipole transition is higher than the magnetic dipole transition observed at 590 nm due to the $^5D_0 \rightarrow {}^7F_1$ transition. The dominant electric dipole transition confirms the presence of Eu^{3+} ions in lattice sites without inversion symmetry in the host lattice [32].

The luminescence intensity of nanophosphors highly depends on the dopant concentration. Fig. 8(a) depicted the intensities of all mentioned peaks increases with increasing Eu^{3+} concentration and the highest intensity observed for 2% Eu^{3+} ion concentration of $SrAl_{12}O_{19}$:Eu^{3+} nanophosphors. For a higher concentration of Eu^{3+}- dopant, the peak intensities decrease with increasing Eu^{3+}-dopant concentration. Fig. 9 shows intensity vs Eu^{3+} dopant concentration for the most prominent peak observed at 614 nm emission spectra. This figure clearly indicated the concentration quenching occurred for 2% Eu^{3+} molar concentration. Energy diffusion among Eu^{3+} ions is often responsible for the concentration quenching process. Also, non-radiative relaxation between adjacent Eu^{3+} ions increased for high-doping concentration. Thus, further, an increase in Eu^{3+} dopant in luminescent centers induces concentration quenching and decreases luminescent intensity [33,34].

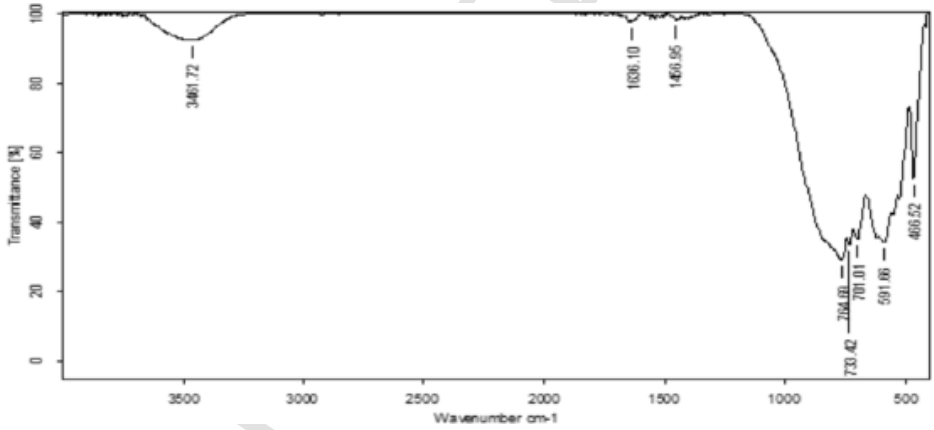


Fig. 7. FITR spectra of $SrAl_{12}O_{19}$nanophosphor.

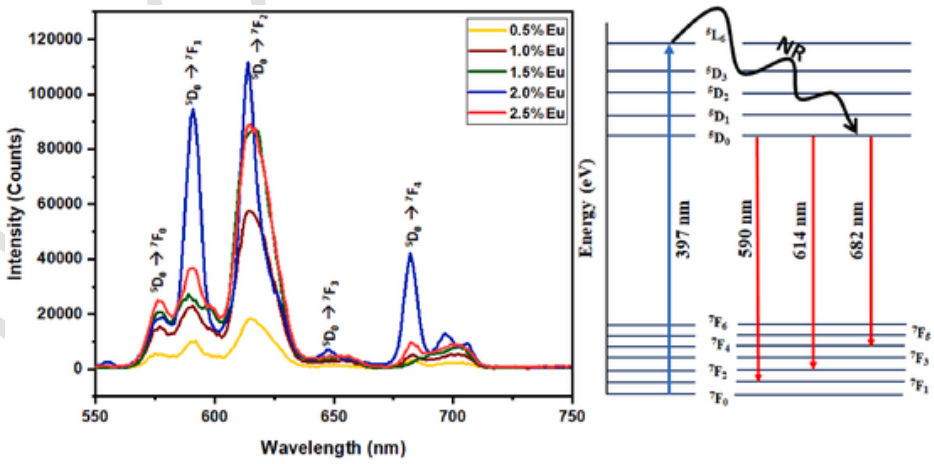


Fig. 8. a) Emission Spectra of $SrAl_{12}O_{19}$: x%Eu^{3+}(x = 0.5,1.0,1.5,2.0, and 2.5) measured at excitation wavelength 397 nm b) The schematic energy level diagram of Eu^{3+} ions in the $SrAl_{12}O_{19}$.

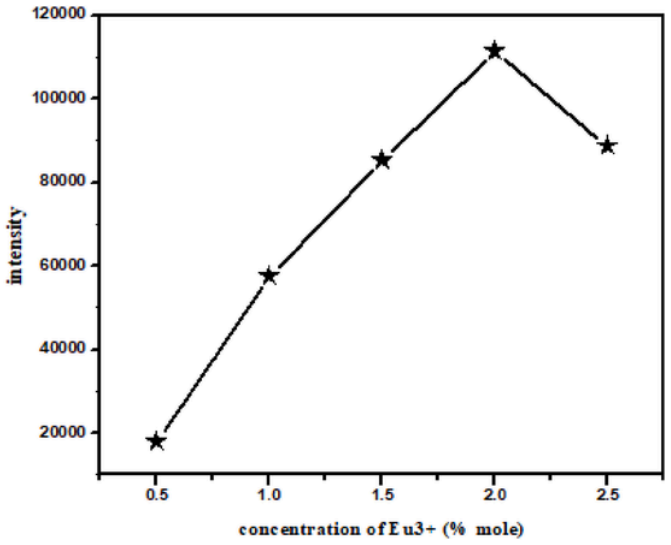


Fig. 9. Intensity vs concentration of Eu^{3+} ion for 614 nm emission peak.

Dexter's theory [35] suggests that the behavior of increasing emission intensity with increasing Eu^{3+}(dopant) concentration and decreasing emission intensity with a higher concentration of Eu^{3+}-dopant infers a non-radiative energy transfer between other Eu^{3+} ions. The exchange and a multipole–multipole interaction with radiation reabsorption between Eu^{3+}-dopant ions give rise to the non-radiative energy transfer [36]. The average distance between the closest Eu^{3+} ions is considered a critical distance where energy transfer occurs. The Blasse's formula [37] could be used to calculate the critical distance R_C for activators Eu^{3+} in $SrAl_{12}O_{19}$:xEu^{3+} can be estimated as;

$$R_c = 2\left(\frac{3V}{4\pi xN}\right)^{1/3} \quad (2)$$

here, x represents critical concentration, V represents the unit-cell volume, and N represents the number of cations. For our sample, $V = 683.48$ Å^3, $N = 6$, and the critical doping concentration for the prepared nanophosphors are estimated as 0.02. Thus, R_C of Eu^{3+} in $SrAl_{12}O_{19}$:xEu^{3+} nanophosphors is calculated ~22 Å. The energy migration of forbidden transitions with typical R_C ~5 Å is typically attributed to the exchange interaction between Eu^{3+} ions and if the R_C value is greater than 5 Å, multipole-multipole transitions are responsible for the concentration quenching mechanism [36]. Thus, the estimated R_C is 22 Å, suggesting the energy migration mechanism in $SrAl_{12}O_{19}$:xEu^{3+} is due to the electric multipole-multipole interactions.

A schematic energy level diagram of emission bands obtained in $SrAl_{12}O_{19}$:Eu^{3+} nanophosphors is displayed in Fig. 8 (b). The diagram suggests that on near-UV excitation of 397 nm wavelength, the electrons jumped from the ground state ($^7F_0$) to the higher energy $^5L_6$ state. Later, the electrons relaxed from the $^5L_6$ state to the lower energy state ($^5D_0$) level via non-radiative transition. From the $^5D_0$ state, electrons jumped to ^7F_J (J = 0,1, 2, 3, 4, 5, and 6) energy levels, providing three distinct emissions due to the $^5D_0 \rightarrow {}^7F_1$, $^5D_0 \rightarrow {}^7F_2$, and $^5D_0 \rightarrow {}^7F_4$ transitions.

The excitation spectrum (measured at 614 nm emission wavelength) and emission spectrum (measured at 397 nm excitation wavelength) for optimized $SrAl_{12}O_{19}$:2%Eu^{3+} are shown in Fig. 10. The excitation spectrum depicts that the prominent peak was observed at 397 nm, the nanophosphors as a broad excitation over a wide wavelength range, corresponding to the visible region. The prominent excitation at 397 nm is allocated to $^7F_0 \rightarrow {}^5L_6$ transitions of Eu^{3+} metal ion. We already have discussed the emission spectrum in the previous paragraph. Also, Fig. 10 confirmed that the studied nanophosphors were down-conversion phosphors, as the energy peak observed for the excitation spectrum was higher than the energy observed for the emission spectrum.

3.2.2. Ultra-violet – visible spectroscopy

Optical absorption and band edge analysis use to understand the band composition and energy difference in amorphous materials and crystalline materials. The energy difference occurs due to the emission of photons with higher energy than the material's energy band. As a result, the absorption spectra reveal the material's atomic vibration and electrical properties [38].

The absorption coefficient was determined using the equation below.

$$(\alpha h\nu)^m = h\nu - E_g \quad (3)$$

here, α, $h\nu$ and E_g represent absorption coefficient, photon energy, and bandgap energy, respectively. m represents the transition parameter, and m values are 1/2 or 3/2 for indirect forbidden transitions, and 2 or 3 values are for allowed and direct forbidden transitions [33].

The measured UV–Visible spectrum for optimized 2% molar Eu^{3+} doped $SrAl_{12}O_{19}$ nanophosphor was re-plotted as $(\alpha h\nu)^2$ against energy ($h\nu$) to estimate the band of the nanophosphors as shown in Fig. 11. The estimated optical band gap for the nanophosphor is estimated as 3.62 eV, which is estimated by extrapolating a straight line at the sharp edge of the curve and intercepts at the axis provided the band gap value [39].

3.2.3. Refractive index

The optical properties and luminescence parameters like Jud-Ofelt (JO) parameters are further investigate using refractive index (n) materials. n value of synthesized nanophosphors is estimated using Herve and Vandamme relation [40,41].

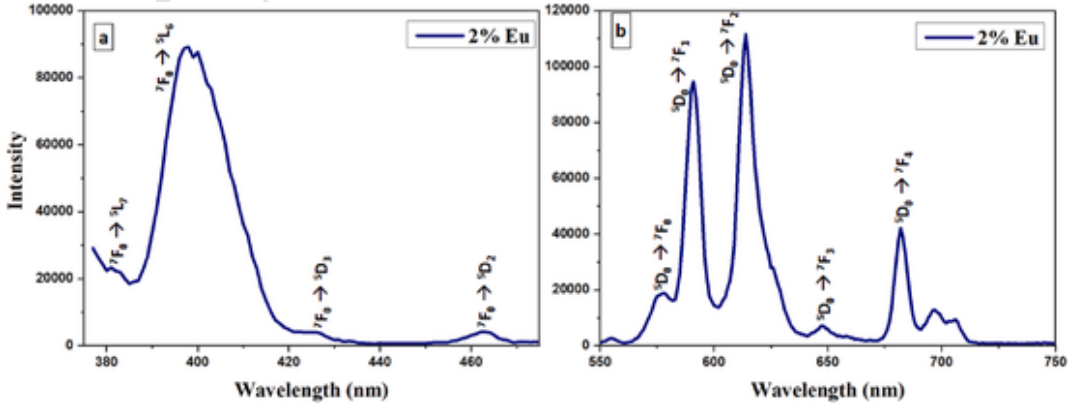


Fig. 10. Excitation and emission spectra of optimized $SrAl_{12}O_{19}$:2%Eu^{3+}nanophosphor.

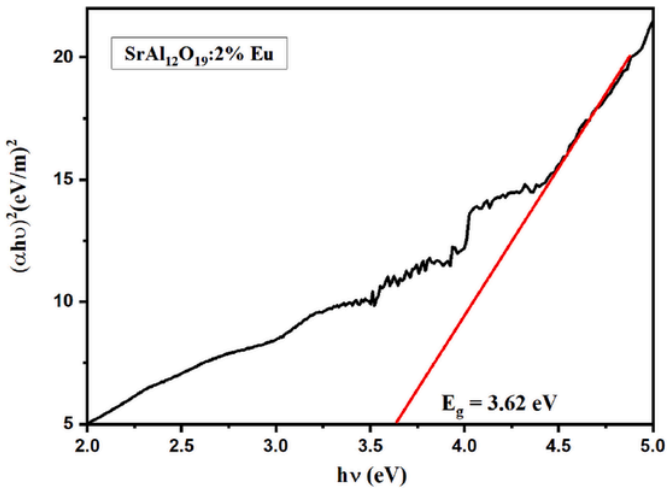


Fig. 11. UV–Vis Spectrum (Tauc Plot) of $SrAl_{12}O_{19}$:2%Eu phosphor.

$$n = \sqrt{1 + \left(\frac{A}{E_g + B}\right)^2} \tag{4}$$

here, A and B are the constants, and their values are respectively given as 13.6 and 3.4 eV. E_g represents the energy bandgap calculated from UV–Vis Spectra. The estimated refractive index for the 2% Eu^{3+} doped $SrAl_{12}O_{19}$ nanophosphor is 2.18.

3.2.4. Judd-Ofelt analysis

3.2.4.1. JO intensity parameters and asymmetric ratio. Judd-Ofelt (JO) analysis of $SrAl_{12}O_{19}$:xEu^{3+} nanophosphors helps to understand the bonding and structure of dopant-Eu^{3+} in the host matrix. The JO intensity parameters ($\Omega_{2,4,6}$) are estimated from emission spectra using JEOS application software [42]. The estimated intensity parameters provide detailed information about luminescence branching ratios, oscillator strengths, excited-state radiative lifetimes, and stimulated emission [19]. The intensity parameters are estimated for the ratio of the integrated intensities of transition $^5D_0$ – ^7F_J and $^5D_0$ – $^7F_1$, using the following equation (Eq. (5)) [42] [–] [44]:

$$\Omega_\lambda = \frac{D_{MD}\nu_1^3}{e^2\nu_\lambda^3 U^\lambda}\frac{9n^3}{n(n^2+2)^2}\frac{J_\lambda}{J_1} \tag{5}$$

where, $D_{MD} = 9.6 \times 10^{-6} Debye^2$, $J_\lambda = \int I_x(\nu)\,d\nu$, the integrated intensity of the transition and ν_x represents the barycenter of the emission transition and average wavenumber in cm^{-1} [45].

The Ω_2 intensity parameter is associated with the symmetry around the Eu^{3+} ion and it is affected by the degree of the covalence bond between Eu^{3+} and the host matrix. Further, the Ω_2 parameter relates to the short-range effects of Eu-O covalence. The Ω_4 and Ω_6 intensity parameters are related to the rigidity and viscosity of the host compound [44,46,47].

The asymmetric ratio or asymmetric factor is a vital parameter to understand symmetry. It is the ratio of the integral intensity of electrical dipole transition (EDT), i.e., $^5D_0 \rightarrow {}^7F_2$, to magnetic dipole transition (MDT), i.e., $^5D_0 \rightarrow {}^7F_1$. The asymmetric ratio quantifies the degree of distortion from the inversion symmetry of the Eu^{3+} ion's local surroundings in a matrix. It is the ratio of the integrated intensities of hypersensitive and magnetic dipole transitions [48,49]. It can be very small or large, depending upon the specific crystallographic site symmetry of Eu^{3+}. The asymmetric ratio R is estimated by the following formula [50,51]:

$$R = I_{EDT}/I_{MDT} \tag{6}$$

where I_{EDT} represents the intensity of EDT $^5D_0 \rightarrow {}^7F_2$, and I_{MDT} represents the intensity MDT $^5D_0 \rightarrow {}^7F_1$.

The calculated JO intensity parameters asymmetric values for different concentrations of Eu^{3+} are presented in Table-3. The estimated intensity parameters for $SrAl_{12}O_{19}$:x%Eu^{3+} nanophosphors show that the JO intensity parameter Ω_2 is greater than Ω_4. This implies that the Eu^{3+} and host interaction is more covalent and the existence of asymmetry around the Eu^{3+} ion site [44,46]. The obtained Ω_2 and Ω_4 are similar for all Eu^{3+} concentrations and do not observe any significant changes. In contrast to Ω_2, Ω_4 is not dependent on symmetry around the Eu^{3+} ion but the electron density on the surrounding host. For the current nanophosphors, the calculated values of Ω_4 are similar, suggesting electron density around Eu^{3+} is nearly the same for all the concentrations of Eu^{3+}.

The asymmetric ratio R is often used in determining the host material quality providing symmetry information around Eu^{3+} covalency. Usually, it is considered that the value of $R < 1.0$ is for symmetric, and > 1.0 is for asymmetric surroundings. Hence, the high asymmetric ratio indicated that the Eu^{3+} ion resides in locations with weak symmetry and no inversion center [52]. For all Eu^{3+} concentrations, the estimated values of R are greater than 1, indicating distortion in symmetry around Eu^{3+} ion in $SrAl_{12}O_{19}$. This increased in relative intensity of hypersensitive dipole transition [53].

3.2.4.2. Radiative transition, stimulated emission cross-section, radiative time-life, and branching ratio parameters. Using the intensity parameter, the radiative transition rates A_λ, which corresponds to the forced electric-dipole transitions, can be calculated as [54,55],

$$A_\lambda = \frac{64\pi^4\nu_\lambda^3}{3h}\frac{n(n^2+2)^2}{9}D_{ED}^\lambda,\ as\ D_{ED}^\lambda = e^2\Omega_\lambda U^\lambda \tag{7}$$

where, D_{ED} = dipole strength for electric dipole transition, h (Plancks constant) = 6.63×10^{-27} erg s. In Eq. (6), U^λ is abbreviation for $\left|J\left|U^\lambda\right|J\right|^2$square reduced matrix elements. The values of U^λ are independent of the chemical environment (i.e., host matrix) of dopant-Eu^{3+} ion [56]. Also, the total radiative transition probability A_λ, which is the sum of all radiative transition was used to estimate the radiative lifetime of the $^5D_0$ transition:

$$\tau = \frac{1}{\sum A_\lambda} \tag{8}$$

Further, total radiative transition probability A_λ use to estimate the branching ratio as $\beta = \frac{A_\lambda}{\sum A_\lambda}$[36]. The branching ratio provides information about the relative intensities of the emission peaks originating from an excited state. The stimulated emission cross-section is important $\sigma(\lambda_p)$ to estimate the performance at room temperature and rate of extraction from the lasing material. The $\sigma(\lambda_p)$ can be estimated as [52,57].:

$$\sigma(\lambda_p) = \frac{\lambda_p^4}{8\pi c n^2 \Delta\lambda_{eff}}A_\lambda \tag{9}$$

Table 3
The calculated J–O intensity parameters and asymmetric ratio for $SrAl_{12}O_{19}$:x%Eu^{3+}.

Concentration (mol%)	Ω_2 (x10^{-20}) (cm^{-2})	Ω_4 (x10^{-20}) (cm^{-2})	Asymmetric ratio (R)
0.5	2.825	1.2981	1.265
1.0	3.4499	1.0165	1.523
1.5	4.0473	0.9501	1.809
2.0	1.8122	1.3241	1.599
2.5	3.3781	1.1095	1.708

UNCORRECTED PROOF

where λ_p represents emission peak wavelength, and $\Delta\lambda_{eff}$ is the effective line-width found, which was obtained by considering the ratio of the area of the emission band to its maximum height.

The estimated values for different concentrations of Eu^{3+} ion of $SrAl_{12}O_{19}$:x%Eu^{3+} nanophosphors are presented in Table-4. The analysis depicts that the *A* and β were highest for the $^5D_0 \rightarrow {}^7F_2$ transition compared to other observed transitions. It was recognized that an emission level with the β value closer to 50% [58,59]. The radiative lifetime is nearly the same for all Eu^{3+} concentrations except for 0.2 mol Eu^{3+} concentrations. We observed 2.167 ms lifetime decay for 0.2 Eu^{3+} concentration suggesting a decrease in symmetry around Eu^{3+} ion which was consistent with the photoluminescence study [53,60].

Further, the trend of $\sigma(\lambda_p)$ for the $^5D_0$ emission transition were seen as $^7F_4 > {}^7F_1 > {}^7F_2$ for the synthesized nanophosphors. The maximum value of $\sigma(\lambda_p)$ is observed for the $^5D_0$-$^7F_1$ transition, and variations are uniform for all prepared Eu^{3+} concentrations. The obtained values of $\sigma(\lambda_p)$ are about one order of magnitude lower than those reported for Eu^{3+}:YAG, but $\sigma(\lambda_p)$ values are of the same order as for Eu^{3+}: $Y_4Al_2O_9$ [57,61]. The $\sigma(\lambda_p)$ values have an exciting application in low-threshold, high-gain devices [62].

3.2.5. Chromaticity analysis

The CIE chromaticity coordinates are essential characteristics in evaluating the luminous qualities of phosphors. The color coordinates are estimated from the emission spectrum using the chromaticity coordinate calculation method based on the CIE 1931 system - color calculator software [63].

The CIE chromaticity diagram of $SrAl_{12}O_{19}$:x%Eu^{3+} (x = 0.5,1.0,1.5,2.0, and 2.5) phosphors is shown in Fig. 12. The CIE chromaticity coordinates of $SrAl_{12}O_{19}$:x%Eu^{3+} phosphors (which were measured at excitation wavelength λex = 397 nm) with varying Eu^{3+} concentrations were presented in Table 5. The CIE values of $SrAl_{12}O_{19}$:Eu^{3+} red phosphor are very close to those of the commercial red-emitting phosphor Y_2O_3:Eu^{3+} (0.61, 0.39) [64,65]. Hence upon UV excitation, the $SrAl_{12}O_{19}$:Eu^{3+} phosphor exhibited bright red light, which will be used for color tuning in solid-state lighting applications.

The correlated color temperature (CCT) is usually used to identify the quality of emitted light for the glasses and can be calculated from the McCamy empirical equation [64]:

$$CCT = 437n^3 + 3601n^2 + 6861n + 5517 \quad (10)$$

where *n* is the inverse of the slope and is equal to $(x - x_e)/(y_e - y)$; the epicenter points are $x_e = 0.332$ and $y_e = 0.186$. The estimated values for different Eu^{3+} concentrations for the synthesized nanophosphors are presented in Table 5. The calculated CCT values show that these nanophosphors are can be useful for warm lighting application, as the standard CCT value for warm lighting application is smaller than 4000 K [66,67]. The highest CCT value was observed for 2% Eu^{3+} dopant concentration in $SrAl_{12}O_{19}$ nanophosphors with CCT value

Table 4
The calculated radiative emission rates, total radiative transition probability, lifetime, branching ratios, and stimulated emission cross-section for $SrAl_{12}O_{19}$:x%Eu^{3+}.

Transition		0.5%mol	1.0%mol	1.5%mol	2.0%mol	2.5%mol
$^5D_0 \rightarrow {}^7F_1$	$A\ (s^{-1})$	151.58	151.65	151.63	151.22	151.61
	β %	24.9	22.99	21.03	32.87	23.05
	$\sigma\ X10^{-22} cm^2$	5.35	8.93	7.88	1.84	6.01
$^5D_0 \rightarrow {}^7F_2$	$A\ (s^{-1})$	304.88	372.76	437.54	196.77	364.88
	β %	47.74	53.94	57.92	40.92	52.95
	$\sigma\ X10^{-22} cm^2$	1.71	4.04	4.59	1.98	2.31
$^5D_0 \rightarrow {}^7F_4$	$A\ (s^{-1})$	71.39	55.64	51.53	74.02	60.82
	β %	9.97	7.16	6.05	13.77	7.85
	$\sigma\ X10^{-22} cm^2$	3.22	3.19	3.97	1.72	2.70
Lifetime	$\tau\ (ms)$	1.639	1.515	1.386	2.167	1.504

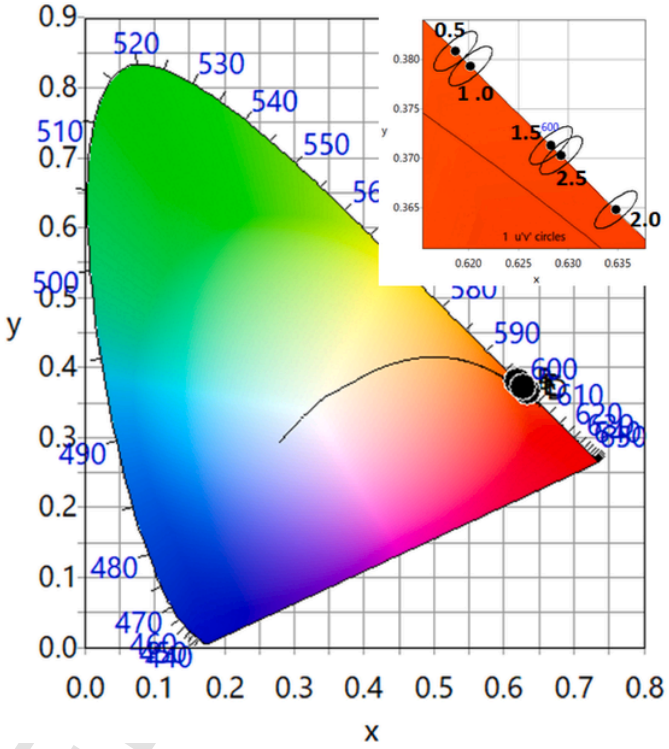


Fig. 12. CIE color chromaticity coordinate diagram for $SrAl_{12}O_{19}$:x%Eu^{3+} (x = 0.5,1.0,1.5,2.0, and 2.5).

Table 5
CIE chromaticity coordinates of the $SrAl_{12}O_{19}$:xEu^{3+} samples under 397 nm excitation.

Concentration	C_x	C_y	CCT
0.5	0.6187	0.3808	1825
1	0.6202	0.3793	1843
1.5	0.6293	0.3703	1983
2	0.6348	0.3648	2100
2.5	0.6283	0.3713	1964

2100. The chromaticity coordinate *x* and *y* were found as 0.6348 and 0.3648, respectively.

The synthesized red color nanophosphors can stand as a replacement for other available red color phosphors and with other suitable phosphors to compensate for the lack of red color if any. Therefore, $SrAl_{12}O_{19}$:x%Eu^{3+} red nanophosphors have the potential for applications in LEDs as the red phosphor.

3.3. Conclusion

A series of Eu^{3+} doped $SrAl_{12}O_{19}$nanophosphors were successfully synthesized using a urea assisted-combustion method. Later, the nanophosphors sintered at 800 °C for 4 h. The Rietveld refinement of the XRD results confirmed the polycrystalline structure of the prepared $SrAl_{12}O_{19}$ as hexagonal with a space group of P63/mmc. Further, XRD results of all dopant concentrations confirmed that the crystalline size decreased with increasing dopant concentration. The average crystalline size was found to be ~30.88–39.18 nm. FTIR analysis indicated the vibrations of metal-oxygen (M – O) groups, which form the magnetoplumbite structure phase. SEM and TEM micrographs confirmed the formation of nanophosphors within the hexagonal plates, and the crystalline grains were, on average, in the nano-size range of 35–60 nm. Further, the estimated bandgap using the absorption edge of UV–vis–NIR spectra and data processing was found to be 3.6 eV. The photoluminescence studies showed that two distinct emission peaks

UNCORRECTED

were observed at 590 and 614 nm, corresponding to the Eu^{3+} ions' $^5D_0 \rightarrow {}^7F_1$ and $^5D_0 \rightarrow {}^7F_2$ transitions, respectively. The temperature at which the $SrAl_{12}O_{19}$ nanophosphors were synthesized and the concentration of Eu^{3+} ions seemed to affect the two distinct emission peaks. A concentration quenching effect of Eu^{3+} ions in the $SrAl_{12}O_{19}$ phosphors was observed when x was larger than 2.0% mole. The emission and excitation spectra for optimized 2% Eu^{3+} showed that the formed nanophosphors were down-converting nanophosphors that fall in the red color region. From Judd-Ofelt's analysis, it observed that $\Omega_2 > \Omega_4$, which indicates high covalency in Eu^{3+} and ligands (i.e., in Eu and O). The high value of the asymmetric ratio suggested that Eu^{3+} locate at the site with distorted symmetry. The radiative transition rate and branching ratio are higher for the $^4D_0 \rightarrow {}^7F_2$ transition but the emission cross-section is maximum for the $^5D_0 \rightarrow {}^7F_1$ transition for all Eu^{3+} concentrations. The CIE-photometry analysis confirmed that the given phosphors are suitable for applications in LEDs as red phosphor, which could potentially replace industrial nanophosphors.

CRediT authorship contribution statement

Priti Chaware: Approval of the version of the manuscript to be published, Writing – original draft, Funding acquisition, Data curation, Formal analysis, and interpretation of data. **Amol Nande:** Approval of the version of the manuscript to be published, Writing – original draft, Writing – review & editing, Conceptualization, Funding acquisition, Data curation, Formal analysis, and interpretation of data. **S.J. Dhoble:** Approval of the version of the manuscript to be published, Writing – review & editing, Conceptualization, Data curation, Formal analysis, and interpretation of data. **K.G. Rewatkar:** Approval of the version of the manuscript to be published, Writing – original draft, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.optmat.2021.111542.

References

[1] B. Zhang, Q. Liu, W. Yan, Y. Chen, A. Shen, H. Zhang, Relation between structure conversion and spectra-tuning properties of Eu^{2+}-doped strontium aluminate phosphor, J. Mater. Sci. 52 (2017) 8188–8199, https://doi.org/10.1007/s10853-017-1027-4.

[2] V.B. Pawade, H.C. Swart, S.J. Dhoble, Review of rare earth activated blue emission phosphors prepared by combustion synthesis, Renew. Sustain. Energy Rev. 52 (2015) 596–612, https://doi.org/10.1016/j.rser.2015.07.170.

[3] M.K. Jang, E.D. Kim, Y.D. Huh, Photoluminescence properties of tunable emission $(Sr_{1-x}Eu_x)_2Ga_2S_5$ phosphors, Optik 226 (2021) 165930, https://doi.org/10.1016/j.ijleo.2020.165930.

[4] S. Singh, V. Tanwar, A.P. Simantilleke, H. Kumar, D. Singh, Synthesis and photoluminescence behavior of of $SrMg_2Al_{16}O_{27}$:Eu^{2+} nanocrystalline phosphor, Optik 225 (2021), https://doi.org/10.1016/j.ijleo.2020.165873.

[5] M.V.D.S. Rezende, J.B. Amaral, M.E.G. Valerio, R.A. Jackson, Optical properties of Pr and Eu-doped $SrAl_{12}O_{19}$: a theoretical study, Opt. Mater. 48 (2015) 105–109, https://doi.org/10.1016/j.optmat.2015.07.032.

[6] D. Dutczak, T. Jüstel, C. Ronda, A. Meijerink, Eu^{2+} luminescence in strontium aluminates, Phys. Chem. Chem. Phys. 17 (2015) 15236–15249, https://doi.org/10.1039/c5cp01095k.

[7] M. Capron, A. Douy, Strontium dialuminate $SrAl_4O_7$: synthesis and stability, J. Am. Ceram. Soc. 85 (2002) 3036–3040, https://doi.org/10.1111/j.1151-2916.2002.tb00575.x.

[8] Y. Tian, P. Zhang, Z. Zheng, Y. Chai, A novel approach for preparation of $Sr_3Al_2O_6$:Eu^{2+}, Dy^{3+} nanoparticles by sol-gel-microwave processing, Mater. Lett. 73 (2012) 157–160, https://doi.org/10.1016/j.matlet.2011.12.100.

[9] A.H. Wako, F.B. Dejene, H.C. Swart, Structural and luminescence properties of $SrAl_2O_4$:Eu^{2+},Dy^{3+},Nd^{3+} phosphor thin films grown by pulsed laser deposition, Phys. B Condens. Matter 480 (2016) 116–124, https://doi.org/10.1016/j.physb.2015.09.049.

[10] C.Y. Lin, S.H. Yang, J.L. Lin, C.F. Yang, Effects of the concentration of Eu^{3+} ions and synthesizing temperature on the luminescence properties of $Sr_{2-x}Eu_xZnMoO_6$ phosphors, Appl. Sci. 7 (2017), https://doi.org/10.3390/app7010030.

[11] M. Misevicius, V. Balevicius, Solid-state synthesis of $SrAl_4O_7$ and luminescence of Eu^{3+}-doped samples, Mater. Chem. Phys. 249 (2020) 122998, https://doi.org/10.1016/j.matchemphys.2020.122998.

[12] K.-Y. Yeh, C.-C. Yang, W.-R. Liu, M.G. Brik, Novel blue-emitting phosphors - $BaBeSiO_4$:Eu^{2+}: luminescence properties and its application for UV-light emitting diodes, Opt. Mater. Express 6 (2016), https://doi.org/10.1364/OME.6.000416.

[13] H. Ali, A.E. Giba, M.A. Khedr, Influence of calcination temperature on the photoluminescence spectral response of Sm-doped YAG nanocrystals as red-emitting phosphor, Optik 218 (2020), https://doi.org/10.1016/j.ijleo.2020.165106.

[14] K. Dev, A. Selot, G.B. Nair, V.L. Barai, N. Singh, F.Z. Haque, M. Aynyas, S.J. Dhoble, Study of luminescence properties of dysprosium-doped $CaAl_{12}O_{19}$ phosphor for white light-emitting diodes, Luminescence 34 (2019) 804–811, https://doi.org/10.1002/bio.3675.

[15] K. Mori, H. Onoda, T. Toyama, N. Osaka, Y. Kojima, Synthesis and fluorescence studies of Eu^{3+}-doped $SrAl_{12}O_{19}$ phosphor, Optik 180 (2019) 183–188, https://doi.org/10.1016/j.ijleo.2018.11.047.

[16] V. Singh, G. Sivaramaiah, N. Singh, J.L. Rao, P.K. Singh, M.S. Pathak, D.A. Hakeem, EPR and PL studies on UVB-emitting gadolinium-doped $SrAl_{12}O_{19}$ phosphors, Optik 158 (2018) 1227–1233, https://doi.org/10.1016/j.ijleo.2017.12.185.

[17] L. Wang, Y. Xu, D. Wang, R. Zhou, N. Ding, M. Shi, Y. Chen, Y. Jiang, Y. Wang, Deep red phosphors $SrAl_{12}O_{19}$:Mn^{4+},M (M = Li^+, Na^+, K^+, Mg^{2+}) for high colour rendering white LEDs, Phys. Status Solidi Appl. Mater. Sci. 210 (2013) 1433–1437, https://doi.org/10.1002/pssa.201228815.

[18] B.R. Judd, Optical absorption intensities of rare-earth ions, Phys. Rev. 127 (1962) 750–761, https://doi.org/10.1103/PhysRev.127.750.

[19] G.S. Ofelt, Intensities of crystal spectra of rare-earth ions, J. Chem. Phys. 37 (1962) 511–520, https://doi.org/10.1063/1.1701366.

[20] B.F. Dos Santos, M.V. Dos Santos Rezende, P.J.R. Montes, R.M. Araujo, M.A.C. Dos Santos, M.E.G. Valerio, Spectroscopy study of $SrAl_2O_4$:Eu^{3+}, J. Lumin. 132 (2012) 1015–1020, https://doi.org/10.1016/j.jlumin.2011.09.008.

[21] V. Singh, M. Seshadri, M. Radha, N. Singh, S.H. Nandyala, Intense infrared, visible up and down emissions in Er^{3+}/Yb^{3+} co-doped $SrAl_{12}O_{19}$ obtained by urea assisted combustion route, J. Mater. Sci. Mater. Electron. 29 (2018) 16516–16522, https://doi.org/10.1007/s10854-018-9745-1.

[22] A. Jain, S.P. Ong, G. Hautier, W. Chen, W.D. Richards, S. Dacek, S. Cholia, D. Gunter, D. Skinner, G. Ceder, K.A. Persson, Commentary: the materials project: a materials genome approach to accelerating materials innovation, Apl. Mater. 1 (2013), https://doi.org/10.1063/1.4812323.

[23] J. Park, A.N. Cormack, Crystal defect chemistry of strontium hexaaluminate magnetoplumbite, Mater. Sci. Technol. 11 (2000) 176–181.

[24] T.R. Wagner, T.J. Styranec, Preparation and crystal structure analysis of $Ba_2BiGa_{11}O_{20}$, J. Solid State Chem. 138 (1998) 313–320, https://doi.org/10.1006/jssc.1998.7790.

[25] I.A. Auwal, S. Güner, H. Güngüneş, A. Baykal, $Sr_{1-x}La_xFe_{12}O_{19}$ ($0.0 \leq x \leq 0.5$) hexaferrites: synthesis, characterizations, hyperfine interactions and magneto-optical properties, Ceram. Int. 42 (2016) 12995–13003, https://doi.org/10.1016/j.ceramint.2016.05.074.

[26] J.H. You, S.I. Yoo, Magnetic properties of Zn-substituted Y-type hexaferrites, $Ba_2Zn_xFe_{2-x}Fe_{12}O_{22}$, J. Magn. Magn Mater. 471 (2019) 255–261, https://doi.org/10.1016/j.jmmm.2018.09.064.

[27] N.R. Panchal, R.B. Jotania, Physical properties of strontium hexaferrite nano magnetic particles synthesized by a sol-gel auto-combustion process in presence of non ionic surfactant, Nanosci. Nanotechnol. Lett. 4 (2012) 623–627, https://doi.org/10.1166/nnl.2012.1361.

[28] S.N. Kamde, A.K. Nandanwar, P.G. Agone, K.G. Rewatkar, Effect of Cr^{3+} doped on structural, magnetic and electrical properties of sol-gel synthesized $SrFe_{12}O_{19}$ hexaferrite nanoparticles, Integrated Ferroelectrics Int. J. 203 (2019) 150–155, https://doi.org/10.1080/10584587.2019.1674959.

[29] K. Dev, A. Selot, G.B. Nair, C.M. Mehare, F.Z. Haque, M. Aynyas, S.J. Dhoble, Synthesis and photoluminescence study of Dy^{3+} activated $SrAl_{12}O_{19}$ phosphor, Optik 194 (2019) 1–10, https://doi.org/10.1016/j.ijleo.2019.163051.

[30] V.B. Pawade, S.J. Dhoble, Novel blue-emitting $SrMg_2Al_{16}O_{27}$:Eu^{2+} phosphor for solid-state lighting, Luminescence 26 (2011) 722–727, https://doi.org/10.1002/bio.1304.

[31] C.H. Lu, W.T. Hsu, J. Dhanaraj, R. Jagannathan, Sol-gel pyrolysis and photoluminescent characteristics of europium-ion doped yttrium aluminum garnet nanophosphors, J. Eur. Ceram. Soc. 24 (2004) 3723–3729, https://doi.org/10.1016/j.jeurceramsoc.2003.12.009.

[32] Y.H. Zhou, J. Lin, S.B. Wang, H.J. Zhang, Preparation of $Y_3Al_5O_{12}$:Eu phosphors by citric-gel method and their luminescent properties, Opt. Mater. 20 (2002) 13–20, https://doi.org/10.1016/S0925-3467(02)00020-4.

[33] P. Kaur, A. Khanna, M. Fábián, Effects of annealing temperature on structural and photoluminescence properties of Eu, Dy and Sm doped $CaWO_4$ nanoparticles, Ceram. Int. 46 (2020) 27262–27274, https://doi.org/10.1016/j.ceramint.2020.07.211.

[34] R.S. Yadav, R.K. Verma, A. Bahadur, S.B. Rai, Structural characterizations and intense green upconversion emission in Yb^{3+}, Pr^{3+}co-doped Y_2O_3 nano-phosphor, Spectrochim. Acta Part A Mol. Biomol. Spectrosc. 137 (2015) 357–362, https://doi.org/10.1016/j.saa.2014.08.078.

[35] D.L. Dexter, J.H. Schulman, Theory of concentration quenching in inorganic phosphors, J. Chem. Phys. 22 (1954) 1063–1070, https://doi.org/10.1063/1.1740265.

UNCORRECTED PROOF

[36] Y. Zhang, J. Xu, B.B. Yang, Q. Cui, T. Tian, Luminescence properties and energy migration mechanism of Eu^{3+} activated $Bi_4Si_3O_{12}$ as a potential phosphor for white LEDs, Mater. Res. Express 5 (2018) 207–211, https://doi.org/10.1088/2053-1591/aaab8a.
[37] G. Blasse, Energy transfer in oxidic phosphors, Phys. Lett. 28 (1968) 444–445, https://doi.org/10.1016/0375-9601(68)90486-6.
[38] J. Tauc, Optical properties of amorphous semiconductors, in: J. Tauc (Ed.), Amorph. Liq. Semicond., Springer US, Boston, MA, 1974, pp. 159–220, https://doi.org/10.1007/978-1-4615-8705-7_4.
[39] H.K. Obayes, R. Hussin, H. Wagiran, M.A. Saeed, Strontium ion concentration effects on structural and spectral properties of $Li_4Sr(BO_3)_3$ glass, J. Non-Cryst. Solids 427 (2015) 83–90, https://doi.org/10.1016/j.jnoncrysol.2015.07.026.
[40] P. Hervé, L.K.J. Vandamme, General relation between refractive index and energy gap in semiconductors, Infrared Phys. Technol. 35 (1994) 609–615, https://doi.org/10.1016/1350-4495(94)90026-4.
[41] M.M.S. Sanad, M.M. Rashad, Tuning the structural, optical, photoluminescence and dielectric properties of Eu^{2+}-activated mixed strontium aluminate phosphors with different rare earth co-activators, J. Mater. Sci. Mater. Electron. 27 (2016) 9034–9043, https://doi.org/10.1007/s10854-016-4936-0.
[42] A. Ćirić, S. Stojadinović, M. Sekulić, M.D. Dramićanin, JOES: an application software for Judd-Ofelt analysis from Eu^{3+} emission spectra, J. Lumin. 205 (2019) 351–356, https://doi.org/10.1016/j.jlumin.2018.09.048.
[43] K. Binnemans, Interpretation of europium(III) spectra, Coord. Chem. Rev. 295 (2015) 1–45, https://doi.org/10.1016/j.ccr.2015.02.015.
[44] Ž. Antić, R. Krsmanović, V. Dorević, T. Dramićanin, M.D. Dramićanin, Optical properties of Y_2O_3:Eu^{3+} red emitting phosphor obtained via spray pyrolysis, Acta Phys. Pol., A (2009) 622–624, https://doi.org/10.12693/APhysPolA.116.622.
[45] Y. Zhang, J. Xu, B.B. Yang, Q. Cui, T. Tian, Luminescence properties and energy migration mechanism of Eu^{3+} activated $Bi_4Si_3O_{12}$ as a potential phosphor for white LEDs, Mater. Res. Express 5 (2018) 26202, https://doi.org/10.1088/2053-1591/aaab8a.
[46] M. Kumar, T.K. Seshagiri, S.V. Godbole, Fluorescence lifetime and Judd-Ofelt parameters of Eu^{3+} doped $SrBPO_5$, Phys. B Condens. Matter 410 (2013) 141–146, https://doi.org/10.1016/j.physb.2012.10.040.
[47] K. Vuković, S. Ćulubrk, M. Sekulić, M.D. Dramićanin, Analysis of luminescence of Eu^{3+} doped $Lu_2Ti_2O_7$ powders with Judd-Ofelt theory, J. Res. Phys. 38–39 (2016) 23–32, https://doi.org/10.1515/jrp-2015-0003.
[48] P.A. Tanner, Some misconceptions concerning the electronic spectra of tri-positive europium and cerium, Chem. Soc. Rev. 42 (2013), https://doi.org/10.1039/c3cs60033e.
[49] H.Q. Liu, L.L. Wang, S.G. Chen, B.S. Zou, Optical properties of nanocrystal and bulk ZrO_2: Eu^{3+}, J. Alloys Compd. 448 (2008) 336–339, https://doi.org/10.1016/j.jallcom.2006.11.171.
[50] S.Y. Zheng, J.W. Chiou, Y.H. Li, Correlation among photoluminescence and the electronic and atomic structures of Sr_2SiO_4:xEu^{3+} phosphors: X-ray absorption and emission studies, Sci. Rep. 10 (2020) 1–12, https://doi.org/10.1038/s41598-020-69428-7.
[51] I.E. Kolesnikov, A.V. Povolotskiy, D.V. Mamonova, Asymmetry ratio as a parameter of Eu^{3+} local environment in phosphors, J. Rare Earths 36 (2018) 474–481, https://doi.org/10.1016/j.jre.2017.11.008.
[52] W.F. Krupke, Optical absorption and fluorescence intensities in several rare-earth-doped Y_2O_3 and LaF_3 single crystals, Phys. Rev. 145 (1966) 325–337, https://doi.org/10.1103/PhysRev.145.325.
[53] R. Saraf, C. Shivakumara, S. Behera, H. Nagabhushana, N. Dhananjaya, Photoluminescence, photocatalysis and Judd-Ofelt analysis of Eu^{3+}-activated layered BiOCl phosphors, RSC Adv. 5 (2015) 4109–4120, https://doi.org/10.1039/c4ra10163d.
[54] S.S. Babu, P. Babu, C.K. Jayasankar, W. Sievers, T. Tröster, G. Wortmann, Optical absorption and photoluminescence studies of Eu^{3+}-doped phosphate and fluorophosphate glasses, J. Lumin. 126 (2007) 109–120, https://doi.org/10.1016/j.jlumin.2006.05.010.
[55] D.K. Singh, J. Manam, Structural and photoluminescence studies of red emitting $CaTiO_3$:Eu^{3+} perovskite nanophosphors for lighting applications, J. Mater. Sci. Mater. Electron. 27 (2016) 10371–10381, https://doi.org/10.1007/s10854-016-5123-z.
[56] W.T. Carnall, G.L. Goodman, K. Rajnak, R.S. Rana, A systematic analysis of the spectra of the lanthanides doped into single crystal LaF_3, J. Chem. Phys. 90 (1989) 3443–3457, https://doi.org/10.1063/1.455853.
[57] M. Kaczkan, S. Turczyński, M. Malinowski, Spectroscopic properties and Judd–Ofelt analysis of Eu^{3+} in $Y_4Al_2O_9$ crystals, J. Lumin. 196 (2018) 111–115, https://doi.org/10.1016/j.jlumin.2017.12.027.
[58] B. Han, B. Liu, J. Zhang, P. Li, H. Shi, Comparative photoluminescence properties and judd–Ofelt analysis of Eu^{3+} ion-activated metal molybdate phosphors A_2MoO_6:Eu^{3+} (A = La, Y, Gd and Bi), J. Electron. Mater. 46 (2017) 4039–4046, https://doi.org/10.1007/s11664-017-5390-3.
[59] J. Adam, W.A. Sibley, Optical transition of Pr3 + ions in Flurozirconate glass, J. Non-Cryst. Solids 76 (1985) 267–279, https://doi.org/10.1016/0022-3093(85)90004-3.
[60] C.R. Kesavulu, K.K. Kumar, N. Vijaya, K.S. Lim, C.K. Jayasankar, Thermal, vibrational and optical properties of Eu^{3+}-doped lead fluorophosphate glasses for red laser applications, Mater. Chem. Phys. 141 (2013) 903–911, https://doi.org/10.1016/j.matchemphys.2013.06.021.
[61] A. Yousif, S. Som, V. Kumar, H.C. Swart, Comparison and analysis of Eu^{3+} luminescence in $Y_3Al_5O_{12}$ and $Y_3Ga_5O_{12}$ hosts material for red lighting phosphor, Mater. Chem. Phys. 166 (2015) 167–175, https://doi.org/10.1016/j.matchemphys.2015.09.042.
[62] M. Ferhi, C. Bouzidi, K. Horchani-Naifer, H. Elhouichet, M. Ferid, Judd-Ofelt analysis of spectroscopic properties of Eu^{3+} doped $KLa(PO_3)_4$, J. Lumin. 157 (2015) 21–27, https://doi.org/10.1016/j.jlumin.2014.08.017.
[63] O.S.R.A.M. Sylvania L.E.D. ColorCalculator https://www.osram.us/cb/tools-and-resources/applications/led-colorcalculator/index.jsp 2019
[64] C.S. McCamy, Correlated color temperature as an explicit function of chromaticity coordinates, Color Res. Appl. 17 (1992) 142–144, https://doi.org/10.1002/col.5080170211.
[65] X. Huang, Q. Sun, B. Devakumar, Preparation, crystal structure, and photoluminescence properties of high-brightness red-emitting Ca_2LuNbO_6:Eu^{3+} double-perovskite phosphors for high-CRI warm-white LEDs, J. Lumin. 225 (2020) 117373, https://doi.org/10.1016/j.jlumin.2020.117373.
[66] I. Ahemen, D.K. De, F.B. Dejene, B. Viana, White light tunable emissions from ZnS:Eu^{3+} nanophosphors over 330-465nm excitation range for white LED applications, Mater. Res. Express 3 (2016), https://doi.org/10.1088/2053-1591/3/4/045016.
[67] N.A. Matrose, K. Obikese, Z.A. Belay, O.J. Caleb, Spectral investigations of less explored rod-shaped green emitting Ba_2SiO_4:Tb^{3+} phosphors for LED and Photovoltaic applications, Sci. Total Environ. (2019) 135907, https://doi.org/10.1016/j.scitotenv.2019.135907.

UNCORRECTED PROOF

RAINBOW

Multidisciplinary Peer Reviewed Annual Journal

Shri Nagpur Gujarati Mandal's

Scanned with OKEN Scanner

INDEX

22.	महात्मा फुले आणि स्त्री मुक्ती	प्रा. विद्या चोरपगार	128
23.	कवी नारायण सुर्वे यांची कविता	डॉ. राखी मंगेश जाधव	135
24.	ग्रामीण कविता एक वास्तव	डॉ. विजया जि. राऊत	139
25.	ग्रंथालयातील तंत्रज्ञानयुक्त मानव संसाधन	डॉ. रंजना व्यवहारे	148
26.	Impact of Rural Conditions on Girls' Education	Dr. Sandhya Wankhede	153
27.	Citation Analysis of Doctoral Thesis During 1984 To 2008 Submitted To R.T.M. Nagpur University In The Subject Of Marathi Literature: A Study	Dr. Murlidhar S. Hedau	157
28.	Ya Devi Sarva Bhuteshu Sparsharupena Samsthita – Kolkata Durga Puja and The Intangibility Of Heritage	Dr. Supantha Bhattacharyya	163
29.	Different Art To Sustain The Culture Of The Nation	Nirbhay Kumar Trigun	170
30.	प्रेम और प्रकृति : एक चिंतन	डॉ. प्रियंका दुबे पंडित	176
31.	वैज्ञानिक एवं तकनिकी शब्दावली:निर्माण हिन्दी और तेलुगु के विशेष सन्दर्भ में	डॉ. सूर्य कुमारी.पी.	182
32.	कंप्यूटर के विकास सापेक्ष मशीनी अनुवाद में अनेकार्थकता की समस्या	डॉ.राम प्रकाश यादव	188

Gujrati .....

33.	વિદ્યા Knowledge Vs Wisdom બુદ્ધિ	શ્રીમતી વોલ્ગાબેન સંજયભાઈ ઠાકર	194
34.	પદ્યવાર્તાકાર શામળ	પ્રા.ઈલા વૃજલાલ શુક્લ	197
35.	દ્યાવા-પૃથ્વીના કવિ ઉશનસ	ડૉ. અસ્મિતા પાણિક	201
36.	મહાત્મા ગાંધી ના મતે ભારત માં શિક્ષણ વ્યવસ્થા	ડૉ. ભાવેશ ચંદ્રકાન્ત ભૂપતાણી	204

Science .....

37.	Synthesis of Benzimidazole Schiff's Bases Catalysed by Nickel Nanoparticles	Dr. Jay A. Tanna Dr. R. B. Patil	209

Scanned with OKEN Scanner

ISSN 2394-6903

महात्मा फुले आणि स्त्री मुक्ती

प्रा. विद्या चोरपगार
सहायक प्राध्यापक
राज्यशास्त्र विभाग
डॉ. आंबेडकर कॉलेज दिक्षाभूमी, नागपूर

सारांश:–

स्त्री मुक्तीचे आद्य पुरस्कर्ते महात्मा जोतीराव फुले एक कृतीशील विचारवंत होते. धर्मव्यवस्था, विशमता, जातीयता, अस्पृश्यता आणि चातुर्वर्ण्य यासारख्या व्यवस्थांच्या विरोधात उभे राहणारे जोतीराव पहिले व्यक्ती आहेत. समताधिष्ठित समाजाच्या निर्मितीसाठी जोतीराव फुल्यांनी अनेक चळवळी व आंदोलने उभी केली. मानवमुक्ती आणि स्त्रीमुक्तीचे कार्य याच आंदोलनाचा मुख्य घटक होय. अमानवीय ब्राम्हणी पितृसत्तेच्या तावडीतून स्त्रियांच्या मुक्तीसाठी त्यांनी मोठ्या प्रमाणावर कार्य केले. या पार्श्वभूमीवर जोतीराव फुल्यांच्या स्त्रीविशयक विचारांची प्रासंगिकता वर्तमान स्थितीत समजून घेणे गरजेचे आहे.

कि वर्डस (मुख्य संकल्पना)–

वर्णव्यवस्था, जातीव्यवस्था, गुलामगिरी, शोशण, स्त्री शिक्षण, सामाजिक न्याय, मानवी हक्क, प्रथा, परंपरा.

प्रस्तावना:–

सामाजिक न्याय आणि मानवी हक्क दृश्टिकोनाची बीजे फुल्यांच्या समग्र विचारात होती. महात्मा फुल्यांच्या पुर्वी, ब्राम्हो समाज, आर्य समाज, प्रार्थना समाज, परमहंस सभा इत्यादी अनेक अशा संस्थाच्या माध्यमातून समाज सुधारणेचे कार्य सुरू होते. परंतु हे कार्य दलित, अस्पृश्य आणि स्त्री सुधारणांसाठी तितके उपयुक्त ठरले नाही. 1873 मध्ये त्यांनी अंधश्रद्धा, शोशण पुजारी वर्ग आणि भारतीय समाजातील इतर सनातनी वर्गाच्या अत्याचारांपासून बहिश्कृत समाजासाठी, दबलेल्या लोकांच्या मुक्तीसाठी मानवी हक्कांचे संरक्षण करण्याच्या उद्देशाने सत्यशोधक समाजाची स्थापना केली. महात्मा फुल्यांनी 'सत्यशोधक समाज' या चळवळीतून स्त्री शुद्रातीशुद्रांना आणि बहुजन समाजाला समाज सुधारणेचे आव्हान केले. 'या समाजाद्वारे त्यांनी स्त्री शुद्रा–अतिशूद्रांचा शिक्षण–प्रसार, विधवा विवाह, विशमता निर्मुलन आदी कार्याची मुहूर्तमेढ रोवली'.' (लांजेवार, 2016)स्त्रिया आणि कनिश्ठ जाती हे भारतीय समाजातील वंचित आणि बहिश्कृत गट आहेत आणि त्यांच्या मुक्तीसाठी शिक्षण हे सर्वात मुलभूत साधन आहे.त्यामूळे, सर्वाना मोफत आणि सक्तीच्या

Scanned with OKEN Scanner

शिक्षणासाठी महात्मा फुल्यांनी हयातभर कश्ट घेतले. आपल्याच समाजातील उच्चवर्णीय समाजाने शूद्रातिशुद्राला सामाजिक आणि मानसिक गुलामीत ठेवले, ती गुलामी राजकीय गुलामीपेक्षा अधिक पटीने जाचक आहे, हे महात्मा फुल्यांनी ओळखले होते. त्यामुळे जोतीराव फुले राजकीय स्वातंत्र्याच्या पूर्वी सामाजिक स्वातंत्र्याचा आग्रह धरतात. सामाजिक विशमता हा केवळ आर्थिक विशमतेचा परिणाम नव्हताआणि केवळ आर्थिक समानतेच्या उपायांनी सामाजिक विशमतेचे उच्चाटन होणे शक्य नव्हते. त्यासाठी संस्कृतीचे नवे अनुबंधच निर्माण करणे जोतिरावांना आवश्यक वाटत होते'.[2](मोळे,2003). हे अनुबंध त्यांनी सतत निर्माण करण्याचा प्रयत्न केला.

जोतिरावांच्या विचारांनूसार 19 व्या शतकात सावित्रीबाईसारख्या स्त्रीने आपले परम कर्तव्य म्हणून स्त्रीशिक्षणाच्या कार्यात जीवन वाहून घेतले. सावित्रीबाईच्या कार्याने प्रेरित होऊन अनेक महिला त्यांना भेटायला येत होत्या, त्यात आनंदीबाई जोशी, रमाबाई रानडे, ताराबाई शिंदे यांचे नाव अग्रक्रमाने घ्यावे लागेल. या सर्व स्त्रिया त्या काळातील इतिहासाच्या पानांवरील महान कार्याशी परिचीत आहेत. यथास्थितीवादयांसमोरील आव्हानांना, म. फुल्यांनी वैचारिक पद्धतीने विरोध केला, आणि त्यांचे मुक्ती अभियान चालू ठेवले व आधुनिक भारताच्या निर्मितीचा मार्ग मोकळा केला.

आज 21 व्या शतकातही स्त्रीविशयक भेदभाव प्रकर्शाने दिसत आहे. स्त्री–पुरूश असमानतेतुन समाजात विशम वितरण व्यवस्था उभी होताना दिसते. वर्तमानात लाखो स्त्रिया प्रगतीपथावर दिसत असल्या तरी खाजगी आणि सार्वजनिक स्तरावरील त्यांचे संघर्श संपले. असे पूर्णपणे म्हणता येणार नाही. या विशम वितरण व्यवस्थेत आदिवासी, दलित, शेतकरी, मागास, कश्टकरी स्त्रिया अजूनही परिघावरील जीवन जगत आहेत. आज स्त्रिया शिक्षण घेत आहेत आणि समाजाच्या सर्व क्षेत्रात योगदान देताना दिसतात. निर्भय आणि स्वावलंबी होताना दिसत असल्या तरीही काही क्षेत्र अशी आहेत, की जिथे महिला फारशा दिसत नाहीत. शिक्षण, राजकारण, उद्योग, व्यवसाय, कला, साहित्य, विज्ञान, तंत्रज्ञान अशा सर्व ठिकाणी याशिवाय, इतर अनेक ठिकाणी स्त्रीयांचा अल्प सहभाग दिसून येतो. स्त्रीयांवर होतअसलेले अन्याय, अत्याचार, जातीय हिंसाचार, सध्या वेगाने वाढत आहे. युनायटेड नेशन्स ऑर्गनायझेशन, ग्लोवल जेंडर गॅप रिपोर्ट 2020 नुकताच आला आहे. या अहवालानूसार, समाजातील काही क्षेत्रांमध्ये समानतेसाठी किमान 99.5 वर्शे शिल्लक आहेत, याचा अर्थ जोतिराव फुले यांच्या विचारांवर आधारित आदर्श समाज निर्माण करण्यासाठी दीर्घ कालावधी आहे. याअर्थी समानतेच्या मार्गाला पोहचण्यासाठी महात्मा फुलेंच्या विचारांची आजही गरज आहे. या पार्श्वभुमीवर प्रस्तुत शोध निबंध अभ्यासण्याचा हेतु आहे. प्रस्तुत शोध निबंध तीन भागात विभाजित आहे. यापैकी पहिल्या भागात जोतीराव फुल्यांच्या शैक्षणिक कार्याचा आढावा घेण्यात येईल. दुसऱ्या भागात सामाजिक कार्यावर विवेचन केले जाईल. तिसऱ्या भागात निश्कर्श नोंदविण्यात येतील.

महात्मा फुले आणि स्त्री शिक्षण :

जोतिराव फुले हे भारतातील स्त्री शिक्षणाचे पुरस्कर्ते होते. शिक्षणाचा मुख्य हेतु आणिमहत्व तत्कालीन समाजात फुल्यांना जितका समजला तितका अन्य कुणाला फारसा समजला नव्हता. आणि

Scanned with OKEN Scanner

समजला असला तरी स्त्रीयांना शिक्षण दिले तर धर्म बुडेल आणि पुरूशी वर्चस्व कमी होईल, या भितीने स्त्री शिक्षणाकडे दुर्लक्ष करण्यात येत होते. स्त्री शिकली तर कुमार्गाला लागेल, जात, धर्म सारे बुडेल असे शास्त्रोक्त पुरावे देत धर्मभिमानी पंडितांनी सांगायला सुरवात केली होती. परंतु फुल्यांनी त्यांच्या बोलण्याकडे लक्ष दिले नाही. 'अठराव्या शतकात जोतिराव फुले आणि सावित्रीबाई यांनी स्त्रीची दुर्बलता घालवण्याचा प्रयत्न केला. स्त्रीला शिक्षण द्यायला सुरूवात केली. इथून स्त्रीच्या सजगतेची, जागृतीची, सबलतेची सुरूवात झाली.'[3](कांबळे,2020).

1848 मध्ये पत्नी सावित्रीबाई यांच्यासोबत त्यांनी भिडेवाडा, पुणे येथे मुलींसाठी पहिली शाळा सुरु केली. त्यानंतर एका मागोमाग 18 शाळांची निर्मिती करून फुल्यांनी शिक्षण कार्याला गतिमान करण्याचा प्रयत्न केला. घरची आर्थिक स्थिती बेताचीच असताना शाळा चालविणे अत्यंत आव्हानात्मक होते. परंतु म. फुल्यांनी हे आव्हान स्वीकारले. अत्यंत परिश्रमाने सुरू केलेल्या शाळा कोणत्याही परिस्थितीत बंद पडू नये, म्हणून बिटिश सरकारपुढे म. फुले शाळेच्या अनुदानासाठी सतत मागणी करीत असत. 'शिक्षण हे समाजसुधारणेचे मुळ आहे. सत्याचे दर्शन घडविणारे ते महान साधन आहे. अशी फुल्यांची धारणा होती.म्हणूनच ते सार्वत्रिक व सक्तीच्या शिक्षणाचे भोक्ते होते. त्याकाळी शिक्षणविशयक झिरपण्याच्या सिद्धांताला त्यांनी जो कडाडून विरोध केला त्याचे मुळ त्यांच्या सामाजिक मनाच्या बैठकीत आहे.कारण या सिद्धांताने प्रथम वरच्या समाजात शिक्षण जावे व नंतर ते झिरपत झिरपत खालच्या थरापर्यत जाईल अशी कल्पना होती. जातीबद्दल समाजव्यवस्थेत हे कसं शक्य होतं? त्यामुळे फुल्यांनी समाजव्यवस्थेचा हवाला देऊन शिक्षण वरून खाली झिरपत जाणे केवळ अशक्य आहे, शिक्षणप्रसार व्हायचाच असेल तर तो खालून वर झाला पाहिजे असे निर्भयपणे सांगितले'. '(पानतावणे, 2002)हा क्रांतीकारक विचार फुल्यांचा होता. अज्ञानामुळे स्त्रिया आणि शूद्रांचे जीवन कसे विखुरले गेले, ते कोणत्या विशमतेतून जात आहेत, या परिस्थितीचा त्यांनी खोलवर विचार केला होता. अशा अन्यायकारक असमानतेशी लढण्यासाठी शिक्षण हा एकमेव मार्ग आहे, असे त्यांना नेहमी वाटे. 'महात्मा जोतीबा फुले यांनी महारमांगाच्या मुलींसाठी शाळा काढली आणि अस्पृश्य मुलींना शिक्षणाची वाट मोकळी झाली. पारंपारिक रूढी आणि धर्मशास्त्राच्या प्रामाण्याविरूद्ध उभारलेले हे प्रभावी शस्त्र होते. अस्पृश्य स्त्रीच्या भवितव्याची ती नांदी होती. जेथे शूद्रांना ज्ञानी होण्याचा अधिकार नाही असे सांगण्यात आले होते तेथे, अस्पृश्य स्त्रीला अक्षर ओळख आणि नंतर विचारप्रवृत करण्याचा हा पवित्रा होता.'[5](पानतावणे, 2002)

अज्ञानामुळे शुद्रातीशुद्र वर्ग आणि स्त्रीशुद्र तथाकथित उच्चवर्णीयांच्या नीतीला समजू शकत नव्हते. धर्मग्रंथांमध्ये स्त्रियांसाठी असलेले अनेक अमानवीय व जाचक असे तत्वज्ञान हा समाज अज्ञानामुळे ओळखू शकत नव्हता. स्त्रीयां त्यांची गुलामी, शोशण आणि हिंसाचार, याबाबत अनभिज्ञ होत्या हे फुल्यांनी सुद्धा मान्य केले होते. म. फुल्यांनी शोशणाच्या सगळया व्यवस्था संपविण्यासाठी स्त्रीयांना शिक्षण हे साधन समजून, ते शिक्षण समाजातील सर्वच जाती वर्गासाठी समान असले पाहिजे. असे वेळोवेळी समाजाच्या निर्देशनास आणून दिले. इतकेच नाही तर ताराबाई शिंदे, मुक्ता साळवे, पंडिता रमाबाई यांनी जातीविरोधात केलेल्या विद्रोहाला पाठींबा देणारे म. फुले तत्कालीन एकमेव

Scanned with OKEN Scanner

समाज सुधारक होते. शिक्षित समाज, वर्ण–जातीभेदावर आधारित ब्राम्हणशाही, सरंजामी व्यवस्थेच्या कुटनीतीला समजून ही व्यवस्थासंपविण्याचा प्रयत्न करेल, असा विश्वास फुल्यांना होता. त्यामुळे त्यांनी पुरूशांप्रमाणेच स्त्री शिक्षणाचा आग्रह धरला.जेव्हा त्यांनी "उच्च" जातीच्या स्त्रियांना आणि "बहिश्कृत" वर्गातील स्त्री पुरूशांना शिकवायला सुरूवात केली, तेव्हा त्यांना आणि त्यांच्या पत्नीला हिंदू समाजातील पुरोहित वर्गाकडून प्रचंड विरोधाचा सामना करावा लागला. सनातनी विचारसरणीच्या खोल प्रभावाखाली असलेल्या लोकांनी त्यांच्यावर दगडफेक केली, शेणखत फेकले, काहींनी शिवीगाळ केली. परंतु म. फुल्यांनी माघार घेतली नाही.

1848 मध्ये, जोतीरावांनी केवळ महाराश्ट्रातील पहिली शाळाच नव्हे तर सर्व जातीधर्मासाठी भारतातील पहिली शाळा उघडली. शाळा सुरू केल्यामुळे उच्चवर्णीय वर्गाची नाराजी होती. त्यामुळे त्या शाळेत शिकवण्यासाठी एकही शिक्षक उपलब्ध नव्हता. अशा स्थितीत जोतीराव आपल्या पत्नी सावित्रीबाई यांच्यावर शिक्षणाची जबाबदारी सोपवतात.'चुल व मुल यात गुंतून न पडता घराचा उंबरठा ओलांडणारी व सामाजिक कार्यात भाग घेणारी महाराश्ट्रातील पहिली स्त्री सावित्रीबाई याच होत.' (नरके, 2018)महात्मा फुले स्वतःला या कार्यात झोकून देऊन शिक्षण देण्याचे काम करतात. तेव्हा त्यांना वेळोवेळी समाजाकडून अपमानीत व्हावे लागले. सनातन्यांचा इतका दबाव जोतीरावांच्या वडिलांवर होता की, त्यांना वडिलांचे घरही सोडावे लागले. अशा परिस्थितीत फातिमा शेख नावाच्या मुस्लिम महिलेने जोतीराव आणि सावित्री यांना आपल्या घरात आश्रय दिला.

जोतीराव आणि सावित्रीबाईच्या कार्याने प्रेरित होऊन फातिमाने शिक्षण घेतल्यानंतरही अध्यापन सुरूच ठेवले. आणि त्या काळातील पहिल्या महिला मुस्लिम शिक्षिका होण्याचा मान मिळविला. त्या काळात एक मुस्लीम स्त्री शिक्षिका होणे केवढे धाडसाचे होते. पण हे धाडस फातिमा करू शकल्या ते केवळ फुल्यांनी जागवलेल्या आत्मभानामुळे आणि पुरविलेल्या शिक्षण सुविधांमुळे शक्य होऊ शकले.

जोतीराव फुले यांच्या शाळेत, एक 14 वर्शांची मुलगी जी मांग समाजाची होती, तिचे नाव मुक्ता साळवे होते. तिने शाळेच्या कार्यक्रमात स्वतःचा लिहिलेला निबंध वाचला, जिथे कंपनी सरकारही उपस्थित होते, त्यात ती लिहिते की, वेद ब्राम्हणांसाठी आहे, मग आपल्यासाठी का नाही? सांगा आमचा धर्म कोणता? आपल्याला ज्या प्रकारच्या अत्याचाराला सामोरे जावे लागते, तो कोणता धर्म संपवू शकतो? यावरून मुक्ता साळवे यांची निर्भीडता आणि वैचारिक दृश्टी या पाठीमागे जोतीराव फुले यांची शैक्षणिक विचारधारा प्रकर्शाने दिसून येते. याशिवाय पंडिता रमाबाई यांनी त्यावेळी संस्कृत मध्ये पदवी घेतली तेव्हा, समाजाने तिच्या गुणांची वाहवा करणे सोडाच, परंतु आता 'स्त्री स्वतःसोबत समाजाला घेऊन बुडणार' असा कांगावा सवर्णांनी केला. ताराबाई शिंदे यांनी लिहलेला'स्त्री–पुरूश तुलना' हा ग्रंथ, स्त्रियांसाठी चांगला नाही म्हणून हा ग्रंथ स्त्रीयांना वाचनाला बंदी घातली. फुल्यांनी मात्र या दोन्ही स्त्रियांची दखल घेतली. स्त्रियांची कशी कुचंबना होते हे फुल्यांनी आपल्या नियतकालीकातून व ग्रंथांतुन पदोपदी मांडले'.[7] (लांजेवार, 2016)

Scanned with OKEN Scanner

महात्मा फुले आणि त्यांचे सामाजिक कार्य:

म. फुल्यांनी आपले संपूर्ण जीवन दलित, अस्पृश्य यांच्या उत्थानासाठी आणि सर्व स्त्री-पुरूशांच्या समान हक्कांसाठी समर्पित केले. भारतीय समाज वर्ण, जात, वर्ग आणि लिंग याआधारावर विभाजित असल्यामुळे भेदभाव आणि अन्यायाचे मूळ कारण आर्थिक नसून सामाजिक रचना आहे, असे जोतीराव फुले मानत असत.जोतीरावांना'गुलामगिरी' बद्दल प्रचंड चीड होती. त्यामुळे ते कोणत्याही भेदभावाच्याविरोधात उभे राहत असत. याच पार्श्वभूमीवर त्यांनी गुलामगिरी सारखा ग्रंथ लिहीला. "विधवांचे केशवपन, विधवा–पुनर्विवाहास बंदी, स्त्रियांचा हीन दर्जा आणि अज्ञान, त्यांचे शारिरीक व मानसिक शोशण या विरोधात पहिला आवाज या देशात जोतीरावांनी उठवला होता".[8] (भोळे, 2003)

म. फुल्यांनी विधवा पुनर्विवाहाची मोहीम चालवली, बालविवाहाला विरोध केला, गरोदर ब्राम्हण विधवांना सामाजिक अपमान आणि कलंकापासून वाचवण्यासाठी प्रसूती गृह, बालहत्या प्रतिबंधक गृह सुरू केले. जोतीरावांनी काढलेल्या बालहत्या प्रतिबंधक गृहाबद्दल फेब्रुवारी 1871 च्या 'ज्ञानप्रकाश' मध्ये असे प्रसिद्ध करण्यात आले की, 'एका परोपकारी सद्गृहस्थाने गरोदर स्त्रिया आणि मुले यांना आश्रय देण्यासाठी एक स्वतंत्र घर बांधले आहे'.[9](कीर, 2017)खरोखर, बालहत्या प्रतिबंधक गृहऊभे करून जोतीरावांनी ब्राम्हण विधवांची अब्रू वाचवली आणि त्यांना समाजाच्या छळापासूनही वाचविले. याच बालहत्या प्रतिबंधक गृहातून 1873 साली काशीबाई नावाच्या एका ब्राम्हण विधवेस मुलगा झाला. त्या मुलास जोतीरावांनी दत्तक घेतले, त्याचे नाव यशवंत. यशवंताचा फुले दाम्पत्यांनी अतिशय मायेने सांभाळ केला. केशवपन ही प्रथा स्त्रियांसाठी जाचक आणि अन्यायकारक असल्याचे ते मानत असत. त्यामुळे फुल्यांनी नारायण मेघाजी लोखंडे आणि पत्नी सावित्रीबाई यांच्यासमवेत 23 मार्च 1890 रोजी "केशवपन" हिंदू विधवांचा मुंडण विधी प्रथेविरूद्ध 500 नाईंचा संप पुकारला. म. फुल्यांनी सत्यशोधक विचारधारेतुन स्त्रियांचे प्रश्न हे कोणत्याच काळात सारखे नसल्याचे सातत्याने याविशयी प्रबोधन केले आहे. 'जोतीराव फुल्यांनी'कुळंबिनीच्या अखंडामध्ये स्त्रियांचे प्रश्न समान नाहीत यांची जाणीव प्रकट केली होती'.[10] (चव्हाण, 2014)म्हणजेच स्त्रियाचे प्रश्न हे वर्ण, जात,वर्ग आणि लिंग यावर आधारित विशमतेतून पुढे आले आहेत असे ते मानत असत.'जर एखाद्या जोडप्याला मुल झाले नाही तर, स्त्रीवर वांझोटेपणाचा आरोप करणे हे अत्यंत निर्दयपणाचे कृत्य, तिच्या पतीत वांझोटेपणाचे काही दोश नसतील कशावरून? असे आपले विचार जोतीराव स्वतंत्रपणे बोलून दाखवीत. 'अशा स्थितीत त्या स्त्रीने, 'मी दुसरा नवरा करणार आहे,' असे म्हटले तर तिच्या नवऱ्याला काय वाटेल? त्याला तो अपमान, मानखंडना वाटणार नाही काय? पुरूशाने पहिल्या पत्नी पासून मुल नाही म्हणून दुसरा विवाह करावा ही अत्यंत निश्ठूर आणि हृदयशून्य चाल आहे. असे जोतीरावांचे म्हणणे होते." (कीर, 2017)यावरून असे दिसते की, म. फुल्यांनी स्त्रियांशी संबंधित प्रत्येक अत्याचार आणि प्रथा नाकारल्या. स्त्री आणि पुरूश दोघांनाही एका निर्मिकाने निर्माण केले असून सारखेच अधिकारही दिले आहेत. त्यामुळे परस्परांच्या हक्कांबद्दल त्यांनी आदर बाळगावयास हवा, सर्व धर्माची पुस्तके पुरूशांनी लिहिलेली असल्यामूळे त्यांचे न्याय्यहक्क तर ते त्यांना देतच नाही उलट पुरूश जास्त दृश्ट, लोभी,

Scanned with OKEN Scanner

बदफैली व आक्रमक असतात आणि या त्यांच्या दुर्गुणांची सर्वाधिक झळ स्त्रियांनाच लागते'.[12](भोळे, 2003)यावरून म. फुले हे स्त्री–पुरूशांच्या हक्कांबद्दल आणि समानतेसाठी आग्रही असल्याचे दिसतात. सत्यशोधकी विचारातून फुल्यानी भट भिक्षुकांच्या मध्यस्थीशिवाय सत्यशोधक विवाह घडवून आणले आणि विधवांचे पुनर्विवाहही घडवून आणले. 'जोतीरावांनीएका शेणवी जातीतील एका विधवेचा एका शेणवी विधुराबरोबर 7 मार्च 1860 रोजी पुण्यात पुनर्विवाह घडवून आणला.[13](कीर, 2017)अशाप्रकारे म. फुले स्त्रीयांबद्दल अत्यंत प्रागतिक विचार करणारे एकमेव सुधारक होते असे म्हणता येईल.

मुल्यमापन :

वरील प्रमाणे म. फुल्यांच्या स्त्रीविशयक शैक्षणिक आणि सामाजिक कार्याचा आढावा घेतल्यानंतर असे म्हणता येईल की,स्त्री–पुरूश समतेचा सातत्याने पुरस्कार करणारे आणि त्यासाठी अत्यंत मुलगामी युक्तिवाद करणारे जोतीराव हे भारतातील स्त्रीमुक्ती विचारांचे आद्यप्रवर्तक ठरतात. स्त्री–शिक्षण,स्त्रीविशयक अन्याय, रूढीचे निर्मूलन, स्त्रीयांचे स्वातंत्र्य, हक्क अधिकार, या क्षेत्रात त्यांनी ठोस कार्य केले होते.सत्यधर्म, समतामूलक, सर्वसमावेशक, असा समाज उभा राहण्यासाठी जोतीराव फुले आजीवन लढत राहिले. दलित, शोशितांना व स्त्रियांना जी समता मिळावी ती सौजन्याखातर किंवा भूतदयेपोटी, नव्हे तर तो त्यांचा हक्क आहे, म्हणून प्राप्त व्हावी यासाठी फुले सतत संघर्ष करत राहिले. जातिभेद, अस्पृश्यता, स्त्रीदास्य यांचा त्यांनी कडाडून विरोध केला.

परंतु जोतीरावांच्या अनेक उद्दिश्टांपर्यत आपण अजुन पूर्णपणे पोहचू शकलो नाही. सामाजिक समतेचे त्यांचे ध्येय अजूनही प्रत्यक्षात आलेले दिसत नाही. स्त्री शिक्षणाचे गळतीचे प्रमाण वाढत आहे. लिंगभेदाची तीव्रता अधिक व्यापक होत चाललेली दिसते, स्त्रीयांवरील अत्याचार, हिंसाचार वाढत आहे. त्यांचे दुय्यमत्व आज अनेक क्षेत्रात कायम आहे. आदिवासी, दलित, शेतकरी, मागास, कश्टकरी स्त्रीया अजूनही परिघावरील जीवन जगत आहेत. स्त्रीभूणहत्येच्या घटनामंध्ये सुद्धा वाढ होताना दिसत आहे. यावरून समानता प्रत्यक्षात आणण्यासाठी आजही म. फुल्यांचे विचार महत्वाचे ठरतात.

संदर्भ सूची:

1.लांजेवार, ज्यो. (2016). 'फुले आंबेडकर आणि स्त्री–मुक्ती चळवळ'. पृश्ठ, 11, नागपूर: संकेत प्रकाशन.

2. भोळे, भा. ल. (2003). 'आधुनिक भारतातील राजकीय विचार', पृश्ठ, 803, नागपूर : पिंपळापुरे ॲंड पब्लिशर्स.

3. कांबळे, आ. (2020). 'स्त्रियांच्या उन्नतीसाठी', पृश्ठ, 72, पुणे: सुगावा प्रकाशन.

4. पानतावणे गं. (2002). 'प्रबोधनाच्या दिशा', पृश्ठ, 51, वर्धा: नंदिता प्रकाशन.

5. पानतावणे गं. (2002). 'प्रबोधनाच्या दिशा', पृश्ठ, 82, वर्धा: नंदिता प्रकाशन.

6. नरके ह. (2006), 'महात्मा फुले गौरव ग्रंथ',पृश्ठ, 27, मुंबई: महात्मा फुले चरित्र साधने,

456
Scanned with OKEN Scanner

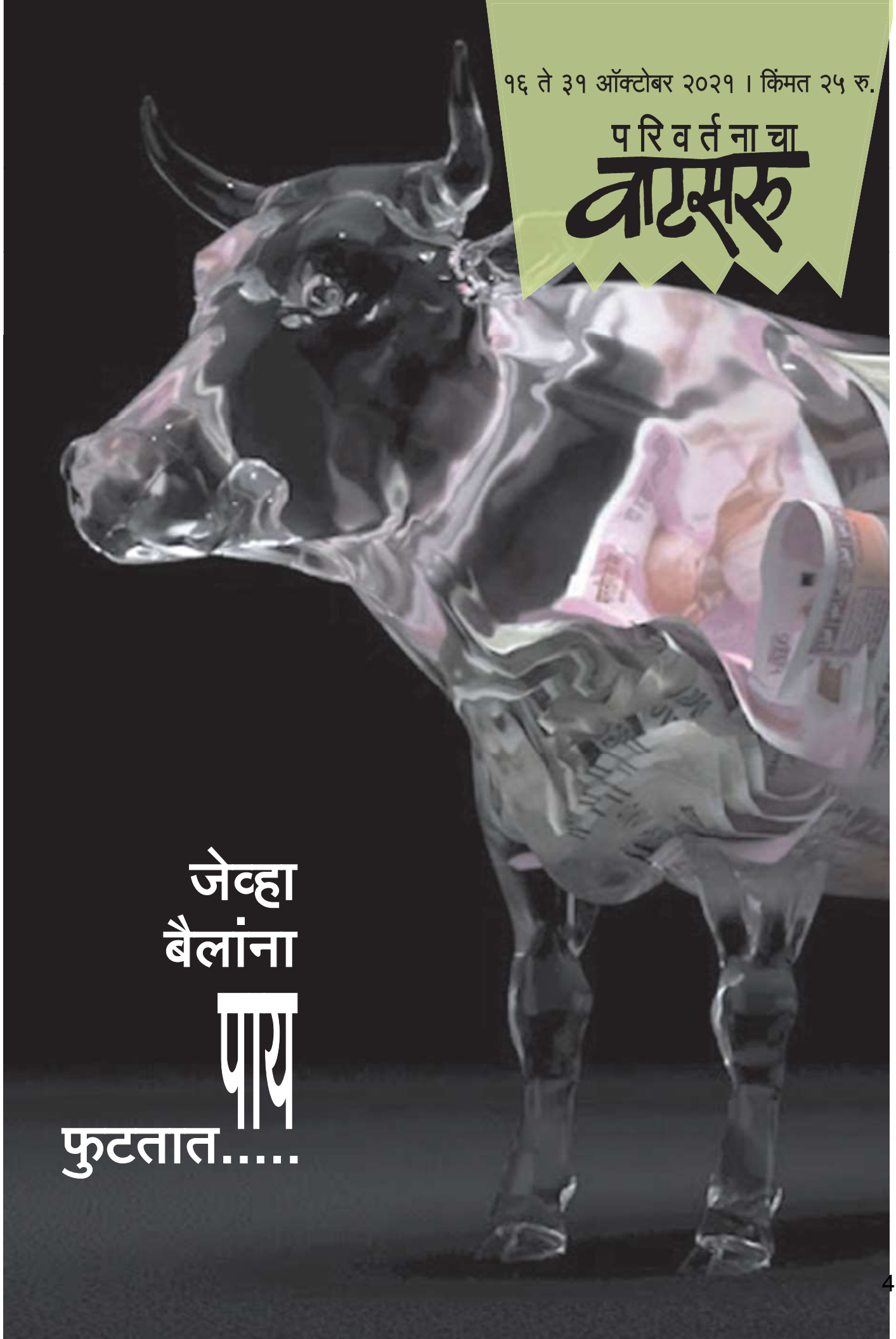
प्रकाशन.
7. लांजेवार, ज्यो. (2016). 'फुले आंबेडकर आणि स्त्रीमुक्ती चळवळ'. पृश्ठ, 17, नागपूरः संकेत प्रकाशन.
8. भोळे, भा. ल. (2003). 'आधुनिक भारतातील राजकीय विचार', पृश्ठ, 799, नागपूरः पिंपळापुरे ॲंड पब्लिशर्स.
9. कीर, ध. (2017). 'महात्मा जोतीराव फुले', पृश्ठ, 119, मुंबईः पॉप्युलर प्रकाशन.
10. चव्हाण, प. (2014). 'स्त्रीवाद आणि स्त्रीवादी दलितत्व', पृश्ठ, 131, मुंबई, शब्द पब्लिकेशन्स.
11. कीर, ध. (2017). 'महात्मा जोतीराव फुले', पृश्ठ, 109, मुंबईः पॉप्युलर प्रकाशन.
12. भोळे, भा. ल. (2003). 'आधुनिक भारतातील राजकीय विचार', पृश्ठ, 806, नागपूर : पिंपळापुरे ॲंड पब्लिशर्स.
13. कीर, ध. 2017. 'महात्मा जोतीराव फुले', पृश्ठ, 107, मुंबईः पॉप्युलर प्रकाशन.

****

Scanned with OKEN Scanner

१६ ते ३१ ऑक्टोबर २०२१ । किंमत २५ रु.

परिवर्तनाचा वाटसरु



जेव्हा बैलांना पाय फुटतात.....

'परिवर्तनाचा वाटसरू'च्या दिवाळी अंकात वाचा..
संजय पवारलिखित

परिवर्तनाचा वाटसरू

वर्ष २१ / अंक १२
किं. २५ रु. / १६ ते ३१ ऑक्टोबर २०२१

ISSN: 2250-3145

वर्गणीचे दर : वार्षिक : ६०० रु., त्रैवार्षिक : १,६०० रु., दशवार्षिक : ५,००० रु., सॉफ्ट कॉपीसाठी वार्षिक २०० रु., सॉफ्ट + छापील ७०० रु. वरील पत्त्यावर ई मनी ऑर्डर, चेक किंवा डिमांड ड्राफ्टने वर्गणी पाठवावी. 'परिवर्तनाचा वाटसरू' या नावाने चेक / डिमांड ड्राफ्ट असावा.

बँक ट्रान्सफरने वर्गणी भरण्यासाठी तपशील
बँक ऑफ इंडिया, फर्ग्युसन कॉलेज रोड शाखा, पुणे । बचत खाते : Pariwartanacha Vatsaru
बचत खाते क्र. : 051410110013969 । आयएफएससी क्र. : BKID0000514 । एमआयसीआर क्र. : 411013014
Google Pay साठीचा मोबाईल नंबर : 8888708963
युपीआय पेमेंटसाठी बार कोड

युजीसी केअर ग्रुप 1मध्ये 'परिवर्तनाचा वाटसरू' पाक्षिकाचा मल्टिडिसिप्लिनरी या कोटीक्रमांतर्गत समावेश केला आहे.

संस्थापक संपादक
अभय कांता*

संपादक
प्रज्ञा दया पवार । नारायण भोसले । माधुरी दीक्षित । सुरेंद्र जोंधळे

व्यवस्थापकीय संपादक
प्रशांत पवार

कार्यकारी संपादक
देवेंद्र इंगळे । दिलीप चव्हाण

संपादक मंडळ
प्रज्वला तट्टे, वीरा राठोड, कलीम अजीम,
मयुरी सामंत, अजित अभंग, राही श्रु. ग., वृषाली मगदूम

सहव्यवस्थापक
प्रकाश वाघमारे

संपर्क पत्ता
५९/६४, कौस्तुभ अपार्टमेंट
दुकान नं. ७ ए, कसबा पेठ
फणी आळी तालमीजवळ, पुणे ४११०११
संपर्क : ९७६३२०६२१२
pwatsaru@yahoo.com
www.pvatsaru.com

*पी. आर. बी. कायद्यानुसार संपादकीय जबाबदारी

या

अं
का
त

समसामायिक

जेव्हा बैलांना पाय फुटतात... ५
राहुल एम. अनु. स्वातीजा मनोरमा

संशोधन

स्त्रियांची राजकीय सत्ताहीनता ३१
विद्या चौरपगार व विकास जांभुळकर

ब्रिटिशकालीन धोरणे व कोळी महादेव उठाव ६६
विलास दुंदा गवारी

टिपण

नवरात्रोत्सवाचे स्थित्यंतर व सांस्कृतिक प्रभुत्व ८७
मेघना मराठे

सावित्रीची पानं

वाल्मिकी स्त्रिया ९७
दीपा टाक

स्त्री आणि मातृत्व १०४
राजश्री भोईगड

पुस्तक ओळख

'धगधगते तळघर'च्या निमित्ताने ११०
दा. गो. काळे

संशोधनपर लिखाण नियमावली ११३

संशोधन

स्त्रियांची राजकीय सत्ताहीनता

विद्या चौरपगार
व
विकास जांभुळकर

भारतीय समाज हा जाती, वर्ग, धर्म, वंश, पंथ या आधारावर तर विभाजित आहेच; पण तो स्त्री आणि पुरुष याही स्तरावर विभाजित आहे. अशा परिस्थितीत स्त्री सुधारणेच्या काळाचा इतिहास पाहिला तर असे दिसते की, स्त्रियांना हक्क व अधिकारांसाठी वेळोवेळी संघर्ष करावा लागला. लोकशाही शासनव्यवस्थेत सर्व स्त्री पुरुषांना मानव म्हणून समान हक्क, अधिकार, साधने, सुविधा, विकासाची समान संधी राज्यघटनेद्वारे प्राप्त होते. 'भारतीय संविधानाने हे अधिकार सर्व नागरिकांना बहाल केले. परंतु ज्या प्रमाणात सर्व स्त्री व पुरुष यांचा समान सामाजिक, आर्थिक, राजकीय विकास होणे गरजेचे होते त्या प्रमाणात झाल्याचे दिसत नाही. सार्वजनिक जीवनातील सर्वच

लेखिका विद्या चौरपगार नागपूरस्थित डॉ. आंबेडकर महाविद्यालयात राज्यशास्त्राच्या सहाय्यक प्राध्यापक असून, विकास जांभुळकर राष्ट्रसंत तुकडोजी महाराज नागपूर विद्यापीठात राज्यशास्त्राचे सहयोगी प्राध्यापक आहेत.

ईमेल- chourpagarvidya@gmail.com
vikasnagpur@gmail.com

क्षेत्रांमध्ये महिला या घटकाचा सहभाग अत्यल्प किंवा दुबळा राहिला.'[१] जगातील कोणत्याही राष्ट्राच्या तुलनेत दक्षिण आशियातील देशात शक्तिशाली महिला राज्यकर्त्या अधिक प्रमाणात आहेत, उदा. चंद्रिका कुमारतुंगा (श्रीलंका) बेनझीर भुट्टो (पाकिस्तान) खलिदा जिया (बांगलादेश). भारतात तर इंदिरा गांधी, सोनिया गांधी, ममता बॅनर्जी, मायावती, उमा भारती, शीला दीक्षित, प्रतिभाताई पाटील, सुषमा स्वराज, मीराकुमारी अशा प्रसिद्ध राजकारणी महिलांची नावे घेता येतील. परंतु 'महिलांचे राजकीय क्षेत्रातील वर्चस्व राजकारणातील उच्च स्थान काबीज करण्यात व्यर्थ ठरले. ग्रामीण स्तरावरील राजकारण तर पूर्णपणे पुरुषांच्या हातात आहे. या भागात स्त्रियांना अजूनही घरगुती कामातच गुंतवून ठेवले जाते. यावर तोडगा काढण्यासाठी महिलांचा राजकारणात सहभाग वाढविण्यासाठी आरक्षणाची तरतूद आशियाई राष्ट्रांनी केली.'[२] भारतात १९९३मध्ये आरक्षणाची तरतूद करण्यात आली. परंतु मागील १७ वर्षापासून संसद आणि लोकसभेतील ३३ टक्के आरक्षणाचा प्रश्न निकाली लागला नाही.

आतापर्यंत जी सरकारे पदावर आली त्यांनी निवडणुकीतील अजेंडामध्ये आरक्षणाचा अंतर्भाव निश्चितच केला आहे. परंतु सघन चर्चा अथवा निर्णय मात्र अजूनपर्यंत झालेला नाही. 'स्त्रियांनी पंचायत राज व्यवस्था, माहिती तंत्रज्ञान ते बचत गट अशा विविध क्षेत्रात प्रगती केलेली दिसून येत असली तरी त्याचवेळी स्त्रियांच्या विरुद्ध जाणारे लिंग गुणोत्तर, परिघावरील स्त्रियांवरचे नवनवे प्रकार, संसदेत स्त्रियांचे प्रमाण या सगळ्यांमुळे

स्त्रियांची प्रगती झाली आहे किंवा होत आहे असे म्हणण्यास मन धजत नाही.'[३] महिलांच्या दुय्यम राजकीय स्थितीतील सर्वव्यापीपणा हे दर्शवितो की, जवळपास या सर्वच राष्ट्रातील महिलांची राजकीय स्थिती दुय्यम आहे. 'बार्बरा नेल्सन आणि नजमा चौधरी यांनी वीमेन अँड पॉलिटिक्स वर्ल्डवाईड.' या संपादित केलेल्या पुस्तकातील ४३ देशातील महिला सहभागाच्या अभ्यासावरून असे निष्कर्ष नोंदविले आहे की, 'कोणत्याही देशातील राजकीय व्यवस्थांमध्ये महिलांचे स्थान व दर्जा दुय्यम आहे'[४] भारतात घराण्याचा वारसा घेऊन सत्तेत सक्षमपणे कार्यरत असलेल्या स्त्रिया, आरक्षणाचा आधार घेणाऱ्या स्त्रिया, आणि स्वबळावर राजकीय सक्षम झालेल्या स्त्रियांही आहेत. पण तरीदेखील लोकसंख्येच्या प्रमाणात स्त्रियांचा राजकीय सहभाग दिसत नाही.

'महाराष्ट्रात तर साठीच्या दशकातील विधानसभेवर एका अर्थाने पुरुषांचेच नियंत्रण होते. पुरुषांनी महिलांच्या विधानसभेतील राजकीय सहभागावर बहिष्कार घातला होता. म्हणजेच मतदार महिला होत्या मात्र त्यांना राजकीय सहभागाची संधी उपलब्ध नव्हती. कारण या दशकात महाराष्ट्रातील समाज सरंजामी पद्धतीचा होता. त्यांनी पुरुषांना राजकारण करण्याचा अधिकार दिला होता.'[५] राजकारणातील पुरुषसत्तेच्या प्रभावाचे हे अत्यंत बोलके उदाहरण आहे. आजच्या दशकातदेखील चित्र फारसे बदललेले दिसत नाही. सर्वच घटक राज्यांमध्ये पुरुष प्रभावी राजकारण दिसून येते. 'लोकशाहीचा हा एक पैलू आहे की, ज्यात बहुतांश संख्येने नागरिक स्त्रिया निर्णय निर्धारण प्रक्रियेत सहभागी व्हावयास

हव्यात आणि हीच गोष्ट राष्ट्रबांधणीत स्त्रियांना समान संधी प्रदान करते. प्रत्यक्षात स्त्रिया दुय्यम दर्जाच्या नागरिक मानल्या जातात. (राजकीय सहभाग व राजकीय शक्तीत) प्रत्यक्षात जगातील बहुतांश राज्यात त्यात भारताचाही समावेश होतो स्त्रियांना पुरुषांच्या बरोबरीने अधिकार दिले आहेत मात्र राजकीय सहभाग नगण्य आहे.'[६]

स्त्री अस्तित्त्वाचे संघर्ष, स्त्रियांचे स्थान, दर्जा आणि प्रतिष्ठा, लिंगभेद, स्त्रियांचे दुय्यमत्व, राजकीय क्षेत्रातील सहभाग, पुरुषसत्तेचा प्रभाव, राजकीय सत्ताहीनता, हक्क व अधिकारांची विषम वितरण व्यवस्था, संधी व सुविधांची वंचितता, निर्णय प्रक्रियेतील सहभाग, स्त्रियांचे सक्षमीकरण हे प्रश्न दिवसेंदिवस अधिक तीव्र होत चालले आहे. अशा प्रश्नांना सोडविण्याच्या दृष्टीने महिलांचा राजकारणामध्ये सहभाग असणे अत्यंत महत्त्वाचे आहे. परंतु मागील ७० वर्षापासून स्त्रियांना राजकीय व्यवस्थेत मोठ्या प्रमाणात वगळण्यात येत आहे. त्यांच्या राजकीय समावेशनाकडे भारतातील कोणताही राजकीय पक्ष फारसा गांभीर्याने बघत नाही. या पार्श्वभूमीवर प्रस्तुत अभ्यास महत्त्वाचा आहे.

गृहीतके :

१. समकालीन राजकारणातील स्त्रिया कमी अधिक प्रमाणात सामाजिक रचनेच्या बळी आहेत.

२. लिंगधिष्ठितता ही राजकीय व्यवस्थामध्ये महत्त्वाचे परिवर्तक म्हणून काम करते.

३. राजकारणातील पुरुषसत्तेच्या प्रभावामुळे स्त्रिया सत्ताहीन

होतात.

अभ्यासाचे महत्त्व :

स्त्री व पुरुषांची सामाजिक व सांस्कृतिक जडणघडण करताना दोघांना वेगवेगळे नियम लावणे म्हणजे लिंगभाव. वास्तविकतः लिंगभेद हा स्त्री व पुरुषांमधील नैसर्गिक भेद आहे. परंतु या भेदाची नैसर्गिक बाजू विचारात न घेता स्त्री व पुरुषांसाठी वेगवेगळे सामाजिक व सांस्कृतिक प्रथा परंपरांची निर्मिती भारतात मोठ्या प्रमाणात झालेली दिसून येते. प्रसिद्ध स्त्रीवादी लेखिका सिमोन द बुव्हा 'द सेकंड सेक्स' या जगप्रसिद्ध ग्रंथात असे म्हणते, 'स्त्री जन्माला घातली जात नाही तर तिला घडविले जाते'. जशी स्त्री घडविली जाते तसाच पुरुष सुद्धा घडविला जातो. आपल्या समाजातील पितृसत्ता, विवाहसंस्था, कुटुंबसंस्था, धर्मसंस्था जन्मलेल्या व्यक्तीला पुरुष असल्याची जाणीव व स्व ओळख देण्याचे कार्य करीत असतात. यामधून अधिकार, सत्ता, हिंसा, जबरदस्तीची भाषा करणारा, 'वर्चस्ववादी पुरुष' निर्माण केला जातो. हा पुरुष पुरुषसत्तेची सर्व स्थाने काबीज करायचा प्रयत्न करीत असतो. आणि सत्तेची मुख्य केंद्रे जिथे जिथे असतील तिथे शिरकाव करतो. राजकारण हे त्यापैकी एक सत्ताकेंद्र आहे, जिथे वर्षानुवर्षेपासून कायमस्वरूपी पुरुषसत्तेचा प्रभाव दिसून येतो. 'भारतीय राजकारण हे पुरुषसत्तेचे वर्चस्व असलेली गुंतागुंतीची प्रक्रिया असलेली, स्त्री-पुरुष समानता आणि न्याय यासाठीच्या संघर्षातील ती अखेरच्या सरहद्दीचे प्रतिनिधित्व करते.'[७]

१९७५नंतर देशात आणीबाणी लागू झाली. या काळात स्त्रियांचे प्रश्न ऐरणीवर आले. वाढती महागाई, हुंडाबळीचे वाढते प्रमाण, लैंगिक अत्याचार, कौटुंबिक हिंसाचारासारखे प्रश्न मोठ्या प्रमाणात निर्माण झाले. '१९८५मध्ये शाहबानोच्या निमित्ताने मुस्लिम स्त्रियांना पोटगीचा हक्क नाकारण्यासाठी कायद्यात केलेली दुरुस्ती व त्यानंतर समोर आलेला अन्यायकारक व्यक्तिगत कायद्यांचा प्रश्न, मथुरा बलात्कार प्रकरण, १९८७चे रूपकुवरचे सती प्रकरण, मंडल आयोगाच्या शिफारशीच्या निमित्ताने दलित ओबीसी स्त्रियांची स्थिती, अशा विविध मुद्द्यांची चर्चा होत होती.'[८] यासर्व प्रश्नांना सोडविण्यासाठी स्त्रियांचे प्रतिनिधित्व फार अल्प आहे, हे जाणवत होते. याच दरम्यान जागतिक स्तरावर झालेल्या आंतरराष्ट्रीय परिषदांमध्ये स्त्री-पुरुष समानतेचे निकष पाळण्याविषयी जगाचे लक्ष वेधले गेले. उदा. कोपनहेगन आंतरराष्ट्रीय महिला परिषद १९८०, व्हिएन्ना परिषद १९९३, नैरोबी व केनिया परिषद १९८५, मानव विकास अहवाल १९९५ इ. यासर्व चर्चा आणि अहवालांनी असे निर्देशनास आणले की, देशाचे प्रतिनिधित्व करणाऱ्या उच्च संस्था मग ती संसद असो की, प्रशासन या सर्व ठिकाणी स्त्रियांची संख्या कमी आहे. 'राजकारणात सक्रिय सहभागाच्या बाबतीत केलेल्या अभ्यासावरून गेल ऑम्वेट म्हणतात, भारतात उत्पादक कामापेक्षाही राजकारणात महिलांचा सहभाग मोठ्या प्रमाणावर वगळला जात आहे.[९] १९५२ ते २०१४पर्यंतच्या प्रत्येक निवडणुकीमध्ये महिलांना वगळण्याची प्रक्रिया घडली. स्त्रियांच्या राजकीय समावेशनाची दखल कोणत्याही पक्षाने तितक्या प्रमाणात

घेतलेली दिसत नाही. या वगळण्याच्या प्रक्रियेला जवळजवळ पंच्याहत्तर वर्ष पूर्ण झाली आहेत. यामागे राजकारणातील संरचनात्मक पातळीवरील लिंगभेद प्रामुख्याने दिसून येतो. सोहिन पाल आणि अनुराधा मेहता असे म्हणतात की, 'भारतात अजूनही पुरुषी वर्चस्व आहे. लिंग असमानतेमुळे स्त्रिया राजकीय सत्तेपासून वंचित आहेत, हे राजकीय वास्तव आहे.'[१०] आणि हे राजकीय वास्तव दिवसेंदिवस अधिक व्यापक होत चालले आहे. स्त्रियांचा राजकारणातील सहभाग हा केवळ स्त्रियांसाठी किंवा तिच्या कुटुंबासाठी महत्त्वाचा नसून देशाच्या सामाजिक, आर्थिक, राष्ट्रीय, शैक्षणिक क्षेत्रातील विकासात महत्त्वाचे योगदान देणारा ठरू शकतो. तेव्हा राजकारणातील स्त्रियांची सत्ताहीनता जातीय, धार्मिक आणि पुरुषसत्ताकतेच्या प्रभावातून निर्माण झालेल्या लिंगभाव परिप्रेक्ष्यातून अभ्यासणे, यादृष्टीने प्रस्तुत अभ्यासाचे महत्त्व आहे.

उद्दिष्ट्ये

१. स्त्रियांचा समाजातील वर्तमानकालीन स्थान, दर्जा व भूमिका समजून घेणे.

२. राजकारणातील सत्तेच्या प्रक्रियेतील स्त्रियांचे दुय्यमत्व आणि सत्ताहिनतेचे विश्लेषण करणे.

३. राजकीय संरचनेमधील स्त्रियांचे स्थान शोधणे.

४. राजकारणातील पुरुषसत्तेचे विश्लेषण करणे.

५. राजकारणातील लिंगधिष्ठिततेचे राजकीय व सामाजिक विश्लेषण करणे.

६. लिंगधिष्ठित राजकारणाचे जातीय आणि धार्मिक दृष्टिकोण अभ्यासणे.

स्त्रियांचा राजकीय प्रवास

प्राचीन काळात या देशात स्त्रियांची सत्ता होती. स्त्रियांना पुरुषांच्या बरोबरीत हक्क, अधिकार स्वातंत्र्य, समता प्राप्त होत असे. परंतु 'अपत्य निर्मिती प्रक्रियेमध्ये पुरुषांचे स्थान स्पष्ट झाल्यानंतर स्त्रीचे महत्त्व कमी होऊन पुरुषप्रधानतेचे आगमन झाले.'[११] पुरुषसत्तेच्या या पर्वात स्त्रियांच्या वाट्याला दुय्यम स्थान आले. अधिकार, सत्ता आणि संपत्ती पासून स्त्रिया वंचित होऊ लागल्या. 'महिलांकडे संपत्तीचा अधिकार नव्हता. सत्ता, संपत्ती आणि अधिकार यांचा एकत्र संबंध असतो यामुळे राजकीय प्रभाव निर्माण करण्यास त्यांच्याकडे साधनसामग्री अपुरी ठरली आहे.'[१२] परिणामी या काळात स्त्रिया सार्वजानिक व्यवहारातून बाजूला फेकल्या गेल्या.

स्त्री सुधारणेच्या कालखंडात १९वे शतक अनेक अर्थाने महत्त्वपूर्ण ठरते. या काळात अनेक सुधारकांनी स्त्रियांच्या सामाजिक, सांस्कृतिक, शैक्षणिक तसेच राजकीय प्रश्नांचा उदारमतवादी दृष्टीने विचार केला. स्त्री-शिक्षण, बालविवाह, जरठ विवाह, सती पद्धती, घटस्फोट, केशवपन, विधवा विवाह, वारसा मालमत्ता असे विविध प्रश्न महिलांनी हाती घेत भारतीय स्वातंत्र्य चळवळीत भाग घेतला. शिक्षणासाठी महात्मा फुले आणि सावित्रीबाई यांनी केलेले कार्य स्त्री विकासाच्या मार्गातील मैलाचा दगड ठरले. 'महात्मा फुले उदारमतवादाची सीमारेषा

पार करून पुढे गेले. त्यांनी भारतीय स्वातंत्र्य चळवळीत स्वातंत्र्य कोणासाठी असा प्रश्न मांडला. महात्मा फुले यांनी राष्ट्रीय काँग्रेस व ब्रिटिश सरकार यांच्या समोर शेतकरी. कामगार महिला व शूद्र, अतिशूद्र यांच्या स्वातंत्र्याचा विचार मांडला. यामुळे भारतीय स्वातंत्र्य चळवळीला व्यापक असा अर्थ प्राप्त झाला.'[१३] ज्या समाजव्यवस्थेत स्त्रियांना ज्ञानी होण्याचा अधिकार नव्हता अशा स्त्रीला अक्षर ओळख आणि नंतर विचारप्रवृत्त करण्याचा फुल्यांचा मानस हा एक प्रकारचा राजकीय लढाच होता.

भारतात पुरुष वारसदार नसताना राज्य करणाऱ्या स्त्रिया होत्या. राज्य करण्याचे शिक्षणही त्यावेळी दिले जात होते. उदा. जिजाबाई, अहिल्यादेवी होळकर, राणी लक्ष्मीबाई व शूर चांदबिबी यांनी रणांगणावर गाजवलेल्या पराक्रमांची इतिहासात नोंद आहे. स्वातंत्र्यचळवळीत महात्मा गांधींनी महिलांना सार्वजनिक जीवनात सक्रीय केले. गांधीनी दिलेल्या आत्मविश्वासामुळे सर्व स्तरातून अनेक स्त्रिया सहकारिता व सविनय कायदेभंग या राष्ट्रीय चळवळीमध्ये सहभाग द्यायला पुढे आल्या. हा स्त्रियांचा राजकीय पटलावरील उदय म्हणायला हरकत नाही. भारतामध्ये मताधिकारासाठी स्त्रियांना युरोपीय चळवळींसारखा वेगळा संघर्ष करावा लागला नाही. भारतात स्त्रियांची राजकीय मतदानाची लढाई स्वातंत्र्य चळवळी सोबतच अविभाज्यपणे जोडल्या गेली होती. याच चळवळीचा एक भाग म्हणजे १९२७मध्ये अखिल भारतीय महिला परिषदेची स्थापना झाली. या परिषदेने वेळोवेळी स्त्रियांच्या सार्वत्रिक मताधिकाराचा प्रस्ताव मांडलेला आहे. '१९२७मध्ये मद्रास विधिमंडळावर

मुथुलक्ष्मी रेड्डी निवडून आल्या. देवदासी आणि बालविवाह प्रथांवर बंदी घालणारे कायदे, गरीब मुलींना शैक्षणिक सवलती, गरीब स्त्रियांना अर्थाजन करण्यासाठी प्रशिक्षण, लहान मुलांसाठी दवाखान्यांची उभारणी, अशा स्वरूपाचे कार्यक्रम त्यांनी राबवण्यासाठी पुढाकार घेतला. आणि लोकप्रतिनिधी या नात्याने स्त्रिया काय करू शकतात याचे उदाहरण घालून दिले.'[१४] पुढे अशाच काही राजकीय भूमिका घेऊन रमाबाई रानडे यांनी स्त्रियांच्या राजकीय विकासाच्या वाटचालीत महत्त्वपूर्ण योगदान दिले.

'रमाबाई रानडे यांनी स्त्रियांना मताधिकार व प्रतिनिधित्व मिळावे यासाठी स्त्रियांचे आंदोलने केले होते. रमाबाई रानडेंना स्त्रियांचे राजकीय स्वातंत्र्य हवे होते परंतु, त्या काळचा समाज पारंपारिक प्रतिगामी होता. त्यामुळे महिलांचा राजकीय सहभाग व स्वातंत्र्य यांना समाज विरोध करीत होता.'[१५] शेवटी या प्रतिगामी पुरुषसत्तेच्या प्रभावामुळे रमाबाईंची अनेक कार्य मागे राहिली. शारदाबाई पवार यांनी रमाबाईंचे राजकीय कार्य पुढे सुरू ठेवण्यात अनेक प्रयत्न केले. '१९३८मध्ये जिल्हा लोकल बोर्डाच्या निवडणुकीसाठी काँग्रेस पक्षामार्फत शारदाबाई पवार निवडणुकीला उभ्या राहिल्या.'[१६] परंतु त्यांचाही हा प्रवास म्हणावा तितका पुढे जाऊ शकला नाही. लोकमान्य टिळक यांच्या नेतृत्वाखाली स्थापन झालेली 'होमरूल लीग'ची चळवळ व ॲनी बेझंटचे राजकीय कर्तृत्व यामधून स्वातंत्र्य प्राप्तीसाठी स्त्री सहभाग वाढायला मदत झाली.

'महात्मा गांधी व पंडित जवाहरलाल नेहरू यांनी महिलांना

नेतृत्व व निर्णय निश्चितीमध्ये सहभागाची संधी दिली होती. मात्र इतर नेत्यांना गांधी नेहरुंची ही भूमिका मान्य नव्हती.'[१७] महात्मा गांधी व पंडित जवाहरलाल नेहरू यांच्या नेतृत्वात सरोजिनी नायडू यांनी देशाच्या राजकीय स्वातंत्र्याचे राजकीय नेतृत्व केले. आणि स्वातंत्र्य प्राप्तीनंतर राजकीय पटलावर अनेक महत्त्वाची राजकीय पदे भूषविली. 'अर्थातच स्वातंत्र्य चळवळीत महिलांचे राजकारण सुरू होण्याची प्रक्रिया सुरू झाली होती. महिलांनी निर्णयनिश्चितीचे राजकारण करण्याची अपेक्षा व्यक्त केली होती मात्र काँग्रेस पक्षाचे स्थानिक नेतृत्व महिलांनी राजकारण करण्याच्या विरोधातील होते. त्यामुळे महिलांचे राजकारण घडले नाही.'[१८]

फुल्यांच्या नंतर स्त्रियांच्या राजकीय प्रवासात डॉ. बाबासाहेब आंबेडकर यांचे योगदान अनेक अर्थाने महत्त्वपूर्ण ठरते. डॉ. आंबेडकरानी त्यांच्या हयातभर निर्माण केलेल्या सामाजिक संघर्षात स्त्रिया मोठ्या प्रमाणात सहभाग घेताना दिसतात. मनुस्मृती दहन, काळाराम मंदिर प्रवेश, आणि महाडचा सत्याग्रह तसेच १९५६चे धर्मांतर अशा सर्व आंदोलनात स्त्रियांचा मोठा सहभाग होता. तेव्हा डॉ. आंबेडकरांच्या आंदोलनातील स्त्रिया प्रत्यक्ष व अप्रत्यक्षपणे सामाजिक व राजकीय अधिकार प्राप्त करण्याचा प्रयत्न करीत होत्या हे स्पष्ट होते. बाबासाहेबांनी केवळ दलित स्त्रियांचेच प्रश्न सोडविले नाही तर सबंध स्त्रीजातीचा विचार वैश्विक दृष्टिकोनातून केला आहे. लिंगभाव समता प्रस्थापित करण्यासाठी डॉ. आंबेडकरांनी सर्वतोपरी प्रयत्न सुरू ठेवले. शेवटी घटनेच्या मार्फत डॉ. आंबेडकरानी स्त्रियांच्या सर्वच

अधिकारांचा सन्मान राखला. 'स्त्रीशोषणावरचा उपायच डॉ. आंबेडकरांची चळवळ आहे. संघर्ष, शील, प्रज्ञा, करुणा हे स्त्रीजीवनाचे अलंकार आहेत. शिका, संघटित व्हा, आणि संघर्ष करा हे शोषितांना व स्त्रियांनाही दिलेले महान तत्त्व आहे.'[१९] डॉ. बाबासाहेब आंबेडकरांच्या नेतृत्वाखाली स्थापन झालेल्या घटना समितीने राज्यघटनेत स्त्रियांना समान प्रौढ मतदानाचा अधिकार दिला. केवळ मताधिकाराचाच अधिकार दिला नाही तर, शैक्षणिक, राजकीय, सामाजिक, आर्थिक, धार्मिक, सांस्कृतिक अधिकार स्त्रियांना बहाल केले.

भारताची पहिली सार्वत्रिक निवडणुक १९५२मध्ये झाली ही निवडणुक स्त्रियांसाठी अनेक पैलूंनी महत्त्वाची ठरली. १९५२पासून स्त्रिया अल्प प्रमाणात का होईना पण राजकारणात उतरल्या. उमेदवार महिलांची संख्या कमी जरी असली तरी अधिकाअधिक राजकीय होण्याच्या दृष्टीने पहिले पथदर्शी पाऊल ठरले. यामधून स्त्रियांचे राजकीय नेतृत्व आकारास येऊ लागले. 'सरोजिनी नायडू, कमलादेवी चटोपाध्याय, अरुणा असफ अली, मॅडम कामा, गोदावरी परुळेकर, अहिल्या रांगणेकर, विमल रणदिवे, विमल चक्रवर्ती, गीता मुखर्जी, मृणाल गोरे, प्रमिला दंडवते, उषा मेहता यांचे सुरुवातीच्या प्रमुखप्रवाही राजकारणाशी कायम नाते राहिले.'[२०] अशा नामवंत स्त्रियांनी केवळ तत्कालीन स्वातंत्र्य विषयक जबाबदाऱ्या सांभाळल्या नाही तर स्वातंत्र्यानंतर मोठमोठ्या राजकीय पदावर गेल्या. स्वातंत्र्योत्तर काळात भारतीय राजकारणातील स्त्रीनेत्या म्हणून इंदिरा गांधी, सोनिया गांधी, प्रतिभा पाटील, शीला दीक्षित, ममता बॅनर्जी, मायावती,

जयललिता, फूलन देवी, जयललिता, उमाभारती, सुषमा स्वराज, वसुंधरा राजे, मीरा कुमारी, राबड़ी देवी, प्रियांका गांधी यांचे राजकीय कर्तृत्व सर्वपरिचित आहे. महाराष्ट्रात सुद्धा असे राजकीय महिला नेतृत्व अलीकडील काळात उदयास येताना दिसते. सुप्रिया सुळे, प्रणिती शिंदे, वर्षा गायकवाड, नवनीत राणा, यशोमती ठाकुर, भावना गवळी इत्यादी. अशा प्रकारे स्त्री नेत्रुत्वाचा उदय काही प्रमाणात आनंद देणारा आहे. पण उल्लेखनीय म्हणजे यापैकी बऱ्याच स्त्रिया ह्या घराणेशाहीच्या वारसदार म्हणून राजकारणात सक्रीय आहेत. स्वबळावर राजकीय रिंगणात उतरलेल्या फार कमी महिला आहेत.

एकंदरीत स्त्रियांच्या राजकीय प्रवासाचा आढावा घेताना असे म्हणता येईल की, सामाजिक सुधारणा चळवळीतून आणि समाजसुधारकांच्या प्रयत्नातून महिलांच्या सबलीकरणाला चालना मिळाली. महिलांचा सामाजिक दर्जा यामधून निश्चितच सुधारला. परंतु राजकीय समावेशनाची प्रक्रिया मात्र घडून आली नाही. स्वातंत्र्य प्राप्तीनंतर महिलांचा राजकारणात समावेश होईल, देशाचे प्रतिनिधित्व करण्याची संधी स्त्रियांना पुरुषांच्या बरोबरीत मिळेल असा आशावाद स्त्रियांमध्ये निर्माण झाला होता परंतु परिस्थितीत फारसा बदल झालेला दिसून येत नाही.

स्त्रियांच्या राजकीय सहभागातील आव्हाने

सामाजिक विषमता : (जात, धर्म, वर्ग, लिंग संदर्भात)

पुरुषसत्ताक, धर्माधिष्ठित, पारंपारिक अशा भारतीय समाज व्यवस्थेने स्त्रियांच्या बुद्धी व विवेकाचा वापर स्वतःच्या राजकीय

स्वार्थासाठी केलेला दिसून येतो. यामधून स्त्रिया प्रवाहाच्या बाहेर राहिल्या. '१९७५ साली आंतरराष्ट्रीय स्त्री वर्ष जाहीर झाले. जागतिक पातळीवर स्त्रीवादाची चर्चा सुरू झाली उदारमतवादी स्त्रीवाद, समाजवादी स्त्रीवाद, मार्क्सवादी स्त्रीवाद, जहाल स्त्रीवाद, उत्तर आधुनिक स्त्रीवादी असे विचार प्रवाह स्त्रीवादात उदयाला आले यातून महिलांच्या सबलीकरणाला गती मिळाली.'[२१] महिला सबलीकरणाचा विचार या विचारधारांत असल्यामुळे स्त्रिया सबलीकरणाला समजू लागल्या व सार्वजनिक तसेच खाजगी जीवनात स्वतःचे स्थान व दर्जा निर्माण करण्यासाठी धडपड करू लागल्या.

'महाराष्ट्र विधानसभा पातळीवर राजकीय सहभागाच्या संदर्भात महिला या सामाजिक घटकाला वगळण्याची प्रक्रिया १९६२ ते २००९ या अकरा निवडणुकांमध्ये घडली आहे. हा महिला पुरुष अशा भेदभावाचा परिणाम आहे. लिंग भेदाखेरीज जात व वर्ग या दोन घटकांचाही परिणाम अकरा निवडणुकावर झाला आहे.'[२२] महिलांचा राजकारणात प्रवेश वाढीस लागावा म्हणून कौटुंबिक, राजकीय, सामाजिक, शैक्षणिक, आर्थिक, सांस्कृतिक, पातळीवर ज्या प्रमाणात प्रयत्न होणे गरजेचे होते, त्या प्रमाणात भारतात प्रयत्न होत असलेले दिसून येत नाही. लिंगाधारित जात व पुरुषसत्तेच्या अभ्यासक उमा चक्रवर्ती असे म्हणतात की, 'भारतीय इतिहासात महिलांचा केवळ सामाजिक दर्जा काय आहे, यामध्ये मालमत्ता हक्क, विवाह कायदा, धार्मिक प्रश्न यासारख्या मर्यादित प्रश्नांकडे लक्ष दिले जात होते.'[२३] अर्थातच पुरुषसत्ता, जात, वर्ग, लिंग हे विषय दुर्लक्षित राहिले. किंबहुना

ठेवले गेले.

खऱ्या अर्थाने महिलांचे राजकीय सक्षमीकरण करायचे असेल तर जातीय, धार्मिक, लिंगभावात्मक, राजकारण संपुष्टात येणे गरजेचे आहे. रूपकुवर, भवरी देवी, मथुरा, खैरलांजी, दिल्ली, कोपर्डी, कथुआ, उन्नाव, पायल तडवी, हिंगणघाट जळीत प्रकरण, डॉ. प्रियंका रेड्डी बलात्कार प्रकरण आणि अगदी अलीकडील हाथरसचे सामूहिक बलात्कार प्रकरण अशा जातीय, धार्मिक व लिंगभावाने प्रभावित मानसिकतेतून घडणाऱ्या हिंसाचारावर आवाज उचलण्यासाठी संसदेत महिलांचे प्रतिनिधित्व अपूर्ण आहे. लिंगभेदावर आधारित श्रम विभागणी, घरकाम, स्त्रियांच्या न्यायाबाबत होत असलेला दुजाभाव, वैवाहिक व कौटुंबिक कायदे, संपत्ती, वारसा हक्क, कुटुंब नियोजन, गरिबी, उपासमार, शिक्षण पाणी, ऊर्जा, शेती, मालमत्ता, सातबारा, अन्नसुरक्षा आरोग्य, निर्णय प्रक्रियेतील अनुपस्थिती, या सर्व अदृश्य प्रश्नांना दृश्य करण्यासाठी स्त्रियांचा राजकीय सहभाग अत्यंत तोकडा आहे. कारण कुटुंब आणि समाज अजूनही स्त्रियांना स्वतंत्रपणे विचार करू देण्यास पोषक असे वातावरण देत नाही. त्यामुळे त्या समाजात दुय्यम होत जातात. सामाजिक दुय्यमतेमुळे राजकीय परीघावर दूर दूरपर्यंत स्त्रिया दिसत नाहीत. स्त्रियांवरील हिंसा संपुष्टात आणायच्या असतील तर समताधिष्ठित समाज निर्माण होणे गरजेचे आहे आणि अर्थातच ही जबाबदारी शासनाने घेणे महत्त्वाची आहे. पण तसे होताना दिसत नाही, कारण हिंसा आणि सत्ता यांचा फार निकटचा संबंध असतो. यामध्ये स्त्रियांचे आयुष्य पणाला लागले असते.

स्त्रियांच्या राजकीय सहभागाकडे मर्यादित चौकटीत न पाहता जात, वर्ग आणि लिंगभाव, पुरुषसत्ता या घडणीतून पाहणे महत्त्वाचे आहे. जाती आणि लिंगभाव यांचा अभ्यास करणाऱ्या अभ्यासक वीणा पुनाचा त्यांच्या एका संशोधनात असे म्हणतात की, उच्च जातीतील महिलांवर अत्याचार होतात तेव्हा त्याची दखल गांभीर्याने घेतली जाते. आणि ह्याच घटना खालच्या जातीतील स्त्रियांसोबत घडल्या तर प्रशासन आणि राजकारण तितकी दखल घेत नाही.[२४] याअर्थी महिला अत्याचाराच्या मुळाशी असलेले राजकारण ओळखणे गरजेचे आहे. मुलींच्या जडणघडणी मध्ये कुटुंबव्यवस्थेची मोठी भूमिका असते. स्वातंत्र्य, हक्क अधिकार, न्याय या मुल्यांची ओळख तिला कुटुंबातच झाली तर ती समाजात आत्मविश्वासाने जगू शकते. पण कुटुंब आणि तेथील स्त्रीपुरुष नाते संबंध हेच मुळात असमानतेवर आधारित आहेत. 'धर्म, जात, विवाह, कुटुंब आणि स्त्रीपुरुष नातेसंबंध तसेच पुरुषी परिप्रेक्ष्यातून निर्माण झालेले हितसंबंध या वातावरणात स्त्रीमुक्तीची दिशा कोणती असावी याचा संभ्रम निर्माण होण्याच्या खूप शक्यता असतात.'[२५] यादृष्टीने कुटुंबातील पारंपारिक प्रतिकांमध्ये स्त्रियांना अडकवून ठेवण्याचे राजकारण प्रथमतः घराघरातून थांबणे गरजेचे आहे. प्रख्यात समाजशास्त्रज्ञ शर्मिला रेगे असे म्हणतात की, भारतीय समाजाच्या जात, वर्ग, समुदाय आणि लिंगभाव या प्रमुख वैशिष्ट्यपूर्ण घटकांची गुंतागुंत आहे. स्त्रियांचे आयुष्य जात, वर्ग आणि धार्मिक समुदायांच्या सीमारेषेवर असतात. आणि म्हणूनच स्त्रिया अनेकदा जाती, वर्ग, समुदाय यांच्यातील फरक दाखविणाऱ्या दृश्य खुणा

असतात.'[२६] धर्म, जात आणि लैगिकतेची गुंतागुंत हीच मुळात एक राजकीय खेळी आहे. धर्माच्या नावाखाली स्त्रियांचे होत असलेले शोषण हे शोषण समजले जात नाही तर स्त्रियांचे कर्तव्य म्हणून पाहिले जाते. स्त्रियांच्या धार्मिक भावना वाढीस लागाव्या यादृष्टीने धार्मिक सण, उत्सवांचे आयोजन राजकीय पक्षांच्या पुढाकार – पाठिंब्याने केले जाते. परंतु यामागे केवळ मतांचे राजकारण असते, आणि त्यासाठी स्त्रियांचा वापर केला जातो. पण प्रत्यक्ष अधिकार व न्याय देताना मात्र धार्मिक श्रद्धा, अंधश्रद्धा, धर्मग्रंथ, लिंगभाव यांच्या प्रभावाखाली निर्णय दिले जातात. 'लिंगभाव संदर्भातील असमानतेची व्याप्ती ही अपेक्षेपेक्षा अधिकच तीव्र होत चालली आणि वेगवेगळ्या क्षेत्रात स्त्रियांची प्रगती होण्याऐवजी अधोगतीच झालेली दिसून येत आहे. या अधोगतीस लिंगभाव, जाती, वर्ग, धर्म वंश जबाबदार आहेत.'[२७] यावरून असे म्हणता येईल की, जाती, वर्ग, धर्म, वंश, लिंग या आधारावर स्त्रिया विभाजित केल्या जातात, धर्म, परंपरा व समाजाने घालून दिलेले नियम पाळणे स्त्रियांना बंधनकारक असतात. आणि राजकारण याला अपवादात्मक स्थितीत विरोध करते.

पुरुषसत्तेचा प्रभाव

भारतीय समाजाचा इतिहास पुरुष प्रधान संस्कृतीत विकास पावलेला आहे. त्यामुळे पुरुष प्रधान तत्त्वांचा प्रभाव समाजव्यवस्थेवर दिसून येतो. ज्यामुळे स्त्रिया सर्वच क्षेत्रात दुय्यम ठरत गेल्या. यातूनच काही क्षेत्रे पुरुषांची मक्तेदारी म्हणूनच

उदयाला आली. ज्यात राजकारण हे अत्यंत महत्त्वाचे असे क्षेत्र आहे. 'भारतीय समाजात इतिहास पाहता काही राजघराण्यातील स्त्री सदस्य वगळता इतर सर्वसामान्य स्त्रिया राजकारणापासून व राजकीय सहभागा पासून अनभिज्ञ व विन्मुख राहिल्या. त्यांचा राजकारणाशी अर्थाअर्थी संबंध नव्हता.'[२८]

Women, Political parties and social movements in South Asia २००५ या विषयावरील अहवालात अमृता बसू यांनी असे निष्कर्ष नोदविले की, 'भारतातील बहुतांश राजकीय पक्ष हे पुरुषवर्चस्व असलेले पक्ष आहेत. ते स्त्रिया आणि त्यांच्या हिताकडे दुर्लक्ष करतात. खरे तर भारतीय राजकारणात स्त्रियांनी उच्चपदस्थ आणि महत्त्वाच्या भूमिका बजावल्या आहे. २०१४च्या सार्वत्रिक निवडणुकांमध्ये ९३.६ टक्के स्त्रियांचे डिपॉझीट सुद्धा पक्षाला वाचविता आले नाही. आणि याबाबतीत कोणताच राजकीय पक्ष गंभीर दिसत नाही.'[२९] १९५२पासून तर २०१९च्या सर्वच सार्वत्रिक निवडणुका ह्या स्त्रीप्रधान कधीच राहिल्या नाही. कारण पितृसत्ताक व्यवस्थेचा भाग येथील राजकारण आणि राजकीय संस्था, शासन संस्था आणि पक्ष हे सर्वच आहे. 'राजकारण हे पुरुषांचे क्षेत्र मानत त्यातल्या स्त्रिया तिथे अपघातानेच पोचल्या आहेत असे समजून अपवादात्मक ठरवल्या गेल्या किवा पुरुषाची उपमा देऊन त्याचे समर्थन केले गेले (इंदिरा गांधी त्यांच्या मंत्रिमंडळातील एकमेव पुरुष आहेत असे कौतुकाने म्हटले जायचे!)'[३०] पुरुष प्रधानव्यवस्थेचे प्राबल्य असलेल्या राजकीय व्यवस्थेमध्ये फार अल्प स्त्रियांनी शिरकाव केला आहे. केट मिलेट म्हणते की, आपला समाज पितृसत्ताक आहे येथील

लष्कर, उद्योग, तंत्रज्ञान, विद्यापीठ, राजकीय कार्यालय, वित्त, इतकंच नव्हे तर शक्तीची स्थाने पुरुषांच्या हातात आहे.[३१] केट मिलेटचे विचार येथील पुरुषसत्तेवर अचूक बोट ठेवतात.

'भारतीय स्त्रियांची एकूण शैक्षणिक स्थिती, अनुभव व क्षमता लक्षात घेता; देशातल्या सर्वात उच्च अशा कायदेमंडळात आरक्षणाच्या आधारावर निवडून आलेल्या स्त्रियांना संसदेचे कामकाज पेलणार नाही असे काहींचे मत आहे. काहींच्या मते आरक्षणामुळे संसदेत बीबी बेटींची फौज प्रवेश करेल.'[३२] मंत्रिमंडळात महिलांना खाते वाटप करतानादेखील एक किंवा दोन कॅबिनेट खाती महिलांकडे दिली जातात तसेच तीन चार राज्यमंत्री खाती महिलांकडे दिली जातात. यावरून असे म्हणता येते की, 'विधिमंडळातील सत्तेवर पुरुषांचे नियंत्रण होते. विधिमंडळातील सत्तेचे स्वरुप पुरुषी वर्चस्वाचे गेल्या साठ वर्षात राहिले आहे.'[३३] प्रसिद्ध अर्थतज्ज्ञ नोबेल पारितोषिक विजेते अमर्त्य सेन त्यांच्या आशियाई देशातील 'मिसिंग विमेन'च्या अभ्यासात असे म्हणतात, 'या राष्ट्रातील पुरुषांच्या तुलनेत महिलांच्या गळतीचे प्रमाण आकडेवारी देऊन येथील सामाजिक आणि सांस्कृतिक परिस्थिती जगासमोर आणली.'[३४] या गळतीमागे 'पुरुषसत्ता' आहे असे विधान सेन करतात. राजकारणातील पुरुषी वर्चस्वामुळे अनेक सक्षम अशा स्त्री राज्यकर्त्यांना राजकारणाच्या बाहेर जावे लागले. या क्षेत्रात कोणत्याच प्रकारे समानतेचे तत्त्व पाळले जात नाही त्यामुळे स्त्रिया राजकीयदृष्ट्या सत्ताहीन होतात.

महिलांना संधीची समानता दिली गेली नाही. नागरिक या

नात्याने संसाधने आणि सुविधा यांच्या संदर्भात निर्णय घेण्याचा अधिकार नाकारण्यात आला. संसाधने आणि सुविधा यांच्या वितरणामध्ये हेराफेरीचे सूक्ष्म तत्त्व यामुळे राहिले सहभागाच्या संधींमधूनच राजकीय क्षमतांचा विकास होणार होता, तोही नाकारण्यात आला.'[३५] यावरून हे स्पष्ट होते की, समानता या मुल्याची जोपासना करण्यात आपला समाज कमी पडतोय हे स्पष्ट होत चालले आहे.

राजकीय अभ्यासक प्रमिला जाधव यांनी जेव्हा राजकीय क्षेत्रात सक्रीय असलेल्या बीड जिल्ह्यातील स्त्रियांच्या राजकीय अनुभवावर आधारित चर्चा केली तेव्हा त्यांना मिळालेली उत्तरे विचार करण्यासारखी आहेत. 'स्त्रियांना पुरुषांकडून संधी दिली जाते का? असा महत्त्वाचा प्रश्न विचारला असता केवळ २५ टक्के महिलांनी होय असे उत्तर दिले. तर ७५ टक्के महिलांनी नाही असे उत्तर दिले. मग राजकारणात तुम्ही सहभागी कसे झालात? असा एक प्रश्न विचारला असता आरक्षणामुळे नाईलाजास्तव संधी दिली जाते. असे त्यांनी स्पष्ट केले. आरक्षण दिले नसते तर स्त्रियांना राजकारणात संधीच मिळाली नसती. स्त्रियांच्या राजकारणात सहभाग होत नाही असाही प्रश्न विचारला असता, ७५ टक्के महिलांनी पुरुष प्रधान संस्कृती याला जबाबदार आहे, असे ठामपणे सांगितले.'[३६]

महिलांना राजकीय क्षेत्रामध्ये पुरुषांकडून संधी उपलब्ध करून दिली जात नाही असे ७५ टक्के महिलांचे आहे. यावरून पुरुषांना अडचण निर्माण होते व अन्य दुसरा कोणता पर्याय राहत नाही त्यावेळेस नाईलाज म्हणून महिलांना पुरुषांकडून संधी प्राप्त

होताना दिसते. असे निष्कर्ष या अभ्यासात नोंदविण्यात आले आहे.

महिलांचे राजकीय सक्षमीकरण

'भारतीय राज्यघटनेचा सरनामा, मूलभूत हक्क व मूलभूत कर्तव्य व मार्गदर्शक तत्त्वे यामध्ये स्त्री पुरुष समानता हे तत्त्व व्यक्त होते. राज्यघटना केवळ महिलांना सोबती याची शाश्वती देत नाही तर राज्यसंस्थेने प्रसंगी किंमत मोजूनही महिलांच्या सार्वजनिक हिताचा विचार केला पाहिजे अशी भूमिका घेते. यासाठी राज्यसंस्थेला अधिकार राज्यघटना देते.[३७] याच अधिकाराचा वापर करून संसदेने महिलांना राजकीयदृष्ट्या सक्रीय करण्याचे प्रयत्न नक्की केले. परंतु ते अत्यंत तुटपुंजे होते. १९९०नंतर काही पक्षांनी महिलांना पक्षात सक्रीय करण्याचा प्रयत्न केलेला दिसतो. त्यासाठी त्यांनी महिलांच्या आघाड्या निर्माण केल्या. याचा परिणाम असा झाला की, बहुसंख्येने स्त्रिया राजकारणात दिसू लागल्या. परंतु हा सहभाग सुद्धा उच्च जातीच्या स्त्रियांच्या बाबतीतच घडून आलेला दिसतो. विशेष म्हणजे केवळ मतांचे राजकारण यामधून करण्यात आले. त्यामुळे महिला राजकारणाच्या निर्णय निर्धारण प्रक्रियेत सक्रीय झाल्या नाही. वीणा मुजुमदार यांनी, '१९७५ या वर्षात 'महिलांचा दर्जा'या विषयावर संशोधन करून एक विस्तृत अहवाल तयार केला. या अहवालामुळे स्त्रियासंबंधीचे अतिशय विदारक चित्र समोर आले आणि यातूनच स्त्रियांच्या आरक्षणाचा मुद्दा समोर आला.'[३८]

Representation of Women in Lok Sabha 1952-2014 [४३]

Table No. 1

Representation of Women in Lok Sabha 1952-2014			
Lok Sabha	Total No. of Seats	Women members	Percentage %
1952	489	22	4.49
1957	494	27	5.46
1962	494	34	6.88
1967	523	31	5.92
1971	521	22	4.22
1977	544	19	3.49
1980	544	28	5.14
1984	544	44	8.08
1989	529	28	5.29
1991	509	36	7.07
1996	541	40	7.39
1998	545	44	8.07
1999	543	48	8.83
2004	543	45	8.28
2009	543	59	10.86
2014	543	61	11.23

Source: Election Commission of India, New Delhi.

Notes: *Including one nominated member.

Table No. 2

Women Members of Rajya Sabha

Year	Numbers	Percentage
1952	15	06.94
1954	17	07.79
1956	20	08.62
1958	22	09.52
1960	24	10.25
1962	18	07.62
1964	21	08.97
1966	23	09.82
1968	22	09.64
1970	14	05.85
1972	18	07.40
1974	18	07.53
1976	24	10.16
1978	25	10.24
1980	29	11.98
1982	24	10.16
1984	24	10.24
1986	28	11.98
1988	25	10.59
1990	24	10.34
1992	17	07.29
1994	20	08.36
1996	19	07.81
1998	19	07.75
2000	22	09.01
2002	25	10.20
2004	28	11.43
2006	25	10.41
2008	23	09.50

Table No.3

Representation of Women MPs/MLAs state-wise: [४४]

Elected from House/Assembly	Total voters in the House/ Assembly	No. of Men MPs/MLAs	% of Men MPs/MLAs	Total Women MPs/MLAs	% of Women MPs/MLAs
Loksabha	543	484	89%	59	11%
Rajysabha	244	210	90 %	28	10%
Uttar Pradesh	403	371	92%	32	8%
Maharashtra	288	277	96%	11	4%
West Bengal	294	260	72%	34	12%
Andhra Pradesh	294	260	88%	34	12%
Bihar	243	209	86%	34	14%
Tamil Nadu	234	217	93%	17	7%
Madhya Pradesh	230	205	89%	25	11%
Gujarat	182	166	91%	16	9%
Karnataka	224	221	99%	03	1%
Rajasthan	200	172	86%	28	14%
Odisha	147	140	95%	07	5%
Kerala	140	133	95%	07	5%
Assam	126	112	89%	14	11%
Jharkhand	81	73	90%	08	10%
Punjab	117	103	88%	14	12%
Chhattisgarh	90	79	88%	11	12%
Haryana	90	81	90%	09	10%
Jammu & Kashmir	87	84	97%	03	3%
Uttrakhand	70	65	93%	05	7%
NCT of Delhi	70	67	94%	03	6%
Himachal Pradesh	68	63	93%	05	7%
Tripura	60	57	95%	03	5%
Manipur	60	57	95%	03	5%
Meghalaya	60	59	97%	01	3%
Goa	40	39	98%	01	3%
Nagaland	60	60	100%	00	0%
Puducherry	30	30	100%	00	0%
Arunachal Pradesh	60	58	97%	02	3%
Mizoram	40	40	100%	00	0%
Sikkim	32	28	88%	04	13%

भारतीय संसदेने २२ डिसेंबर १९९२ रोजी आरक्षण विधेयकाला मान्यता दिली. ७३ व ७४वी घटना दुरुस्ती २४ एप्रिल १९९३ रोजी अस्तित्त्वात आली. 'या घटनादुरुस्ती अन्वये त्रिस्तरीय पंचायतीमध्ये व नगरपालिका, महानगरपालिका या संस्थांमध्ये स्त्रियांसाठी त्यात ३३ टक्के जागा आरक्षित ठेवण्यात आल्या. हे आरक्षण केवळ सर्वसाधारण जागांसाठीचे नव्हते तर स्त्रियांसाठी ३३ टक्के अधिकारपदे महापौर-उपमहापौर नगराध्यक्ष सरपंच जिल्हा परिषद अध्यक्ष राखीव ठेवण्यात आली.'[३९] या आरक्षणामुळे महिलांचा राजकारणातील सहभाग निश्चितच वाढला. परंतु लोकसंख्येच्या प्रमाणात हा सहभाग नव्हता. शासनाने महिला, अनुसूचित जाती व अनुसूचित जमाती यांना ५० टक्के आरक्षण देऊन पंचायत व महानगरपालिका यांच्या पातळीवर महिलांचा सहभाग वाढविला. मात्र विधानसभा व लोकसभा या पातळीवरही हे आरक्षण अद्याप पोहचू शकले नाही. '१९९३ साली स्थानिक स्वराज्य संस्थेत महिलांना ३३ टक्के जागा राखीव करण्याचा निर्णय घेतल्यानंतर काही समाजवादी पक्षाच्या नेत्यांनी या निर्णयाबद्दल नाराजी व्यक्त केली होती. महिलांच्या नावावर त्यांचे पती किंवा मुले राजकारण करतील, राजकीय पार्श्वभूमी असणाऱ्या कुटुंबातील महिलांनाच या निर्णयाचा फायदा होईल अशा प्रकारची टीका त्यावेळी केली गेली होती.'[४०] राजकारणात प्रभाव निर्माण होण्यासाठी प्रचंड राजकीय इच्छाशक्ती असावी लागते. जी इच्छाशक्ती महिलांकडे नसते. असा पुरुषांचा समज आहे. ना. नीलम गोऱ्हे (उपसभापती, विधानपरिषद) यांनी, विधानसभेमध्ये महिला आरक्षणाबाबत

महिला सरपंचाना कायद्याचे संरक्षण देण्याचा विधेयक मांडताना काही घटना सभागृहात नोंदविल्या होत्या. ती निरीक्षणे अशी की, ज्या गावामध्ये महिला सरपंच आहे, त्या गावातील प्रमुख दबाव गटाप्रमाणे महिला सरपंच काम करत नसतील तर महिला सरपंचाने घेतलेल्या विकासाच्या निर्णयावर एक दोन वर्षातच अविश्वासाचा ठराव मांडला जातो. पुणे जिल्ह्यातील आंबेगाव तालुक्यातील धोंडमाळ या गावी श्रीमती वत्सलाबाई काळे ही महिला सरपंच का झाली म्हणून त्यांच्यावर अविश्वासाचा ठराव आणला. त्यावेळेपासून सातत्याने वेगवेगळ्या मुख्यमंत्र्यांनी आश्वासने दिली होती की, महिला सरपंचाना आम्ही कायद्याचे संरक्षण देण्याचा प्रयत्न करू.[४१] पण अजून कोणत्याही प्रकारची सुरक्षा महिला सरपंचाना मिळालेली नाही. निवडून आलेल्या स्त्रियांना पुरुषांच्या दबावात काम करावे लागते, हे या घटनेवरून स्पष्ट होते.

'सरकार संसदेत ३० टक्के जागा महिलांसाठी राखीव ठेवण्यात याव्यात यासाठी तयार करण्यात आलेल्या बिलाला खूपच विरोध आहे स्त्रियांच्या सक्षमीकरणासाठी जागा राखीव ठेवणे हा उपाय असू शकतो का? ती एक आपली थोडीशी केलेली वरवरची मलमपट्टी आहे याविषयी चर्चा सर्वत्र चालू आहे. स्त्रियांच्या बाजूने शासनाने उभे राहिल्याचा दावा अगदीच तुटपुंजा किंवा मर्यादित आहे विशेषतः धोरणाचा मसुदा किंवा विधानसभेतील किंवा लोकसभेतील छोट्या-मोठ्या गोष्टींचा पुरते मर्यादित आहे.'[४२] यावरून महिलांच्या राजकीय सत्तेच्या समान सहभागाबत शासन उदासीन असल्याचे निर्देशनास येते.

लोकसभेतील महिला प्रतिनिधित्वाचे प्रमाण गेल्या ७० वर्षापासून फारसे वाढलेले दिसून येत नाही. मागील ५० वर्षातील हे प्रमाण ३.४% ते ६.७% इतक्या प्रमाणात राहिलेले दिसते. १९८४-८५मध्ये संख्या प्रमाण वाढलेले दिसत असले तरी ते जास्त नाही. नंतर २००९ आणि २०१४मध्ये महिलांची राजकीय टक्केवारी वाढली असे लक्षात येत असले तरी लोकसंख्येच्या प्रमाणात ही वाढ नाही.

लोकसभेप्रमाणेच वरिष्ठ सभागृह म्हणजे राज्यसभा इथे सुद्धा चित्र सारखेच आहे. लोकसभेच्या तुलनेत प्रमाण जास्त असले तरी पुरुषांच्या तुलनेत नक्कीच कमी आहे.

महिलांना राजकीय क्षेत्रातून वगळण्याची प्रक्रिया

वरील आकडेवारी स्त्री प्रतिनिधित्वाचे वास्तव चित्र दाखविते. १६व्या लोकसभेत केवळ ५४३ पैकी केवळ ५९ महिलांचा संसदेत समावेश आहे. म्हणजेच महिला केवळ ११ टक्केच आहेत. राज्यसभेत २४४ सदस्यात २८ स्त्रिया खासदार आहेत यावरून लक्षात येते की, राजकारणात पुरुषांचे प्रमाण आणि मक्तेदारी किती मोठ्या प्रमाणात आहे. मिझोराम, नागालँड, पाँडिचेरी या राज्यांत महिलांना खातेही उघडता आले नाही. जम्मू काश्मीर, ओरिसा, केरळ येथील महिलांनी प्रथमच खाते उघडले. पुरोगामी समजल्या जाणाऱ्या महाराष्ट्रात सुद्धा राजकीय चित्र फारसे समाधानकारक नाही. जवळपास सर्वच घटकराज्यांमध्ये महिला प्रतिनिधित्व अल्प प्रमाणात आहे. 'महिला सबलीकरण उद्दिष्टांची पूर्ती करायची असेल तर महिलांना राजकीय प्रक्रियेचा

सर्व पातळ्यांवर होणाऱ्या निर्णय प्रक्रियांमध्ये सहभागी करून घेतले पाहिजे. प्रत्येक पातळीवरील निर्णय निश्चितीच्या मंडळावर महिलांना समान संधी व पूर्ण सहभाग मिळाला पाहिजे. कायदेमंडळ, कार्यकारी मंडळ, न्यायमंडळ, सहकार, सल्लागार, समित्या, मंडळे, विश्वस्त संस्था यासारख्या महत्त्वाच्या संस्थांच्या निर्णय प्रक्रियेत महिलांना अधिकार असले पाहिजे.'[४५] परंतु असे होताना दिसत नाही. निवडून आल्यानंतर सत्तेचा मोह आणि कुरघोडीचे राजकारण यामध्ये सर्वच पक्ष व्यस्त असतात. याचे परिणाम असे की, सरपंच पदापासून राजकारणाची सुरवात करीत असलेल्या स्त्रिया विधानसभा, विधान परिषद, लोकसभा राज्यसभा अशा सत्तेच्या केंद्रस्थानी असलेल्या गृहात किती प्रमाणात पोहचू शकल्या हा खरोखरच संशोधनाचा विषय आहे. 'गेली पन्नास वर्षे स्त्रियांच्या राजकीय सहभागाच्या बाबतीत भेदभावाचे प्रकार दिसून येत आहेत. सर्व प्रकारच्या निर्णयक्षम संस्थांमध्ये स्त्रियांना वगळणे आणि खालच्या आर्थिक वर्गाची आणि ग्रामीण स्त्रियांची राजकीय प्रक्रियेमध्ये पूर्ण अनुपस्थिती दिसत आहे.'[४६]

निष्कर्ष

स्त्रियांना समानतेचा दर्जा मिळावा, निर्णय निर्धारण प्रक्रियेमध्ये सहभाग वाढावा, सत्तेतील सहभाग वाढावा या अनुषंगाने राज्यघटनेने बहाल केलेली साधने पुरेशी आहेत. या आधारावर स्त्रिया सामाजिक क्षेत्रात सक्रिय झालेल्या दिसतात. उदा. महागाई विरोधी आंदोलने, विद्रोही आंदोलन, आदिवासी आंदोलन,

पर्यावरण, पाणी प्रश्नांचे आंदोलन, भूमिहीनांचे आंदोलन, शेतकरी आंदोलन, सामाजिक अत्याचार विरोधी आंदोलन, दारूबंदी, हुंडाबळी, दलित महिलांवरील अत्याचार विरोधी आंदोलन, अंधश्रद्धा निर्मुलन आंदोलन, स्त्रीमुक्ती आंदोलन, नागरिकत्वाशी संबंधित मुस्लिम स्त्रियांनी केलेले शाहीनबाग येथील आंदोलन इत्यादि अनेक अशा आंदोलनातून स्त्रियांचा सहभाग वाढलेला दिसतो. पण यासर्व प्रश्नांची उकल ज्या राजकीय व्यवस्थेतून होते, तिथे मात्र स्त्रिया मोठ्या संख्येने पोहचल्या नाही. राजकीय प्रतिनिधित्वामध्ये पुरुष आणि महिला यांच्यातील समान नेतृत्वाचे तत्त्व पाळण्यात येत नाही, हे स्पष्टपणे म्हणता येईल. निवडणुकांमध्ये राजकीय पक्ष महिलांचे संघटन करताना दिसत असले तरी स्वतंत्रपणे महिला राजकारणात सक्षम होण्याच्या दृष्टीने म्हणावे तितके ते गंभीर नाहीत. भारतीय संविधानाने समतेच्या अधिकारात जात, वंश, धर्म, पंथ, लिंग या आधारावर कुठेही भेदाभेद केला जाणार नाही अशी हमी दिली असताना सुद्धा उघडउघडपणे राजकारणात लिंगभेद बघायला मिळतो. हा प्रश्न जातीय, धार्मिक, तसेच लिंगभाव पातळीवर अधिक जटिल होत चाललेला आहे. स्त्रियांच्या राजकीय सहभागाबाबत शासन फारसे गंभीर दिसत नाही. स्त्रियांना अजूनही कौटुंबिक जबाबदारीमधून बाहेर पडता येणे शक्य होत नाही. राजकीय चर्चा, आंदोलने, निवडणुका, भाषणे, राजकीय संवाद, राजकीय घडामोडी यापासून स्त्रिया फार लांब आहेत. स्त्रियांना राजकारणातलं काय कळतं असे म्हणणारे पुरुष संख्येने जास्त आहेत. ज्या स्त्रिया राजकारणात सक्रीय आहेत त्यांची अनेक

प्रकारे अवहेलना केली जाते. समाज माध्यमांवर त्यांना ट्रोलिंग केले जाते. राजकारणातील भ्रष्टाचार, स्पर्धा, हेवेदावे, जातीय व धार्मिक संघर्ष, चढाओढ, झुंडशाही, लोकशाहीचे अवमूल्यन या सर्वांमध्ये स्त्रिया स्वतःला टिकवून ठेवू शकत नाही. स्त्रियांना राजकीयदृष्ट्या पोषक असे वातावरण या क्षेत्रात मिळत नाही. त्यामुळे राजकारणापासून स्त्रिया दूर राहतात व सत्ताहीन होत जातात.

यासर्व चर्चेमधून शेवटी हे सिद्ध होते की, समकालीन राजकारणातील स्त्रिया कमी अधिक प्रमाणात सामाजिक रचनेच्या बळी आहेत. लिंगधिष्ठितता ही सामाजिक आणि राजकीय रचनांमध्ये महत्त्वाचे परिवर्तक म्हणून काम करते आहे. त्यामुले स्त्रिया दिवसेंदिवस राजकीयदृष्ट्या अधिक सत्ताहीन आणि दुय्यम ठरत आहे. समाजाचे जसजसे आधुनिकीकरण होईल तसतसे स्त्रियांचे समाजातील स्थान उंचावेल असा विश्वास घटनाकारांना होता. परंतु एकंदरित स्त्रियांच्या प्रश्नाकडे बघता लक्षात येते की, स्त्रीप्रश्नाची व्यापकता दिवसेंदिवस रुंदावत आहे. 'लैगिक विषमतावादी गैरसमज आणि भेदभाव केला गेल्याने समकालीन समाजामध्ये सर्व ठिकाणी स्त्रिया दुय्यम बनविल्या जातात.'[४७] हे दुय्यमत्व समूळ नष्ट करायचे असेल तर स्त्रियांनी बिगर राजकीय राहून चालणार नाही हे त्यांनी समजले पाहिजे.

आपण आधुनिक झालो असलो तरी लिंगभाव पातळीवर अजूनही मागासलेले आहोत. केट यंग यांनी म्हटल्याप्रमाणे, सर्व प्रकारच्या साधनसामुग्रीच्या मालकी पासून स्त्रियांना वंचित ठेवले जाते.आणि सामाजिकरणातून त्यांना दुय्यम स्थान

स्वीकारण्यास भाग पाडले जाते.[४८] स्त्रियांना राजकारणात अजिबातच स्थान नाही असे म्हणता येणार नाही. केंद्रस्थानी असलेल्या सत्तेला स्त्रियांच्या प्रश्नांकडे लक्ष वेधून घेणे ही स्त्रियांची जबाबदारी आहे. आणि यासाठी स्त्रियांना राजकीय व्यवस्थेत प्रत्यक्ष सहभागी होणे गरजेचे आहे. राजकीय सत्तेसाठी संविधान हा मार्ग अत्यंत सविनय तसेच उदारमतवादी आहे. महिलांच्या राजकीय सहभागाने स्त्री प्रश्नांकडे गांभीर्याने बघितले जाईल. विषमता रहित स्त्री-पुरुष समानतेवर आधारित लोकशाही समताधिष्ठित समाजनिर्मितीसाठी सर्वच क्षेत्रातील लिंगभाव नष्ट होणे गरजेचे आहे. त्यासाठी महिलांनी सुद्धा राजकीय सत्तेच्या सहभागासाठी पुढे येणे गरजेचे आहे.

संदर्भसूची

१. मोहिनी कारंडे (संपा.)'स्त्री सक्षमीकरण विविधांगी प्रवास' 'महिलांचे राजकीय सबलीकरण', वैशाली पवार, मैत्री पब्लिकेशन, पुणे, १४ एप्रिल २०१६.

२. गेल ऑम्वेट , "Women in Governance In South Asia' EPW ऑक्टोबर २९, २००५, पृ. ४७४६

३. स्वाती देहाडराय, अनघा तांबे (संपा.) 'भारतातील स्त्रिया एक ओळख' प्रकाशक, क्रांतिज्योती सावित्रीबाई फुले, स्त्री अभ्यास केंद्र, सावित्रीबाई फुले पुणे विद्यापीठ, पुणे

४. Niroj Sinha ,'Women In Politics' Gyan Publishing House, New Delhi, २००६ , पृ. ११-१२

५. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. ३७

६. प्रशांत अमृतकर, 'स्त्रियांनी राजकारण पंचायतराज संस्थेतील स्त्री सहभाग'

चिन्मय प्रकाशन, औरंगाबाद २०१४, पृ.१३
७. स्त्रीवादी सामाजिक विचार' विद्युत भागवत, डायमंड पब्लिकेशन, पुणे प्रथमावृत्ति २००८ पृ.२.
८. वंदना भागवत, अनिल सपकाळ, गीताली वि. मं. (संपा.) संदर्भासहित स्त्रीवाद: स्त्रीवादाचे समकालीन चर्चाविश्व, शब्द पब्लिकेशन, प्रथमावृत्ति १२ जानेवारी २०१४, 'अधिकाअधिक राजकीय होताना' किरण मोघे, पृ.३८९.
९. वृषाली देशपांडे, 'महिला आणि राजकारण', पुण्यनगरी, रविवार,१३ ऑक्टोबर २०१९
१०. Sohin Pal And Anupama Mehata, "Where are the women? in political power is still a mail domain' June ०४/२०१६
११. आ.ह.साळुंखे, 'हिंदू संस्कृती आणि स्त्री' लोकवाङ्मय गृह मुंबई, जानेवारी २०१७, पृ.२
१२. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. ११६
१३. गेल आम्वेट, 'ज्योतिबा फुले आणि स्त्री मुक्तीचा विचार', लोकवाङ्मय गृह मुंबई, १९९०
१४. वंदना भागवत, अनिल सपकाळ, गीताली वि. मं. (संपा.) संदर्भासहित स्त्रीवाद : स्त्रीवादाचे समकालीन चर्चाविश्व, शब्द पब्लिकेशन, प्रथमावृत्ति १२ जानेवारी २०१४, 'अधिकाअधिक राजकीय होताना' किरण मोघे संदर्भासहित स्त्रीवाद पृ.३८६
१५. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. १९
१६. तत्रैव, १९
१७. तत्रैव, १२१
१८. तत्रैव, १२१
१९. अरुणा सबाने, 'डॉ. आंबेडकर आणि स्त्री', आकांक्षा प्रकाशन, नागपूर, पृष्ठ १५१,

२०. संदर्भासहित स्त्रीवाद : स्त्रीवादाचे समकालीन चर्चाविश्व, वंदना भागवत, अनिल सपकाळ, गीताली वि.मं. (संपा.) शब्द पब्लिकेशन, प्रथमावृत्ति १२ जानेवारी २०१४, 'अधिकाअधिक राजकीय होताना' किरण मोघे संदर्भासहित स्त्रीवाद पृ.३८७
२१. सुमंत यशवंत, 'मिळून साऱ्याजणी', पुणे १९९९
२२. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. ९२
२३. उमा चक्रवर्ती, "Conceptualizing Brahmanical Patriarchy in Early India. Gender, Cast, Class and State
२४. वीणा पुनाचा, "Challenging Caste and Gender Ideologies', EPW November २९,२००३, रिसिश, ५०४७
२५. संदीप सारंग/ वंदना महाजन (संपा.), 'कल्चरली करेक्ट' ग्रंथाली प्रकाशन, मुंबई, प्रथम आवृत्ती १० मार्च २०१८, पृष्ठ १७
२६. शर्मिला रेगे, 'स्त्री: असलेली घडवलेली आणि दाखवलेली, दिवाळी अंक ,१९९७
२७. स्वाती देहाडराय, अनघा तांबे (संपा.) 'भारतातील स्त्रिया एक ओळख' प्रकाशक: क्रांतिज्योती सावित्रीबाई फुले स्त्री अभ्यास केंद्र, सावित्रीबाई फुले पुणे विद्यापीठ, पुणे
२८. प्रशांत अमृतकर, 'स्त्रियांनी राजकारण पंचायतराज संस्थेतील स्त्री सहभाग' चिन्मय प्रकाशन, औरंगाबाद २०१४, पृ, १३
२९. Dr. Vibhuti Patel and Radhika khajuria Political Feminism in India An Anlaysis of Actors Debates and Strategies page 13,14,https://www.academia.edu/28071852/ Political Feminism in India An Anlaysis of Actors Debates and Strategies
३०. वंदना भागवत, अनिल सपकाळ, गीताली वि. मं. (संपा.) 'संदर्भासहित स्त्रीवाद : स्त्रीवादाचे समकालीन चर्चाविश्व', शब्द पब्लिकेशन, प्रथमावृत्ति १२ जानेवारी २०१४, 'अधिकाअधिक राजकीय होताना' किरण मोघे, पृ.३८८

३१. Editor Niroj Sinha, Women In Indian Politics " Patriarchy, Politics -nd Women' Gyan Publishing House New delhi, २००६, पृ. ४४
३२. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. १०७
३३. तत्रैव,१०७
३४. गेल ऑम्वेट , "Women in Governance In South Asia' EPW , ओक्टोंबर २९, २००५, पृ. ४७४६
३५. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. ९५
३६. प्रमिला जाधव, 'स्थानिक स्वराज्य संस्थेत महिलांचा सहभाग व सामाजिक परिवर्तन' चिन्मय प्रकाशन, औरंगाबाद, पृ, १२५
३७. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. १३५
३८. भारती पाटील, 'स्त्रिया: समाज आणि राजकारण', हर्मिस प्रकाशन, पुणे, २०१४, पृ. ८१
३९. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. १४१
४०. प्रमिला जाधव, 'स्थानिक स्वराज्य संस्थेत महिलांचा सहभाग व सामाजिक परिवर्तन' चिन्मय प्रकाशन, औरंगाबाद, पृ १२१,१२२
४१. नीलम गोऱ्हे, ' विधान परिषद व माझे कामकाज' पद्मगंधा प्रकाशन, पुणे जून २००८, पृ.१४०,१४१
४२. योगिनी वेंगुर्लेकर, 'सामाजिक चळवळी आणि सरकार', डायमंड पब्लिकेशन, पुणे, २००९, पृ. ३२७
४३. Election Commission of India, New Delhi. Table no.1 to 2
४४. https://adrindia.org/sites/default/files/WomensrepresentationsamongsallsMPssandsML-ssEnglish.pdf

४५. वैशाली पवार, 'महिलांच्या सत्ता संघर्षाचा आलेख', डायमंड पब्लिकेशन पुणे, २०१२, पृ. १३७
४६. रेहाना घडियाली, 'समकालीन भारतातील नागरी स्त्रिया', डायमंड पब्लिकेशन, पुणे २००८, मराठी अनुवाद : मंजुषा गोसावी, पृ.३८८
४७. वंदना सोनालकर, शर्मिला रेगे, 'पितृसत्ता व स्त्रीमुक्ती' प्रकाशक, दिलीप चव्हाण नाना क्रांतीसिंह पाटील अकादमी अहमदनगर २००७. पृ, १७
४८. भारती पाटील, 'स्त्रिया: समाज आणि राजकारण', हर्मिस प्रकाशन, पुणे, २०१४, पृ. ६१

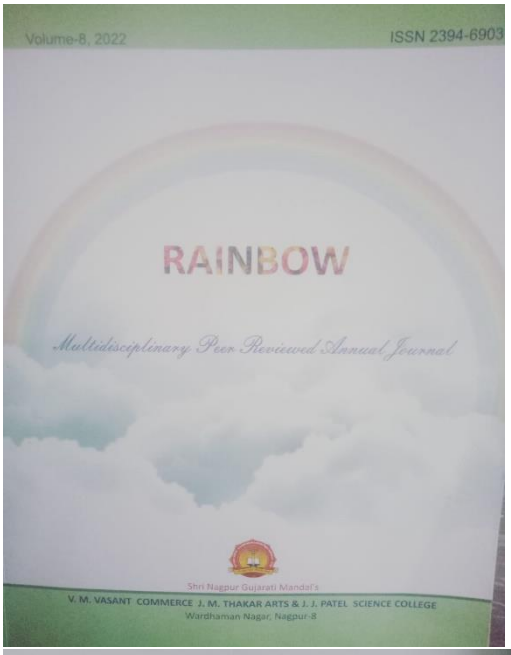
संशोधन

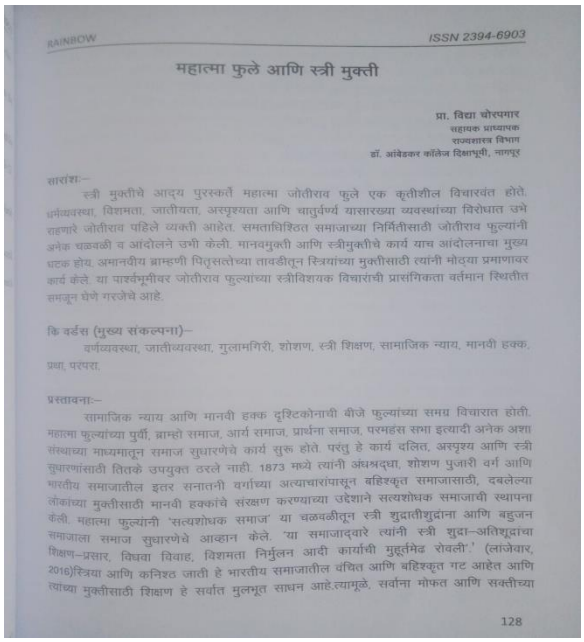
ब्रिटिशकालीन धोरणे व कोळी महादेव उठाव

विलास दुंदा गवारी

प्राचीन काळापासून आदिवासी जमाती भौगोलिकदृष्ट्या विशिष्ट प्रदेशात वास्तव्य करतात. त्यांची स्वतःची वेगळी संस्कृती, बोली भाषा, निसर्गावर आधारीत जीवनशैली, चालीरिती, देवदेवता, शेतीपद्धती व समाजव्यवस्था आहे. आजही हे जमात समूह इतर समुदायांच्या सामाजिक आणि आर्थिक व्यवस्थांपासून अलिप्त आहेत. वसाहतकाळात त्यांना जंगली जमाती (forest tribe) किंवा डोंगरी जमाती (hill tribe) म्हणून ओळखले जात असे. भारतीय राज्य घटनेत त्यांचा उल्लेख अनुसूचित जमाती (Scheduled tribe) असा करण्यात आला आहे. भारतीय राज्यघटनेतील कलम ३४२ नुसार भारतात ७०३ जमाती निश्चित केल्या आहेत. (गायकवाड, २०२१, पृ. ४५) महाराष्ट्रात ४५ आदिवासी जमातींचे वास्तव्य असून यातील गोंड, कोळी महादेव, भिल्ल, ठाकर, वारली, कोकणा या काही महत्त्वाच्या जमाती आहेत.

लेखक मुंबई विद्यापीठाच्या इतिहास विभागात संशोधक आहेत.
ईमेल- vilas.gawari79@gmail.com





महात्मा फुले आणि स्त्री मुक्ती

प्रा. विद्या चोरपगार
सहायक प्राध्यापक
राज्यशास्त्र विभाग
डॉ. आंबेडकर कॉलेज दिक्षाभूमी, नागपूर

सारांशः–

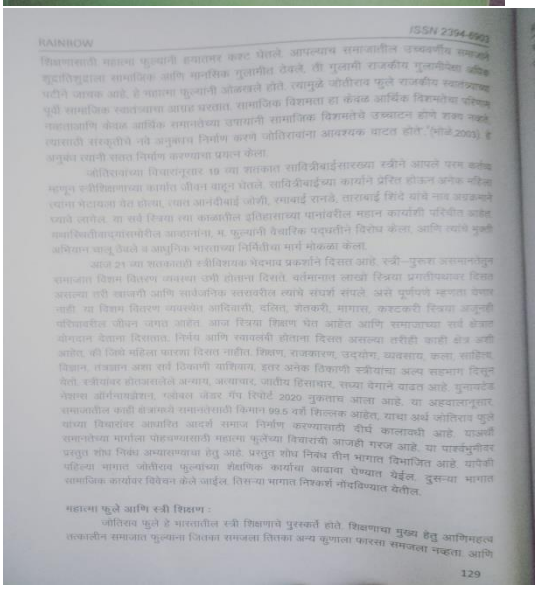
स्त्री मुक्तीचे आद्य पुरस्कर्ते महात्मा जोतीराव फुले एक कृतीशील विचारवंत होते. धर्मव्यवस्था, विशमता, जातीयता, अस्पृश्यता आणि चातुर्वर्ण्य वासरख्या व्यवस्थांच्या विरोधात उभे राहणारे जोतीराव पहिले व्यक्ती आहेत. समताधिष्ठित समाजाच्या निर्मितीसाठी जोतीराव फुल्यांनी अनेक चळवळी व आंदोलने उभी केली. मानवमुक्ती आणि स्त्रीमुक्तीचे कार्य याच आंदोलनाचा मुख्य घटक होय. अमानवीय ब्राम्हणी पितृसत्तेच्या तावडीतून स्त्रियांच्या मुक्तीसाठी त्यांनी मोठया प्रमाणावर कार्य केले. या पार्श्वभूमीवर जोतीराव फुल्यांच्या स्त्रीविशयक विचारांची प्रासंगिकता वर्तमान स्थितीत समजून घेणे गरजेचे आहे.

कि वर्डस (मुख्य संकल्पना)–

वर्णव्यवस्था, जातीव्यवस्था, गुलामगिरी, शोशण, स्त्री शिक्षण, सामाजिक न्याय, मानवी हक्क, प्रथा, परंपरा.

प्रस्तावनाः–

सामाजिक न्याय आणि मानवी हक्क दृश्टिकोनाची बीजे फुल्यांच्या समग्र विचारात होती. महात्मा फुल्यांच्या पूर्वी, ब्राम्हो समाज, आर्य समाज, प्रार्थना समाज, परमहंस सभा इत्यादी अनेक अशा संस्थांच्या माध्यमातून समाज सुधारणेचे कार्य सुरू होते. परंतु हे कार्य दलित, अस्पृश्य आणि स्त्री सुधारणांसाठी तितके उपयुक्त ठरले नाही. 1873 मध्ये त्यांनी अंधश्रद्धा, शोशण पुजारी वर्ग आणि भारतीय समाजातील इतर सनातनी वर्गाच्या अत्याचारांपासून बहिश्कृत समाजासाठी, दबलेल्या लोकांच्या मुक्तीसाठी मानवी हक्कांचे संरक्षण करण्याच्या उद्देशाने सत्यशोधक समाजाची स्थापना केली. महात्मा फुल्यांनी 'सत्यशोधक समाज' या चळवळीतून स्त्री शुद्रातीशुद्रांना आणि बहुजन समाजाला समाज सुधारणेचे आव्हान केले. 'या समाजाद्वारे त्यांनी स्त्री शुद्रा–अतिशूद्रांचा शिक्षण–प्रसार, विधवा विवाह, विशमता निर्मुलन आदी कार्याची मुहूर्तमेढ रोवली'.' (लाजेवार, 2016)स्त्रिया आणि कनिश्ठ जाती हे भारतीय समाजातील वंचित आणि बहिश्कृत गट आहेत आणि त्यांच्या मुक्तीसाठी शिक्षण हे सर्वात मुलभूत साधन आहे.त्यामूळे, सर्वांना मोफत आणि सक्तीच्या



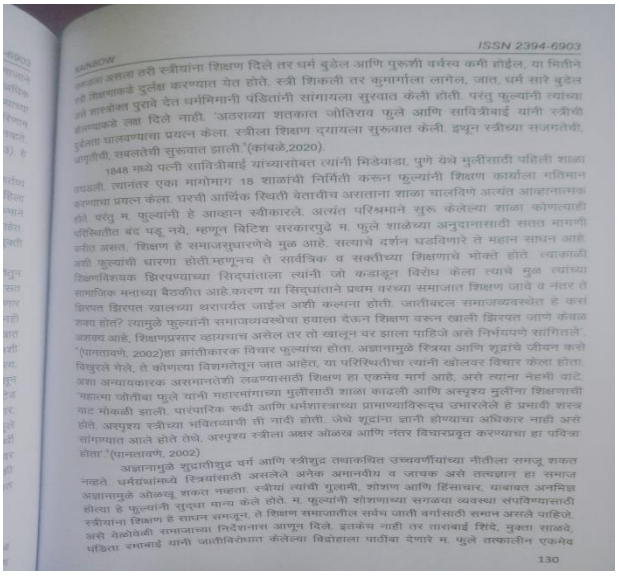
शिक्षणासाठी महात्मा फुल्यांनी हयातभर कष्ट घेतले, आपल्याच समाजातील उच्चवर्णीय समाजाने शुद्रातीशुद्रांना सामाजिक आणि मानसिक गुलामीत ठेवले, ती गुलामी राजकीय गुलामीपेक्षा अधिक घातीने जास्त आहे, हे महात्मा फुल्यांनी ओळखले होते. त्यामुळे जोतीराव फुले राजकीय स्वातंत्र्याच्या पूर्वी सामाजिक स्वातंत्र्याचा आग्रह धरतात. सामाजिक विशमता हा केवळ आर्थिक विशमतेचा परिणाम नसतानाही केवळ आर्थिक समानतेच्या उपायांनी सामाजिक विशमतेचे उच्चाटन होणे शक्य नाही, त्यासाठी संस्कृतीचे नवे अनुकरण निर्माण करणे जोतिरावांना आवश्यक वाटत होते."(भोळे,2003). हे अनुकरण त्यांनी सतत निर्माण करण्याचा प्रयत्न केला.

जोतिरावांच्या विचारानुसार 19 व्या शतकात सावित्रीबाईसारख्या स्त्रीने आपले परम कर्तव्य म्हणून स्त्रीशिक्षणाच्या कार्यात जीवन वाहून घेतले. सावित्रीबाईंच्या कार्याने प्रेरित होऊन अनेक महिला एपुढे येताना दिसतात. त्यात आनंदीबाई जोशी, रमाबाई रानडे, ताराबाई शिंदे यांचे नाव अग्रक्रमाने घ्यावे लागेल. या सर्व स्त्रिया त्या काळातील इतिहासाच्या पानांवरील महान कार्याशी परिचीत आहेत. त्यांनीसुद्धा सामाजिक आव्हानांना, म. फुल्यांनी वैचारिक पद्धतीने विरोध केला, आणि त्यांचे मुक्ती अभियान पुढे चालले व आधुनिक भारताच्या निर्मितीचा मार्ग मोकळा केला.

आज 21 व्या शतकातही स्त्रीविशयक भेदभाव प्रकर्शाने दिसत आहे. स्त्री–पुरूश असमानतेतून समाजात विशम वितरण व्यवस्था उभी होताना दिसते. चर्चामध्ये लाखो स्त्रिया प्रगतीपथावर दिसत असल्या तरी खालची आणि सार्वजनिक क्षेत्रातील त्यांचे संघर्श संपले, असे पूर्णपणे म्हणता येणार नाही. या विशम वितरण व्यवस्थेत आदिवासी, दलित, शेतकरी, मागास, कष्टकरी स्त्रिया अजूनही परिघावरील जीवन जगत आहेत. आज स्त्रिया शिक्षण घेत आहेत आणि समाजाच्या सर्व क्षेत्रात योगदान देताना दिसतात. निर्णय आणि स्थानिक पातळीची होताना दिसत असल्या तरीही काही क्षेत्र अशी आहेत, की जिथे महिला चारचा दिसत नाहीत. शिक्षण, राजकारण, उद्योग, व्यवसाय, कला, साहित्य, विज्ञान, तंत्रज्ञान असा सर्व ठिकाणी चालिल्य, इतर अनेक ठिकाणी स्त्रीयांचा अल्प सहभाग दिसून येते. स्त्रीयांवर होतअसलेले अन्याय, अत्याचार, जातीय हिंसाचार, सध्या वेगाने वाढत आहे. युनायटेड नेशन्स वीमेनप्रोग्रेस, ग्लोबल जेंडर गॅप रिपोर्ट 2020 नुकताच आला आहे, या अहवालानुसार, समाजातील काही क्षेत्रामध्ये समानतेसाठी किमान 99.5 वर्शे लागणार आहेत, याचा अर्थ जोतिराव फुले यांच्या विचारांवर आधारित आदर्श समाज निर्माण करण्यासाठी दीर्घ कालावधी आहे. याअर्थी समानतेच्या मार्गाला पोहचण्यासाठी महात्मा फुलेंच्या विचाराची आजही गरज आहे. या पार्श्वभुमीवर प्रस्तुत शोध निबंध अभ्यासण्याचा हेतु आहे. प्रस्तुत शोध निबंध तीन भागात विभाजित आहे. यापैकी पहिल्या भागात जोतीराव फुल्यांच्या शैक्षणिक कार्याचा आढावा घेण्यात येईल. दुसऱ्या भागात सामाजिक कार्यावर विवेचन केले जाईल. तिसऱ्या भागात निश्कर्श नोंदविण्यात येतील.

महात्मा फुले आणि स्त्री शिक्षण :

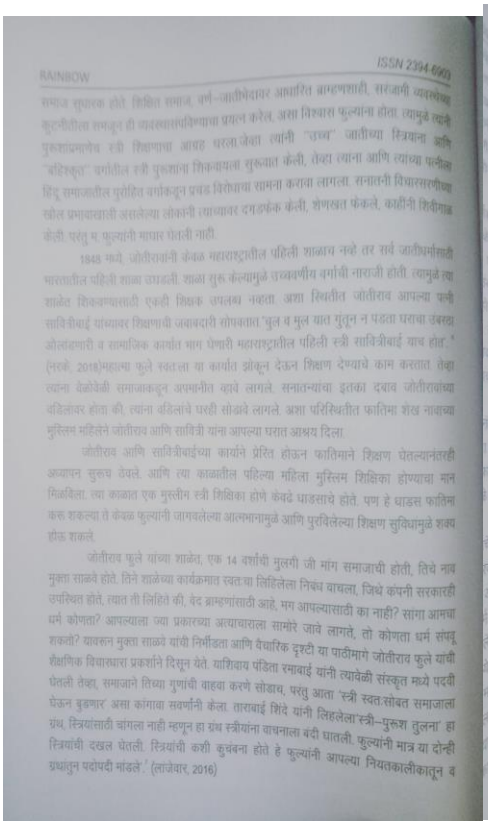
जोतिराव फुले हे भारतातील स्त्री शिक्षणाचे पुरस्कर्ते होते. शिक्षणाचा मुख्य हेतु आणिमहत्व तत्कालीन समाजात फुल्यांना जितका समजला तितका अन्य कुणाला फारसा समजला नव्हता. आणि



जातला असला तरी स्त्रीयांना शिक्षण दिले तर धर्म बुडेल आणि पुरूशी वर्चस्व कमी होईल, या भितीने त्या शिक्षणाकडे दुर्लक्ष करण्यात येत होते. स्त्री शिकली तर कुमार्गाला लागेल, जात, धर्म सारे बुडेल अशी शास्त्रांचा पुराणे देत धर्ममिमांसी पंडितांनी सांगायला सुरवात केली होती, परंतु फुल्यांनी त्यांच्या शंकाकडे लक्ष दिले नाही. 'अठराव्या शतकात जोतिराव फुले आणि सावित्रीबाई यांनी स्त्रीची दुर्दशा घालवण्याचा प्रयत्न केला. स्त्रीला शिक्षण दयायला सुरुवात केली. इथून स्त्रीच्या सजगतेची जागृतीची, सबलतेची सुरुवात झाली."(कांबळे,2020).

1848 मध्ये पत्नी सावित्रीबाई यांच्यासोबत त्यांनी भिडेवाडा, पुणे येथे मुलींसाठी पहिली शाळा उघडली. त्यानंतर एका मागोमाग 18 शाळांची निर्मिती करून फुल्यांनी शिक्षण कार्याला गतिमान करण्याचा प्रयत्न केला. घरची आर्थिक स्थिती बेताचीच असताना शाळा चालविणे अत्यंत आव्हानात्मक होते परंतु म. फुल्यांनी हे आव्हान स्वीकारले. अत्यंत परिश्रमाने सुरू केलेल्या शाळा कोणत्याही परिस्थितीत बंद पडू नये, म्हणून ब्रिटिश सरकारपुढे म. फुले शाळेच्या अनुदानासाठी सतत मागणी करीत असत. 'शिक्षण हे समाजसुधारणेचे मुळ आहे. सत्याचे दर्शन घडविणारे ते महान साधन आहे अशी फुल्यांची धारणा होती,म्हणूनच ते सार्वत्रिक व सक्तीच्या शिक्षणाचे भोक्ते होते. त्याकाळी शिक्षणविशयक शिरपण्याच्या सिद्धांताला त्यांनी जो कडाडून विरोध केला त्याचे मुळ त्यांच्या सामाजिक मनाच्या बैठकीत आहे.कारण या सिद्धांताने प्रथम वरच्या समाजात शिक्षण जावे व नंतर ते शिरपत झिरपत खालच्या थरापर्यंत जाईल अशी कल्पना होती. जातीबद्दल समाजव्यवस्थेत हे करणे शक्य होते? त्यामुळे फुल्यांनी समाजव्यवस्थेचा हयाला देऊन शिक्षण वरून खाली झिरपत जाणे केवळ अशक्य आहे, शिक्षणप्रसार व्हायचाच असेल तर तो खालून वर झाला पाहिजे असे निर्भयपणे सांगितले. "(पानतावणे, 2002)हा क्रांतीकारक विचार फुल्यांचा होता. अज्ञानामुळे स्त्रिया आणि शुद्रांचे जीवन कसे विखुरले गेले, ते कोणत्या विशमतेतून जात आहेत, या परिस्थितीचा त्यांनी खोलवर विचार केला होता. अशा अन्यायकारक असमानतेशी लढण्यासाठी शिक्षण हा एकमेव मार्ग आहे, असे त्यांना नेहमी वाटे. 'महात्मा जोतीबा फुले यांनी महारमांगाच्या मुलींसाठी शाळा काढली आणि अस्पृश्य मुलींना शिक्षणाची वाट मोकळी झाली. पारंपारिक रुढी आणि धर्मशास्त्राच्या प्रामाण्याविरूद्ध उभारलेले हे प्रभावी शस्त्र होते. अस्पृश्य स्त्रीच्या भवितव्याची ती नांदी होती. जेथे शुद्रांना ज्ञानी होण्याचा अधिकार नाही असे सांगण्यात आले होते तेथे, अस्पृश्य स्त्रीला अक्षर ओळख आणि नंतर विचारप्रवृत्त करण्याचा हा पवित्रा होता."(पानतावणे, 2002)

अज्ञानामुळे शुद्रातीशुद्र वर्ग आणि स्त्रीशुद्र तथाकथित उच्चवर्णीयांच्या नीतीला समजू शकत नव्हते. धर्मसंस्थांमध्ये स्त्रियांसाठी असलेले अनेक अमानवीय व जाचक असे तत्वज्ञान हा समाज अज्ञानामुळे ओळखू शकला नव्हता. स्त्रीया त्यांची गुलामी, शोशण आणि हिंसाचार, याबाबत अनभिज्ञ होत्या हे फुल्यांनी सुद्धा मान्य केले होते. म. फुल्यांनी शोशणाच्या सगळया व्यवस्था संपविण्यासाठी स्त्रीयांना शिक्षण हे साधन समजून, ते शिक्षण समाजातील सर्वच जाती वर्गासाठी समान असले पाहिजे, असे वेळोवेळी समाजाच्या निदर्शनास आणून दिले. इतकेच नाही तर ताराबाई शिंदे, मुक्ता साळवे, पंडिता रमाबाई यांनी जातीविरोधात केलेल्या विद्रोहाला पाठींबा देणारे म. फुले तत्कालीन एकमेव



समाज सुधारक होते. शिक्षित समाज, वर्ण-जातीभेदावर आधारित ब्राम्हणशाही, सरंजामी व्यवस्थेच्या कुटनीतीला समजून ही व्यवस्थासपविण्याचा प्रयत्न करेल, असा विश्वास फुल्यांना होता. त्यामुळे त्यांनी पुरुषांप्रमाणेच स्त्री शिक्षणाचा आग्रह धरला.जेव्हा त्यांनी "उच्च" जातीच्या स्त्रियांना आणि "बहिष्कृत" वर्गातील स्त्री पुरुषांना शिकायला सुरुवात केली, तेव्हा त्यांना आणि त्यांच्या पत्नीला हिंदू समाजातील पुरोहित वर्गाकडून प्रचंड विरोधाचा सामना करावा लागला. सनातनी विचारसरणीच्या स्रोत प्रभावासाठी असलेल्या लोकांनी त्यांच्यावर दगडफेक केली, शेणखत फेकले, काहींनी शिवीगाळ केली, परंतु म. फुल्यांनी माघार घेतली नाही.

1848 मध्ये, जोतीरावांनी केवळ महाराष्ट्रातील पहिली शाळाच नव्हे तर सर्व जातीधर्मांसाठी भारतातील पहिली शाळा उघडली. शाळा सुरू केल्यामुळे उच्चवर्णीय वर्गाची नाराजी होती. त्यामुळे त्या शाळेत शिकवण्यासाठी एकही शिक्षक उपलब्ध नव्हता. अशा स्थितीत जोतीराव आपल्या पत्नी सावित्रीबाई यांच्यावर शिक्षणाची जबाबदारी सोपवतात."धूल व मुल यात गुंतून न पडता पराचा उकरडा ओलांडणारी व सामाजिक कार्यात भाग घेणारी महाराष्ट्रातील पहिली स्त्री सावित्रीबाई याच होत." (नरके, 2018)महात्मा फुले स्वतःला या कार्यात झोकून देऊन शिक्षण देण्याचे काम करतात तेव्हा त्यांना वेळोवेळी समाजाकडून अपमानीत व्हावे लागले. सनातन्यांचा इतका दबाव जोतीरावांच्या वडिलांवर होता की, त्यांना वडिलांचे घरही सोडावे लागले. अशा परिस्थितीत फातिमा शेख नावाच्या मुस्लिम महिलेने जोतीराव आणि सावित्री यांना आपल्या घरात आश्रय दिला.

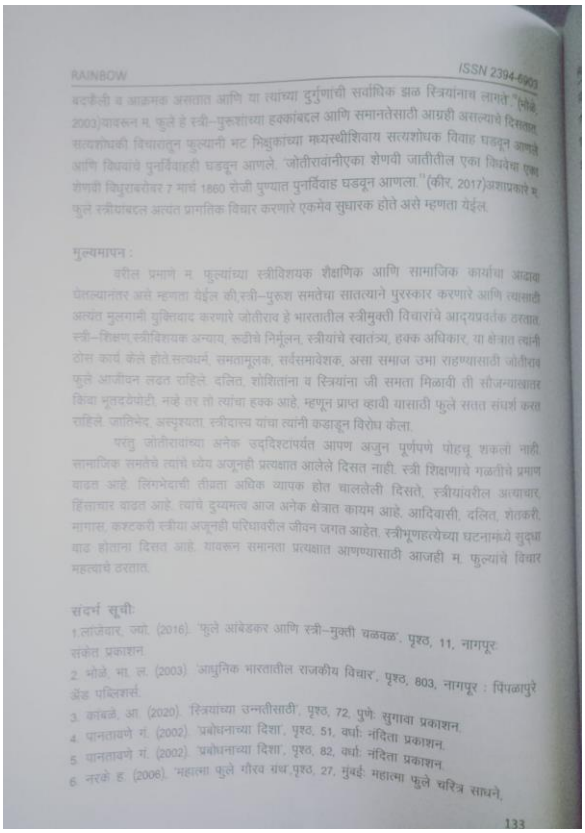
जोतीराव आणि सावित्रीबाईंच्या कार्याने प्रेरित होऊन फातिमाने शिक्षण घेतल्यानंतरही अध्यापन सुरुच ठेवले. आणि त्या काळातील पहिल्या महिला मुस्लिम शिक्षिका होण्याचा मान मिळविला. त्या काळात एक मुस्लीम स्त्री शिक्षिका होणे केवढे धाडसाचे होते. पण हे धाडस फातिमा करू शकल्या ते केवळ फुल्यांनी जागवलेल्या आत्मभानामुळे आणि पुरविलेल्या शिक्षण सुविधांमुळे शक्य होऊ शकले.

जोतीराव फुले यांच्या शाळेत, एक 14 वर्शीची मुलगी जी मांग समाजाची होती, तिचे नाव मुक्ता साळवे होते. तिने शाळेच्या कार्यक्रमात स्वतःचा लिहिलेला निबंध वाचला, जिथे कंपनी सरकारही उपस्थित होते, त्यात ती लिहिते की, वेद ब्राम्हणांसाठी आहे, मग आपल्यासाठी का नाही? सांगा आमचा धर्म कोणता? आपल्याला ज्या प्रकारच्या अत्याचाराला सामोरे जावे लागते, तो कोणता धर्म संपवू शकतो? यावरुन मुक्ता साळवे यांची निर्भीडता आणि वैचारिक दृष्टी या पाठीमागे जोतीराव फुले यांची शैक्षणिक विचारधारा प्रकर्शाने दिसून येते. याशिवाय पंडिता रमाबाई यांनी त्यावेळी संस्कृत मध्ये पदवी घेतली तेव्हा, समाजाने तिच्या गुणांची वाहवा करणे सोडाय, परंतु आता 'स्त्री स्वतःसोबत समाजाला घेऊन बुडणार' असा कांगावा सवर्णांनी केला. ताराबाई शिंदे यांनी लिहलेला"स्त्री–पुरुश तुलना" हा ग्रंथ, स्त्रियांसाठी चांगला नाही म्हणून हा ग्रंथ स्त्रीयांना वाचनाला बंदी घातली. फुल्यांनी मात्र या दोन्ही ग्रंथातुन पदोपदी मांडले." (लाजेवार, 2016)

महात्मा फुले आणि त्यांचे सामाजिक कार्य:

म. फुल्यांनी आपले संपूर्ण जीवन दलित, अस्पृश्य यांच्या उत्थानासाठी आणि सर्व स्त्री–पुरुशांच्या समान हक्कांसाठी समर्पित केले. भारतीय समाज वर्ण, जात, वर्ग आणि लिंग याआधारावर विभाजित असल्यामुळे भेदभाव आणि अन्यायाचे मूळ कारण आर्थिक नसून सामाजिक रचना आहे, असे जोतीराव फुले मानत असत.जोतीरावांना"गुलामगिरी" बद्दल प्रचंड चीड होती. त्यामुळे ते कोणत्याही भेदभावाच्याविरोधात उभे राहत असत. याच पार्श्वभूमीवर त्यांनी गुलामगिरी सारखा ग्रंथ लिहीला. "विधवांचे केशवपन, विधवा–पुनर्विवाहास बंदी, स्त्रियांचा हीन दर्जा आणि अज्ञान, त्यांचे शारिरीक व मानसिक शोशण या विरोधात पहिला आवाज या देशात जोतीरावांनी उठवला होता." (भोळे, 2003)

म. फुल्यांनी विधवा पुनर्विवाहाची मोहीम चालवली, बालविवाहाला विरोध केला, गरोदर ब्राम्हण विधवांना सामाजिक अपमान आणि कलंकापासून वाचवण्यासाठी प्रसूती गृह, बालहत्या प्रतिबंधक गृह सुरू केले. जोतीरावांनी काढलेल्या बालहत्या प्रतिबंधक गृहाबद्दल फेब्रुवारी 1871 च्या 'ज्ञानप्रकाश' मध्ये असे प्रसिद्ध करण्यात आले की, 'एका परोपकारी सद्गृहस्थाने गरोदर स्त्रिया आणि मुले यांना आश्रय देण्यासाठी एक स्वतंत्र घर बांधले आहे."(कीर, 2017)खरोखर, बालहत्या प्रतिबंधक गृहऊभे करून जोतीरावांनी ब्राम्हण विधवांची अब्रू वाचवली आणि त्यांना समाजाच्या छळापासूनही वाचविले. याच बालहत्या प्रतिबंधक गृहातून 1873 साली काशीबाई नावाच्या एका ब्राम्हण विधवेस मुलगा झाला. त्या मुलास जोतीरावांनी दत्तक घेतले, त्याचे नाव यशवंत. यशवंताचा फुले दाम्पत्यांनी अतिशय मायेने सांभाळ केला. केशवपन ही प्रथा स्त्रियांसाठी जाचक आणि अन्यायकारक असल्याचे ते मानत असत. त्यामुळे फुल्यांनी नारायण मेघाजी लोखंडे आणि पत्नी सावित्रीबाई यांच्यासमवेत 23 मार्च 1890 रोजी "केशवपन" हिंदू विधवांचा मुंडण विधी प्रथेविरूद्ध 500 नाईंचा संप पुकारला. म. फुल्यांनी सत्यशोधक विचारधारेतुन स्त्रियांचे प्रश्न हे कोणत्याच काळात सारखे नसल्याचे सातत्याने यावियशी प्रबोधन केले आहे. 'जोतीराव फुल्यांनी कुळंबिनीच्या अखंडामध्ये स्त्रियांचे प्रश्न हे वर्ण, जात,वर्ग आणि लिंग यावर आधारित केली होती'." (यव्हाण, 2014)म्हणजेच स्त्रियाचे प्रश्न हे वर्ण, जात,वर्ग आणि लिंग यावर आधारित विशमतेतून पुढे आले आहेत असे ते मानत असत.'जर एखादया जोडप्याला मुल झाले नाही तर, स्त्रीवर वांझोटेपणाचा आरोप करणे हे अत्यंत निर्दयपणाचे कृत्य, तिच्या पतीत वांझोटेपणाचे काही दोश नसतील कशावरून? असे आपले विचार जोतीराव स्वतंत्रपणे बोलून दाखवीत. 'अशा स्थितीत त्या स्त्रीने, 'मी दुसरा नवरा करणार आहे,' असे म्हटले तर तिच्या नवऱ्याला काय वाटेल? त्याला तो अपमान, मानखंडना वाटणार नाही काय? पुरुशाने पहिल्या पत्नी पासून मुल नाही म्हणून दुसरा विवाह करावा ही अत्यंत निश्ठूर आणि हृदयशून्य चाल आहे. असे जोतीरावांचे म्हणणे होते." (कीर, 2017)यावरून असे दिसते की, म. फुल्यांनी स्त्रियांशी संबंधित प्रत्येक अत्याचार आणि प्रथा नाकारल्या. स्त्री आणि पुरुश दोघांनाही एका निर्मिकाने निर्माण केले असून सारखेच अधिकारही दिले आहेत. त्यामुळे परस्परांच्या हक्कांबद्दल त्यांनी आदर बाळगावयास हवा, सर्व धर्मांची पुस्तके पुरुशांनी लिहिलेली असल्यामूळे त्यांचे न्याय्यहक्क तर ते त्यांना देतच नाही उलट पुरुश जास्त दृश्ट, लोभी,



बदकैली व आक्रमक असतात आणि या त्यांच्या दुर्गुणांची सर्वाधिक झळ स्त्रियांनाच लागते."(भोळे, 2003)यावरून म. फुले हे स्त्री–पुरुशांच्या हक्कांबद्दल आणि समानतेसाठी आग्रही असल्याचे दिसतात. सत्यशोधकी विचारातून फुल्यांनी भट भिक्षुकांच्या मध्यस्थीशिवाय सत्यशोधक विवाह घडवून आणले आणि विधवांचे पुनर्विवाहही घडवून आणले. 'जोतीरावांनीएका शेणवी जातीतील एका विधवेचा एका शेणवी विधुराबरोबर 7 मार्च 1860 रोजी पुण्यात पुनर्विवाह घडवून आणला."(कीर, 2017)अशाप्रकारे म. फुले स्त्रीयांबद्दल अत्यंत प्रागतिक विचार करणारे एकमेव सुधारक होते असे म्हणता येईल.

मुल्यमापन :

वरील प्रमाणे म. फुल्यांच्या स्त्रीविशयक शैक्षणिक आणि सामाजिक कार्याचा आढावा घेतल्यानंतर असे म्हणता येईल की,स्त्री–पुरुश समतेचा सातत्याने पुरस्कार करणारे आणि त्यासाठी अस्यंत मुलगामी युक्तिवाद करणारे जोतीराव हे भारतातील स्त्रीमुक्ती विचारांचे आद्यप्रवर्तक ठरतात. स्त्री–शिक्षण,स्त्रीविशयक अन्याय, रूढीचे निर्मूलन, स्त्रीयांचे स्वातंत्र्य, हक्क अधिकार, या क्षेत्रात त्यांनी ठोस कार्य केले होते.सत्यधर्म, समतामुलक, सर्वसमावेशक, असा समाज उभा राहण्यासाठी जोतीराव फुले आजीवन लढत राहिले. दलित, शोशितांना व स्त्रियांना जी समता मिळावी ती सौजन्याखातर किंवा भूतदयेपोटी, नव्हे तर ती त्यांचा हक्क आहे, म्हणून प्राप्त व्हावी यासाठी फुले सतत संघर्श करत राहिले. जातिभेद, अस्पृश्यता, स्त्रीदास्य यांचा त्यांनी कडाडून विरोध केला.

परंतु जोतीरावांच्या अनेक उद्दिश्टांपर्यंत आपण अजून पूर्णपणे पोहचू शकलो नाही. सामाजिक समतेचे त्यांचे ध्येय अजूनही प्रत्यक्षात आलेले दिसत नाही. स्त्री शिक्षणाचे गळतीचे प्रमाण वाढत आहे. लिंगभेदाची तीव्रता अधिक व्यापक होत चाललेली दिसते. स्त्रीयांवरील अत्याचार, हिंसाचार वाढत आहे. त्याचे दुश्परिणाम आज अनेक क्षेत्रात कायम आहे. आदिवासी, दलित, शेतकरी, मागास, कश्टकरी स्त्रीया अजूनही परिघावरील जीवन जगत आहेत. स्त्रीभूणहत्येच्या घटनांमध्ये सुद्धा वाढ होताना दिसत आहे. यावरून समानता प्रत्यक्षात आणण्यासाठी आजही म. फुल्यांचे विचार महत्त्वाचे ठरतात.

संदर्भ सूची:

1.लांजेवार, ज्यो. (2016). 'फुले आंबेडकर आणि स्त्री–मुक्ती चळवळ'. पृश्ठ, 11, नागपूर: संकेत प्रकाशन.

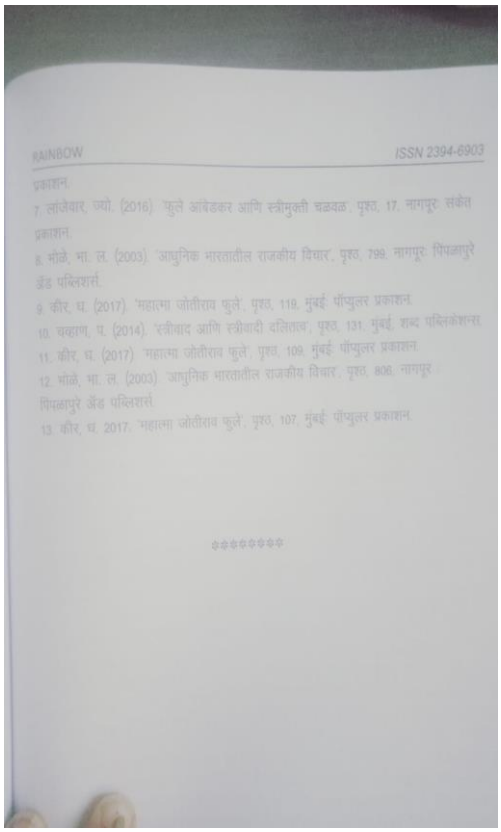
2. भोळे, भा. ल. (2003). 'आधुनिक भारतातील राजकीय विचार', पृश्ठ, 803, नागपूर : पिंपळापुरे ॲंड पब्लिशर्स.

3. कांबळे, आ. (2020). 'स्त्रियांच्या उन्नतीसाठी', पृश्ठ, 72. पुणे: सुगावा प्रकाशन.

4. पानतावणे गं. (2002). 'प्रबोधनाच्या दिशा', पृश्ठ, 51, वर्धा: नंदिता प्रकाशन.

5. पानतावणे गं. (2002). 'प्रबोधनाच्या दिशा', पृश्ठ, 82, वर्धा: नंदिता प्रकाशन.

6. नरके ह. (2006). 'महात्मा फुले गौरव ग्रंथ',पृश्ठ, 27, मुंबई: महात्मा फुले चरित्र साधने,



प्रकाशन.

7. लांजेवार, ज्यो. (2016). 'फुले आंबेडकर आणि स्त्रीमुक्ती चळवळ'. पृश्ठ, 17. नागपूर: संकेत प्रकाशन.

8. भोळे, भा. ल. (2003). 'आधुनिक भारतातील राजकीय विचार', पृश्ठ, 799. नागपूर: पिंपळापुरे ॲंड पब्लिशर्स.

9. कीर, ध. (2017). 'महात्मा जोतीराव फुले', पृश्ठ, 119. मुंबई: पॉप्युलर प्रकाशन.

10. यव्हाण, प. (2014). 'स्त्रीवाद आणि स्त्रीवादी दलितत्व', पृश्ठ, 131. मुंबई: शब्द पब्लिकेशन्स.

11. कीर, ध. (2017). 'महात्मा जोतीराव फुले', पृश्ठ, 109. मुंबई: पॉप्युलर प्रकाशन.

12. भोळे, भा. ल. (2003). 'आधुनिक भारतातील राजकीय विचार', पृश्ठ, 808. नागपूर : पिंपळापुरे ॲंड पब्लिशर्स.

13. कीर, ध. 2017. 'महात्मा जोतीराव फुले', पृश्ठ, 107. मुंबई: पॉप्युलर प्रकाशन.

****

ORIGINAL ARTICLE

Kluver- Barrera Demonstration of different apparatus of Olfactory System in *Garra mullya*

Ramdas S Bagade
Department of Zoology, Dr Ambedkar College,
Deekshabhoomi, Nagpur 440010

Abstract
The neuroepithelial surface of the olfactory organ is where receptor cells are stimulated to produce odour. It has an olfactory innervations. Fish use olfactory cues and signals for a number of life functions, such as communication, schooling, migration, feeding, and reproduction. We describe the olfactory system of G. mullya's light-microscopy structure in this paper. Throughout vertebrate evolution, the morphology of the olfactory bulb has remained largely consistent. The olfactory organ is the most important organ for chemosensation. It is paired in G. mullya and connected to the forebrain by medial and lateral olfactory pathways (smell and taste). It is therefore pedunculated. The olfactory rosette of this fish is oval in shape, with a central raphe from which the lamellae on either side radiate in a parallel pattern. The four concentric layers that make up the olfactory bulb are the outer olfactory nerve layer, glomerular layer, mitral cell layer, and innermost granular cell layer. The olfactory bulb contains the glomerular layer, mitral cells, granular cells, and nervus terminalis cells. Because it terminates on the first telecephalon by two fibres, the olfactory bulb is pedunculated.

Keywords : Kluver-Berrera, olfactory rosette, olfactory bulb, *Garra mullya*

IINTRODUCTION.

Olfaction is primarily produced by the stimulation of receptor cells on the olfactory organ's neuroepithelial surface. It is surrounded by olfactory nerve fibres (Hansen and Zeiske, 1998). Numerous fish life processes, including migration, communication, feeding, schooling, defence, and reproduction, depend heavily on olfactory signals and cues (Wilson, 2004; Camacho et al., 2010). The main and accessory olfactory systems in higher vertebrates can be separated into separate functional systems (Raisman, 1972). In teleosts, the olfactory system, which includes two olfactory rosette, olfactory bulbs, olfactory tracts, and olfactory lobes, is the main organ. The olfactory epithelium, which covers a large portion of the surface of the olfactory rosette, a structure found within the olfactory chambers, is where the olfactory receptor cells are situated on the fish rostrum. Although the size and shape of the rosette varies greatly across different species, in most instances it has a longitudinal ridge (raphe) with two rows of olfactory lamellae radiating from it, thus increasing its surface area enormously (Zeiske et al., 1992). Olfactory epithelium is a complex tissue comprising sensory and non-sensory epithelia. Sensory epithelium is located on the raphe and central region of the olfactory lamella in majority

of the species. The sensory epithelium is present in patches in some species also (Yamamoto, 1992).

Studies of the olfactory organ and bulb are carried out by some investigators (Hara, 1975; Ichikawa, 1976; Ichikawa and Ueda, 1977; Kosaka and Hama, 1979 a, b; Zeiskie *et al.*, 1979; Kleerekoper, 1982; Schreibman *et al.*, 1986; Hansen and Zeiske, 1998). In this work we are reporting the structure of olfactory system in *G. mullya* by light microscopy. Morphology of the olfactory bulb is rather consistent across vertebrate lineage. In teleosts, olfactory bulb comprises following concentric layers:(1) outer olfactory nerve layer (ONL),(2) glomerular layer (GL),(3) mitral cell layer (MCL) and(4) internal cell layer i.e. granular cell layer (GCL). In teleosts, only primary receptor cells are located in the olfactory mucosa i.e., axons of these cells represent the primary olfactory projections (fila olfactoria, olfactory nerve) and reach the glomerular layer of the olfactory bulbs (Nieuwenhuys and Meek, 1990). Secondary olfactory projections originate in the large mitral cells and run in the lateral and medial olfactory tracts. While the medial olfactory tract (MOT) appears to carry information related to sexual behavior, lateral olfactory tract (LOT) mediates feeding behavior and alerting responses (Hara, 1993).

MATERIALS AND METHODS

G. mullya is a migratory fish shows potamodromous migration. It is a macrosmatic fish with a predominantly developed olfactory organ (Singh, 1978). This fish is a annual breeder and breeds naturally in running water and is available throughout the year, can be transported and maintained under laboratory conditions easily and better suited for experimental purposes; therefore it was selected for the present study.

Kluver and Barrera (1953) technique:

Sections of olfactory organ with bulb were deparaffinised in xylene and passed up to 90% alcohol. They were stained in 0.1% solution of luxol fast blue in 90% alcohol for 4 to 7 hours at 57□C. Sections were rinsed in 90% alcohol to wash off an excess stain and brought down to distilled water through descending grades of alcohol, differentiated quickly in 0.1% lithium carbonate solution (1 dip only), then differentiated in 70% alcohol till sections became transparent off white and fibers remained bluishgreen in colour. Sections were washed thoroughly in distilled water and stained in 0.1% cresyl violet solution for hours then differentiated in several changes of 95% alcohol, dehydrated; cleared in xylene and mounted in DPX.

OBSERVATIONS

In *G. mullya* (Fig. 01), a pair of olfactory chambers is situated dorso-laterally on the snout region, anterior to the eyes. Olfactory chambers are connected with external environment through two separate nasal apertures (Fig. 02). Olfactory system is composed of olfactory rosette (OR) caudally connected by a short olfactory nerve (ON) to the olfactory bulb (OB). Olfactory bulb is caudally attached to the forebrain (Telencephalon) by a long medial olfactory tract (MOT) and a lateral olfactory tract (LOT) thus olfactory bulb is pedunculated in this fish (Fig.03). Each olfactory rosette is oval in shape and has a central raphe, from which radiate the lamellae on both the sides in parallel fashion (Fig. 04). The olfactory epithelium is folded to form the lamellae. 18 to 26 lamellae are observed. Each lamella is crescentic in shape and bears a linguiform process along its concave margin

(Fig.03). Each lamella is composed of epithelium which shows sensory and non-sensory regions (Fig.04). Sensory region is at the basal area having columnar pseudo-stratified cells and consists of ciliated olfactory receptor cells (cORC), microvillous olfactory receptor cells (mORC), columnar ciliated non-sensory cells (cNSC), polygonal columnar supporting cells (SC), small sized scanty mucous secreting goblet cells (GC) and oval basal cells (BC) (Fig.05 & 06). Non-sensory region is at apical area with stratified squamous type cells and consists of columnar ciliated non-sensory cells (cNSC), flattened, less cuboid epidermal cells (EC), large sized numerous mucous secreting goblet cells (GC) and basal cells (Fig.07). In the lamellae, epithelium encloses a central lumen called central core (Stromal sheet), which is separated by a basal lamina (BL) from the epithelium and is filled with loose fibers, blood vessels (BV), connective tissue (CT) and bundles of axon arising from the bottom of the receptor cells (Fig.06 & 07). The lamellae receive fascicles or fibers from basal end and extend into olfactory nerve. The olfactory nerve is short and connected caudally to olfactory bulb. The olfactory bulb is concentrically laminated four layered structure. Outer layer is olfactory nerve layer (ONL) which has axons of olfactory receptor cells (cORC). Below ONL, axons group together, forming glomeruli, called as glomerular layer (GL). The glomeruli innervate bigger sized neurons called mitral cells which constitute mitral cell layer (MCL). In the centre, densely packed small sized neurons are present, constituting internal cell layer also called as granular cell layer (GCL) (Fig.08 & 09). The fibers (axons) from the olfactory bulb forming primary olfactory nerve layer are intensely stained and innervate profusely forming glomerular structure to the large sized mitral cells which show moderate Niss'l staining. Smaller cells found in the innermost granular cell layer (GCL) show intense Niss'l staining (Fig. 09 & 10). Some cells are placed dorsomedial and ventromedial in position and exhibit intense staining. These are the giant cells of nervus terminalis (NT) (Fig.11). As the medial olfactory tract (MOT) and lateral olfactory tract (LOT) extend caudally from the olfactory bulb towards telencephalon, some fibers entering MOT and LOT are observed. These fibers show moderate Niss'l stain (Fig.12).

DISCUSSION

According to histology, the lamellar epithelium of G. mullya surrounds a central lumen known as the stromal sheet. In Etroplus suratensis, loose nerve fibres, blood vessels, and connective tissue are contained in a thin stromal sheet that is separated from the epithelium by a basal lamina (Ghosh and Chakrabarti., 2014). Lamellae in G. mullya radiate outward from the median raphe on both sides. On the olfactory lamellae of the sensory epithelium are the sensory and nonsensory areas. Varied species have different locations for these zones (Yamamota, 1982). The sensory region is located in the basal area, while the non-sensorial zone is at the apical area. However in the cyprinid *L. rohita* sensory region at the middle of lamella and non sensory region is at the proximal and basal region of lamella (Bhute *et al.*, 2007), in *Rhodeses amarus*, sensory region is at the base and middle of lamella and non sensory region is at the proximal end (Baby *et al.*, 2000), in *H. fossilis*, sensory region occupies middle of the lamellae (Masram, 2010) and in *O. striatus* (Khaparde, 2010) sensory region is at the proximal part of lamellae.

As in other teleosts, olfactory bulb comprises four layers from superficial to deep most: olfactory nerve layer (ONL), glomerular layer (GL), mitral cell layer (MCL) and innermost granular cell layer (GCL) in *G. mullya*. Similar as in *L. rohita* (Bhute, 2004),

H. fossilis (Masram, 2010) and *N. notopterus* (Patle and Baile, 2014). Olfactory fibers entered the olfactory bulb and peripherally form the olfactory nerve layer in *L .rohita* (Baile et al, 2008), *H. fossilis* (Masram and Baile, 2014) *N. notopterus* (Patle and Baile, 2014). These axons march inward and synapse with the dendrite of mitral cell in glomerular layer (Kosaka and Hama, 1982; Oka, 1983; Khan *et al.*, 1999; Bhute *et al.*, 2007 and Baile and Patle, 2014). Glomeruli are histologically distinct units that serve as the basic modules in the information processing (Shepherd, 1994) and as a relay station to several higher brain areas. Axons of mitral cells originate in the basal part of the soma, become myelinated after some distance (Kosaka and Hama, 1982) and project in the medial and lateral olfactory tracts (Fujita *et al.*, 1988). They terminate on various telencephalic areas (Satou, 1992). Same pattern of organization is observed in the present study. In the olfactory bulb of *G. mullya*, on ventromedial and dorsomedial side, giant cells of the nervus terminalis have been identified. These ganglion cells are also noted in *I. punctatus* (Bass,1981); *C. butrachus* (Khan *et al.*, 1998, 1999), *C. mrigala* (Biju *et al.*, 2003), *L. rohita* (Bhute *et al.*, 2007 and in *Channa gachua* (Baile and Patle, 2011).

Nervus terminalis neurons travel caudally via medial olfactory tract (MOT) and project to the retina, various brain areas and pineal organ suggesting their role in reproductive behavior, conduction of sex related olfactory stimuli and modulation of visual inputs to the brain (Stell *et al.*, 1984; Biju *et al.*, 2003; Singru *et al.*, 2003). The most highly appreciated organ for chemosensation (smell and taste) is the olfactory organ which is paired in *G. mullya*, connected to the forebrain by medial and lateral olfactory tracts and thus it is pedunculted. Olfactory rosette in this fish is oval in shape and has a central raphe, from which radiate the lamellae on both the sides in parallel fashion. Olfactory bulb comprises concentric four layers i.e outer olfactory nerve layer, glomerular layer, mitral cell layer and innermost granular cell layer. In the olfactory bulb: glomerular layer, mitral cells, granular cells and giant cells of nervus terminalis are observed. The olfactory bulb terminates on the foremost telecephalon by two tracts (LOT and MOT) and is thus pedunculated.

REFERENCES

Baby, S.M. Ueck, M. Prasada Rao, P.D. (2000). Gonadotropin releasing formone immuno reactive neurons and associates nicotimide adrnine nucleotide phosphate diaphorase positive neurons in the brain of teleosts, Rhodus amarus. General and comparative Endocrinology, 120:44-54.

Baile, V.V. and Patle, P. (2011). Cytoarchitectonic study of the brain of a dwary snake head, channa gachua (Ham). I. The telencephalon. Fish physiology and Biochemistry, 37:993-1004.

Baile, V.V. Rant, I.N. and Bhute, Y.V. (2008). Organization of olfactory system, foretrain and pituitary gland of teleost, Notopterus notopterus, Annals of Neurosciences, 15:43-50.

Bass, A.H. (1981 a.) Organization of the telencephalon in the channel carfish, Ictalurus punctatus. J. Morphol.169:71-90.

Bhute, Y.V. Masram, S.C. Rant, I.N. Baile, V.V. (2007). Cytoaschitectonic pattern of the olfactory system, Forebrain and pituitary gland of the Indian major carp, Labeo rohita. Annals of Neurosciences. Volume 14.2007.

Bhute, Y.V. (2004). Studies on olfactory organ and Hypothalamo-Hypophysial-Gonadal Axis in the male carp *Labeo rohita (Ham.).* Thesis for Ph.D. in R.T.M. Nagpur University.

Biju, K.C. Singru, P.S. Schreibman, M.P. Subhedar, N.K. (2003). Reproductive phae related expression of GnRG-like immunoreactivity in the olfactory recepter neurons, their projections to the olfactory bulb and in the nervous terminalis in the female Indian major carp *Cirrhinus mrigala (Ham*). *General and comparative Endocrinology*, **133:** 358-367.

Camacho, S. Ostos-Garrido, M.V. Domezain, A. Carmona, R. (2010). Study of the olfactory epithelium in the developing sturgeon characterization of the crypt cells. *Chemical senses*. **35**:147-156.

Fujita, I. Satou, M and Ueda, K. (1988). Morphology of physiologically identifies mitral cells in the carp olfactory bulb: a light microscopic study after intra cellular staining with HRP, J. Comp Neuro 1,267:253-268.

Ghosh, S.K and Chakrabarti, P. (2014). Histophysiological studies on the olfactory epithelium of Banded pearl spot Etroplus suratensis (Blch,1790). Journal of Entomology and Zoology studies. 2(1):78-82.

Hansen, A. and Zeiske, E. (1998). The peripheral olfactory organ of the zebra fish, *Danio rerio;* an ultrastructural study. *Chem. Senses*, **23**:39-48.

Hara, T.J. (1993). Chemoreception. In the physiology of fishe's, Eds. Evans, D.H. CRC Press, Boca raton, PP:191-218.

Hara.T.J. (1994). The diviersity of chemical stimulation in fish olfaction and gestation. *Reviews in Fish Biology and Fisheries*, **41-35**.

Ichikawa, M. and Ueda, K. (1977). Fine structure of the olfactory epithelium in the goldfish*, Carassius auratus*. A study of retrograde degeneration*. Cell Tissue Res*. **183:** 445-55.

Ichikawa, M. (1976). Fine sturucture of the olfactory bulb in the goldfish, *Carassius auratus. Brain Res. Amsterdam.* **115:** 43-56.

Khan, F.A. Jain, M.R. Saha, S.G. Subhedar, N.K(1998). FMRF amide – like immune reactivity in the olfactory system responds to morphine treatment in the teleost clarias butrachus: involvement of opiate receptors. General and comparative Endocrinology. 110:79-87.

Khan, F.A. Saha, S.G., Sarkar, S. Subhedar, N.K. (1999). B-endomorphin like immuno reactivity in the forebrain and pituitary of teleost *Clarias batrachus (linn)*. General and comparative Edocrinology, **113:** 290-301.

Khaparde K.P. and Baile (2010). Studies on the olfactory organ related to reproductive cycle in the snakehead ophiocephalus striatus (Bloch), Thesis for P.H.D. in R.T.M. Nagpur University Nagpur.

Kleerekoper,H.(1982). Research in olfaction in fishes: Historical aspects in chemoreception in fishes (ed. T.J. Hara). *Elsevier, Amsterdam*.PP. 1-4.

Kluver, H. and Barrera, E. (1953). A method for the combined staining of cells and Fibres in the Nervous system. J. Neuropathalo. Exp. Neurol. 12: 400-403.

Kosaka, T. and Hama, K. (1979a). A new type of neuron with a distinctive axon initial segment. *Brain Res*. **163:** 151-155.

Kosaka, T. and Hama, K. (1979b). Ruffed cell: A new type of neurons with a distincitve initial unmylinated portion of the axon in the olfactory bulb of the gold fish *(Carassius auratus). J. Comp. Neural.* **186**: 301-320.

Kosaka, T. and and Hama, K.(1982). Synaptic Organizati on in the teleost olfactory bulb of the gold fish (Carassius auratus). J. Comp. Neurol, 212:365-384.

Masram, S.C.(2010). Role of neuno peptides and Neurono smone in the Regulation of pituitary gland activity some food fishes. Thesis for Ph.D work R.T.M. Nagpur University.

Masram, S.C. and Baile, V.V. (2014). Ultrastructure of the olfactory organ in the striped Snakehead *Ophiocephalus striatus* (Bloch*). Int.J. pharm. Bio Sci*. July; **5(3):** (B) 955-964.

Nieuwenhuys, R. And Meek, J (1990). The telencephalon of actionpterygian fishes, in cerebral cortex, vol.8A Jones, E. G. And Peters, A., Eds. *Plenum Press, New York,* PP 31-73.

Oka, Y. Golgi(1983). Electron microscopic studies of the mitral cells in the gold fish olfactory bulb, Neuroscience, 8:723-742.

Patle, P.J. and Baile, V.V. (2014). Morphology, morphometry and Neuro anatomy of the olfactory Epithelium and the olfactory bulb of a Feather back Fish, Notopterus notopterus. Int. J. of lofe sciences, vol. 2 (1): 1-12.

Raisman, G. (1972). An experimental study of the projection of the amygadale to the accessory olfactory bulb and its relationship to the concept of a dual olfactory system, *Exp. Brain Res*; **14**:395-408.

Satou, M. (1992). Synaptic organization of the olfactory bulb and its central projectic. *In Fish Chemoreception,* Eds. Hara T.J. Chapman and Hall, London, PP:40-59.

Schreibman, M.P. Margalis-Numo, H. and Halpen-Sebold, L. (1986). Structural and Functional relationship between olfactory and reproductive system from birth to lid age in fish, in chemical signals in vertebrates. *H. Ecology, Evolution and comparative Biology* (eda. D. Auvall, D. Muller Schwarz and Silverstain, R.D.). Plenum Press, New York, PP.155-172.

Shepherd, G.M.(1994). Discrimination of molecular signals by the olfactory by the olfactory receptor neuron. Neuron, 13:771-190.

Singh, S.P. (1978). The functional anatomy of the olfactory organs in a hill-stream fish *Garraa mullya* (Ham). 144**(3):** 220-224.

Singru, P.S. Sakharkar, A.J. Subhedar, N.K. (2003). Neuronal nitric oxide synthase in the olfactory system of an adult teleost fish, *Oriocromis mossambicus. Brain, Res.* **977,** 157-168.

Stell, W.K. Walker, S.E. Chohan, K.S. Ball, A.K. (1984). The gold fish nervous terminalis: a luteinzing hormone – releasing hormone and mollus can cardio exitatory peptide immune reactive olfactoretinal pathway. Proceedings of the National academy of sciences USA, 81:940-944.

Wilson, DA. (2004). Fish smell. Focus on "odorant specificity of single olfactory bulb neurons to amino acids in the channel catfish". *J. Neurophysiol***, 92**:38-39.

Yamamoto, M.(1982). Comparative morpholosy of the peripheral organ in teleosts. In chemoreception in fishes, Eds., Hara, T.J. Elsevier, Amsterdam (The Nether lands), PP:39-59

Zeiske, E; Breucker, H. and Melinkat, R. (1979). Gross morphology and finr structure of the olfactory organ of rainbow fish (Ather informes, Melanotaeniidae), *Acta. Zool.* Stockh. 60:173-18.

Zeiske, E. Theisen, B. and Breucker, H. (1992). Structure, Development and Evolutionary aspect of the peripheral olfactory system, Fish chemoreception, Hara, T. J. Ed, London. Chapman and Hall, 1992, PP. 13-39.

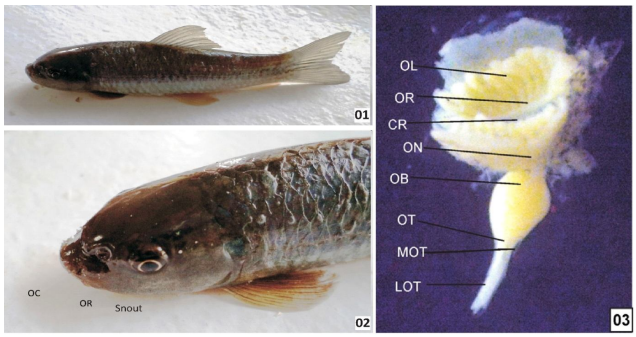


Fig. 1: Lateral view of fish *Garra mullya* (Sykes). **Fig. 2:** Lateral view showing olfactory rosette (OR) in the olfactory chamber (OC). **Fig. 3:** Whole view of olfactory organ showing olfactory rosette (OR) with olfactory lamellae (OL) connected by short olfactory nerve (ON) to the olfactory bulb (OB) andolfactory tract (OT) showing lateral olfactory tract (LOT), medial olfactory tract (MOT).

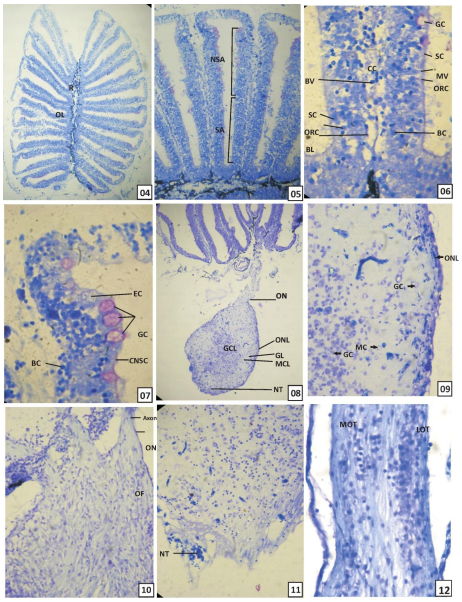


Fig. 04: Transverse section of olfactory rosette showing central elongated raphe (R), parallel arranged olfactory lamellae (OL), each lamella shows sensory area (SA) and non sensory area (NSA). Kluver and Barrera x100X. Fig. 05: Transverse section of olfactory rosette showing the lamellae receiving a fiber fascicles from the olfactory receptor cells. Kluver and Barrera x400X. Fig. 06: Transverse section of sensory epithelium showing olfactory receptor cells (ORC), microvillus receptor cells (MRC), basal cells (BC), supporting cells (SC), gobletcells (GC), ciliated non sensory cells (CNSC) and central core (CC) is separated by basallamina (BL) filled with blood vessels (BV. Kluver and Barrera x400X. Fig. 07: Transverse section of non sensory epithelium showing large sized goblet cells (GC), ciliated non sensory cells (CNSC), basal cells (BC) and epidermal cells (EC). Kluver and Barrera x400X. Fig. 08: Saggital section of olfactory bulb showing outer olfactory nerve layer (ONL), glomerular layer (GL), mitral cells layer (MCL) and innermost granular cells layer (GCL). Kluver and Barrera 100X. Fig. 09: Saggital section of olfactory bulb showing intensely stained olfactory nerve layer (ONL), moderately stained glomerular cells (GC), moderate Niss'l stained large sized mitral cells (MC) and innermost intensely stained small sized granular cells (GC). Kluver and Barrera x400X. Fig. 10: Saggital section of anterior olfactory bulb showing olfactory fiber (OF) penetrate peripherally in the olfactory bulb. Kluver and Barrera x400X. Fig. 11: Saggital section of posterior olfactory bulb showing intense Niss'l stained nervus terminalis (NT). Kluver and Barrera x400X. Fig. 12: Saggital section of olfactory tract showing moderately staining Niss'l stainingfibers entering the medial olfactory tract (MOT) and lateral olfactory tract (LOT). Kluver and Barrera x400X.

I J R B A T, Issue (IX), Vol. III, Sept 2021: 175-184
A Double-Blind Peer Reviewed & Refereed Journal
OPEN ACCESS
e-ISSN 2347 – 517X
Original Article

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY

© VMS RESEARCH FOUNDATION www.ijrbat.in

SURFACE CELLULAR DETAILS OF THE OLFACTORY ROSETTE: A SCANNING ELECTRON MICROSCOPIC (SEM) STUDY IN HILL STREAM CYPRINIDIAE, GARRA MULLYA (SYKES)

R S Bagade[1*], DVNS Suresh[1] and V V Baile[2]
[1]Department of Zoology, Dr. Ambedkar College, Deekshabhoomi, Nagpur 440010, India.
[2]Ex-Professor, Post Graduate Teaching Department of Zoology, RTM Nagpur University, Nagpur 440033, Maharashtra, India.
*Corresponding author: sureshdvns@gmail.in

Communicated: 29.06.21 | Revision : 29.07.21 & 04.09.2021 Accepted: 11.09.2021 | Published: 30.09.2021

ABSTRACT

Electron microscopic study is an important tool to characterize the fine structure of olfactory cells to understand the role of olfactory system at cellular level. In this work we are reporting the structure of olfactory system in *G. mullya* by electron microscopy. Olfactory rosette in this fish is oval in shape and has a central raphe from which radiate the lamellae on both the sides in parallel fashion. The surface epithelium of median raphe having the stratified epithelial cells (SEC) which provided with inconspicuous and conspicuous labyrinthine pattern micro-ridges, opening of mucous secreting goblet cells (GC) and long ciliated non sensory cells (cNSC) in the bundles. Each lamella is composed of two distinct regions, sensory and non sensory. Sensory epithelium is composed of abundant micro-villous receptor cells (MRC), ciliated olfactory receptor cells (cORC), mucous secreting goblet cells (GC), small rod like supporting cells (SC), stratified epithelial cells (SEC) and long ciliated non-sensory cells (cNSC). Transitional region of apical sensory and non sensory region shows stratified epithelial cells (SEC), supporting cells, micro-villous receptor cells and many mucous secreting goblet cells opening. Arrangement of microridges may protect the sensory epithelium from mechanical injuries and help in holding the mucus over the epithelium.

Key words: - Olfactory rosette; cORC; cNSC; SEM; Hill-stream fish; *Garra mullya*

INTRODUCTION :

Hill streams are unique aquatic ecosystems characterized by shallow, narrow channels, low temperature high altitude, different types of substratum and high current of water. In the course of evolution, nature has provided hill stream fishes with unique anchorage system to combat swift, shooting and turbulent water flow (Ojha and Singh, 1992) to successfully adapt to this unique environment. Strength of the current considerably influences the fauna. Although, the rate of water flow varies in different seasons, it is always much higher than in the rivers and streams of plain. Fishes therefore have developed adhesive organs to withstand the rapid flow of water. Fishes inhabiting hill streams can be conveniently divided into two groups. Members of one group are temporary inhabitants of the hill streams and migrate up only at certain periods of their life specifically for spawning purposes. These species move up by muscular efforts and do not exhibit special modifications. Members of the other group live permanently in the rivers and streams of hills and many of them posesses some adaptive features. These modifications are chiefly manifested in the form of adhesive structures usually located at anterior end and on the fins (Arunkumar et al., 1990).

All hill stream fishes are necessarily bottom-living forms, their head and bodies are much flattened and in highly specialized species of Bornean sucker, Balitora, Glyptosternum, Glyptothorax and Pseudoecheneis, their body becomes leaf like. Members of single genus *Garra* show all possible gradations in the shape of their bodies. While those living in the ponds and tanks have more or less cylindrical body, those living in rapid streams have distinct flattened body. In Species

like *Garra abhoyai* and *G. rossicus,* dorsal surface in-front of the dorsal fin is smooth due to the absence of scales. *G. mullya* has very well developed cycloid scales over its body. Thorax on the ventral surface is scale less and smooth (Saxena, 1959).

Organs responsible for detection of chemicals in water are located on the exposed body surface of the fish. Common chemical sense was originally named by Parker way back in 1912. Chemoreception mainly depends on the sense of taste (gustation) and on smell (olfaction). These are the major pathways for detection and identification of chemical stimuli in the environment (Hara, 1994).

Olfaction is accomplished principally by the stimulation of receptor cells on neuroepithelial surface of the olfactory organ. It is innervated by the olfactory nerve (Hansen and Zeiske, 1998). Olfactory signals and cues serve a crucial role for several life functions in fish such as migration, communication, feeding, schooling, defense, and reproduction (Wilson, 2004; Camacho et al., 2010). Sensing the chemical environment is critical for all organisms. Diverse animals from insects to mammals utilize highly organized olfactory system to detect, encode and process chemo-stimuli that may carry important information critical for health, survival, social interactions and reproduction (Marc Spehr and Munger, 2009). The structural and functional link between the olfactory and reproductory systems; puberty related changes in olfactory epithelium are also reported (Schreibman et al., 1984).

In teleosts, principal organ is olfactory system consists of a pair of olfactory rosette, olfactory bulbs, olfactory tracts and olfactory lobes.

The olfactory receptor cells are located in the olfactory epithelium which covers much of the surface of olfactory rosette, a structure found within the olfactory chambers on the fish rostrum. Although the size and shape of the rosette varies greatly across different species, in most instances it has a longitudinal ridge (raphe) with two rows of olfactory lamellae radiating from it, thus increasing its surface area enormously (Zeiske et al., 1992).

Olfactory epithelium is a complex tissue comprising sensory and non-sensory epithelia. Sensory epithelium is located on the raphe and central region of the olfactory lamella in majority of the species. The sensory epithelium is present in patches in some species also (Yamamoto, 1992).

Electron microscopic study is an important tool to characterize the fine structure of olfactory cells to understand the role of olfactory system at cellular level. Scanning electron microscopic studies of the olfactory organ and bulb are carried out by some investigators (Hara, 1975; Ichikawa, 1976; Ichikawa and Ueda, 1977; Kosaka and Hama, 1979 a, b; Zeiskie et al., 1979; Kleerekoper, 1982; Schreibman et al., 1986; Hansen and Zeiske, 1998).

MATERIAL & METHODS

Scanning Electron Microscopy (SEM)

Scanning Electron Microscopy (SEM) was carried out at the SEM facility centre of division of Entomology, Indian Agriculture Research Institute Pusa, New Delhi and Department of Metallurgy, VNIT, Nagpur.

Adult female fishes were anaesthetized with 2% paraldehyde solution. The olfactory resettes were removed and fixed without any loss of the time in ice cold glutaraldehyde (PH 7.2) containing paraformaldehyde for 24 hours. After fixation, tissue was washed 3-4 times in cold PBS (PH 7.45) for 30 min. interval and dehydrated in series of acetone (from 30% acetone to 100% acetone). Tissue was dried with the help of critical

CC BY NC

point drier, coated on stub and observed under the Scanning Electron Microscope.

RESULTS AND DISCUSSION:

In *Garra mullya*, olfactory rosette is present in olfactory chamber on the snout. Olfactory chamber allows water in through incurrent nostrils and is expelled through excurrent nostrils (Fig-01 & 02).

Scanning Electron Microscopy:

In *G. mullya,* olfactory rosette is oval in shape and consists rows of linguiform lamellae on each side of median raphe (Fig-03 & 04).

The surface epithelium of median raphe having the stratified epithelial cells (SEC) which provided with inconspicuous and conspicuous labyrinthine pattern micro-ridges, opening of mucous secreting goblet cells (GC) and long ciliated non sensory cells (cNSC) in the bundles. Mucin droplets are found over the SEC (Fig-05). Each lamella is composed of two distinct regions, sensory and non-sensory (Fig -06). Olfactory lamellae are radiating outward from central raphe. They also exhibit stratified epithelium with intermittent clusters of ciliated processes (Fig-07). Sensory epithelium is composed of abundant micro-villous receptor cells (MRC), ciliated olfactory receptor cells (cORC), scanty mucous secreting goblet cells (GC), small rod like supporting cells (SC), stratified epithelial cells (SEC) and long ciliated non-sensory cells (cNSC) (Fig-08,10). Apical surface of MRC is broad and consists of numerous microvilli (Fig-09), while cORC are limited in number raised in small round knobs and provided with four cilia (Fig-10). Apical surface of supporting cells having small rod like projections intermingling with microvillous cells, olfactory receptor cells and ciliated non sensory cells (Fig-09,10). Apical surface of goblet cells opening are seen and stratified epithelial cells which are flat and provided with fingerprint like micro ridges while ciliated non-sensory cells have dense bundles found in patches (Fig-08,09). Apical non sensory epithelium shows a dense mat of cilia with long ciliated non sensory cells (Fig -11). Transitional region of apical sensory and non sensory region shows stratified epithelial cells (SEC), supporting cells, micro-villous receptor cells and many mucous secreting goblet cells opening (Fiig-12 &13).

Olfaction plays a major role in fish as the olfactory organ interact with the environment and involving in various life activities include feeding, prey detection sex recognition, migration, reproduction and social interaction.

In the studied fish *Garra mullya*, the olfactory organs are paired situated dorsolaterally on the snout anterior to the eyes. Each organ present in the olfactory chamber that has two separate apertures through which water enters and leaves through it. Similar structure as also observed in *L. rohita* (Bhute and Baile, 2007); *N. notopterus* (Patle and Baile, 2014); red tail shark, *Epalzeorhynchos bicolar* (Mokhtar et al., 2014); and in other teleosts (Zeiske et al., 1992). In *G. mullya* olfactory rosette is oval in shape, has a central raphe from which radiate the lamellae on both sides in parallel fashion. Such similarities are observed in *L. rohita* (Bhute and Baile, 2007); *Catla catla* (Kumari, 2008); *Puntius sarana* (Ghosh and chakrabarti, 2014, JR Somatkar, DS Dabhade and HV Wanjari,2017).

In *G. mullya,* olfactory epithelium is folded to form the lamellae. Each lamella is crescentic in shape and bears a linguiform process along its concave margin as in *P. sarana* (Ghosh and Chakrabarti, 2014); *Catla catla* (Kumari, 2008); *Epalzeorhy nchos bicolar* (Mokhtar et al., 2014). Foldings on the lamellae of olfactory epithelium increases the surface area of the epithelium as well as the sensitivity and efficiency of the olfactory system (Zeiske et al., 1979; Ghosh and Chakrabarti,

CC BY NC

2014; Patle and Baile, 2014 and Mokhtar et al., 2014). These views are supported by our study as olfactory rosette in *G. mullya* is a multi-lamellar rosette comprising (18-26) number of lamellae which may provide more surface area for the binding of odorants and sensory activity.

In *G. mullya*, scanning electron microscopiy reveral the surface study of olfactory rosette. The surface epithelium of median raphe contained stratified epithelial cells with labyrinth pattern of microridges and few goblet cells. The arrangement of microridges may protect the sensory epithelium from mechanical injuries and help in holding the mucus over the epithelium. Goblet cells secrete mucin droplets probably protect olfactory epithelium from external injuries and allows smooth flow of water through the olfactory chamber. Similar findings recorded by (Ghosh and Chakrabarti, 2014) in *Puntius sarana* and (Mokhtar et al., 2014) in *Epalzeorhynchos bicolar*. The sensory epithelial surface occupied broad microvillous receptor cells, ciliated olfactory cells intermingled in different proportions. Microvillous receptor cells on lamellae may have significant role in reproduction. In the olfactory epithelium of *Cirhinus mrigala* the presence of microvillous receptor cells played a significant role in the regulation of reproduction (Biju et al., 2003; Chakrabarti et al., 2011). In *Sinocyclocheilus jii* (Waryani et al., 2013). In *S. argus* (Chakrabarti et al., 2011) Micro villous receptor cells might from a different olfactory transduction mechanism for pheromones or amino acids. Bhute and Baile (2007) also advocated that the receptor neurons perceive and process signals of pheromone, which is important step in the breeding pattern of *L. rohita.*

Ciliated olfactory receptor cells are found limited in number and form part of the olfactory transduction mechanism are stimulated by odour-bearing substances and also enable the fish to detect food. They are also responsible for detection of bile salts and amino acid odorants. Similar views are observed by (Zeiske et al, 2003. Chakrabarti et al., 2010; Ghosh and Chakrabarti, 2009). Mucous secreting goblet cells are on both sensory and non-sensory surface of epithelium in *G. mullya*. Secreted mucin from the mucous cells probably helps for coagulating microscopic debris and there by keeps the receptor ready for new stimuli. This is confirmity with the findings of Bandyopadhyay and Dutta (1998) in *H. fossilis* and Ghosh and Chakrabarti (2009) in *Wallago attu*. Adequate ventilation is necessory to bring the odorants in the olfactory chamber for perceiving the chemical signals (Belanger et al., 2003). Ventilation of the olfactory chamber takes place by synchronous beating of cilia of ciliated-nonsensory cells (Hara, 1993). Since the raphe surface and sensory epithelium in *G. mullya* covered in the bundles of cilia, also is covered with a dense mat of cilia, probably the ventilation of olfactory chamber in this fish is achieved due to the beating action of cilia of ciliated non sensory cells as in Patle and Baile (2014). In the transitional zone of sensory and non-sensory epithelium of *G.mullya* consists of stratified epithelial cells provided with unbranched linearly arranged microridges on their apical surface that help in holding mucous film over the epithelium and in protecting the sensory receptor cells from mechanical injuries. The goblet cells are distributed between the stratified epithelial cells of the sensory and non-sensory epithelium. The mucus covering the olfactory lamellae constitutes an important medium in which odourants are diffused as in *L. bata* (Ghosh and Chakrabarti, 2011).

CONCLUSION:

Conclusively, olfactory rosette in this fish is oval in shape and has a central raphe from which

CC BY NC

radiate the lamellae on both the sides in parallel fashion. Under scanning electron microscope, the surface of olfactory rosette shows the following : microvillous olfactory receptor cells and ciliated olfactory receptor cells, ciliated non sensory cells in bundles and mats of cilia, mucous secreting goblet cells opening with mucin droplets, small rod like supporting cells and stratified epithelial cells with finger like microridges. Arrangement of microridges may protect the sensory epithelium from mechanical injuries and help in holding the mucus over the epithelium.

REFERENCES:

Arunkumar, S. Indrajit, S. and Singh, B.R. (1990). The morphology of the sisorid fish, *Glyptothorax pectinopterus*, *Jap. J. itchyol*; 36. No.4. 427-431.

Baby, S.M. Ueck, M. Prasada Rao, P.D. (2000). Gonadotropin releasing formone immuno reactive neurons and associates nicotimide adrnine nucleotide phosphate diaphorase positive neurons in the brain of teleosts, Rhodus amarus. General and comparative Endocrinology, 120:44-54.

Bandyopadhyay, S.K. and Datta, N.C. (1998). Morpho anatomy and histology of the olfactory organ of an air breathing cat fish Hetero pneustes fossilis (Bloch). Journal of animal morphology and physiology, 43:85-96.

Belanger, R.M. Smith, C.M. Corkum, L.D. Zielinski, B.S.(2003). Morophology and histochemistry of the peripheral olfactory organ in the round goby, Neogobis melanostomus (Teleoste : Gobidae). Journal of morphology, 257:62-71.

Bhute, Y.V. and Baile, V.V (2007). Organization of the olfactory system of the Indian Major Carp Labeo rohita (Ham): A scanning and Transmission Electron Microscopy study. Journal of Evolutionary Biochemistry and physiology, vol. 43. No. 3. PP. 342-349.

Bhute, Y.V. Masram, S.C. Rant, I.N. Baile, V.V.(2007). Cytoaschitectonic pattern of the olfactory system, Forebrain and pituitary gland of the Indian major carp, Labeo rohita. Annals of Neurosciences. Volume 14.2007.

Biju K. C. Sings, P. S. Schreibman, M. P. Subhedas, N.(2003). Reproduction phase related expression of GnRH like immune reactivity in the olfactory receptor neurons, their projection to the olfactory bulb and in the nervus terminalis in the female Indian major carp cirrhinus mrigala (Ham). Gen. Comp. Endocrinology; 133:358-567.

Camacho, S. Ostos-Garrido, M.V. Domezain, A. Carmona, R. (2010). Study of the olfactory epithelium in the developing sturgeon characterization of the crypt cells. *Chemical senses*. 35:147-156.

Chakrabarti, P. and Ghosh, S. K.(2014). Histoarchitecture and scanning electron microscopic studies of the olfactory epithelium in the exotic fish Puntius jovanicus (Blecker). Arch. Pol. Fish. 18:173-177.

Chakrabarti, P. and Ghosh, S.K. (2011). Histolgical and ultrastuctural studies of the olfactory epithelium of spotted butter fish scatophagus of the olfactory epithelium of spotted vol.70. No.2. PP. 74-79.Anat.126:457-476.

Ghosh, S. K. and Chakrabarti, P. (2014). Structural characterization of the olfactory epithelium of fresh water olive barb, Puntius sarana (Hamilton, 1822). International Journal of Aquatic Biology. 2(3):147-154.

Ghosh, S.K and Chakrabarti, P(2014). Histophysiological studies on the olfactory

CC BY NC

epithelium of Banded pearl spot Etroplus suratensis (Blch,1790). Journal of Entomology and Zoology studies. 2(1):78-82.

Ghosh, S.K. and Chakrabarti, P.(2009). Cellular architecture and funcltinal as pects of the olfactory rosette of wallgoattu (Blecker). Turkish Journal of fisheries and Aquatic sciences 9:187-190.

Ghosh, S.K. and Chakrabarti, P.(2011). Distribution and organi zation of Different cells lininy the olfactory epithelium of Indian minor carp, Labeo bata (Ham.1822): A light and scanning Electron Microscopic Analysis. Pakistan Journal of Biological Sciences.

Hansen, A. and Zeiske, E. (1998). The peripheral olfactory organ of the zebra fish, *Danio rerio;* an ultrastructural study. *Chem. Senses*, 23:39-48.

Hansen, A. and Reutter, K. (2004). Chemosensury system in Fish: Structural, Functional and Eoological Aspects. In the senses of Fish: Adaptations for the Reception of Natural stimuli, Eds., Von Der Emde G, Modgans J, Kapoor B.G. Narosa Publishing House, New Delhi, PP: 55-89.

Hara, T.J. (1975). Olfaction in Fish. Prog. *Neurobiol. (Oxford*). 5: 271-335.

Hara, T. J. Ed, London. Chapman and Hall, 1992, PP. 13-39.

Hara, T.J.(1993). Chemoreception. In the physiology of fishe's, Eds. Evans, D.H. CRC Press, Boca raton, PP:191-218.

Hara.T.J. (1994). The diviersity of chemical stimulation in fish olfaction and gestation. *Reviews in Fish Biology and Fisheries*, 41-35.

Ichikawa, M. (1976). Fine sturucture of the olfactory bulb in the goldfish, *Carassius auratus. Brain Res. Amsterdam.* 115: 43-56.

Ichikawa, M. and Ueda, K. (1977). Fine structure of the olfactory epithelium in the goldfish, *Carassius auratus*. A study of retrograde degeneration. *Cell Tissue Res*. 183: 445-55.

JR Somatkar, DS Dabhade and HV Wanjari, (2017), Histopathology of Labeo rohita fish infected with Trichodinid parasites, IJRBAT, Special Issue (2), Vol-V, 1211-1215

Kosaka, T. and Hama, K. (1979a). A new type of neuron with a distinctive axon initial segment. *Brain Res*. 163: 151-155.

Kosaka, T. and Hama, K. (1979b). Ruffed cell: A new type of neurons with a distincitve initial unmylinated portion of the axon in the olfactory bulb of the gold fish *(Carassius auratus). J. Comp. Neural.* 186: 301-320.

Kleerekoper,H.(1982). Research in olfaction in fishes: Historical aspects in chemoreception in fishes (ed. T.J. Hara). *Elsevier, Amsterdam*.PP. 1-4.

Kumari, K. (2008). Morphology and Morphometry of the olfactory Rosette of a Teleostean Fish; Catla catla (Ham). Our nature, 6:30-37.

Marc spehr and Munger S.D. (2009). Olfactory receptor G: Protein coupled receptor and beyond. *Journal of Neurochemistry*. 109. 1570-1583.

Masram, S.C.(2010). Role of neuno peptides and Neurono smone in the Regulation of pituitary gland activity some food fishes. Thesis for Ph.D work R.T.M. Nagpur University.

Mokhtar, D.M. and Abd-Elhafeez, H.H (2014). Light and Electron-microscopic studies of olfactory organ of Red- tails hark, Epalzeorhynchos bicolar (Teleostei :

CC BY NC

Cyprinidae). Journal society of microscopes. Published by Elsevier Ltd.

Ojha, J. and Singh, S. K. (1992). Functional morphology of the anchorage system and food scrapers of a hill stream fish, *Garra lamta* (ham) *J.Fish Biol;* 41, 159-161.

Patle, P.J. and Baile, V.V. (2014). Morphology, morphometry and Neuro anatomy of the olfactory Epithelium and the olfactory bulb of a Feather back Fish, Notopterus notopterus. Int. J. of lofe sciences, vol. 2 (1): 1-12.

Schreibman, M.P. Margalis-Kazan, H Halpern-Sebald, L. O' Neill, P.A. and Silverman, R.C.(1984). Structural and functional links between olfactory and reproductive system: Puberty related changes in olfactory epithelium, *Brain Res*. 203: 180-183.

Schreibman, M.P. Margalis-Numo, H. and Halpen-Sebold, L. (1986). Structural and Functional relationship between olfactory and reproductive system from birth to lid age in fish, in chemical signals in vertebrates. *H. Ecology, Evolution and comparative Biology* (eda. D. Auvall, D. Muller Schwarz and Silverstain, R.D.). Plenum Press, New York, PP.155-172.

Saxena, S .C. (1959). Adhessive apparatus of a hill stream cyprinid fish *Garra mullya (Sykes). proc.Natm. Inst. Sci;* India. 26, 176-188.

Wilson, DA. (2004). Fish smell. Focus on "odorant specificity of single olfactory bulb neurons to amino acids in the channel catfish". *J. Neurophysiol*, 92:38-39.

Waryani, B. Zhao, Y. Zhang, C. Dai, R. Abbasi, A.R.(2013). Anatomical studies of the olfactory epithelium of two caves fishes sinocyslosheilus jii and S. fuscodorsalis (Cyprini forms: cyprinidar) from china. Pakistan J. Zool. Vol.45(4), PP.1091-1101.

Yamamoto, M.(1982). Comparative morpholosy of the peripheral organ in teleosts. In chemoreception in fishes, Eds., Hara, T.J. Elsevier, Amsterdam (The Nether lands), PP:39-59.

Yamamoto, M.(1992). Comparative morphology of the peripheral olfactory organ in teleosts, in *Fish Chemorception*, Hara T.J., Ed., Chapman and Hall, London, 39-58.

Zeiske, E; Breucker, H. and Melinkat, R. (1979). Gross morphology and finr structure of the olfactory organ of rainbow fish (Ather informes, Melanotaeniidae), *Acta. Zool.* Stockh. 60:173-18.

Zeiske, E. Theisen, B. and Breucker, H. (1992). Structure, Development and Evolutionary aspect of the peripheral olfactory system, Fish chemoreception,

Zeiske, E. Kasumyan, A. Bartsch, P. and Hansen, A.(2003). Early development of the olfactory organ in sturgeons of the genus Acipensor: A comparative and electron microscopic study. Anatomy and Embryology, 206:357-372.

CC BY NC

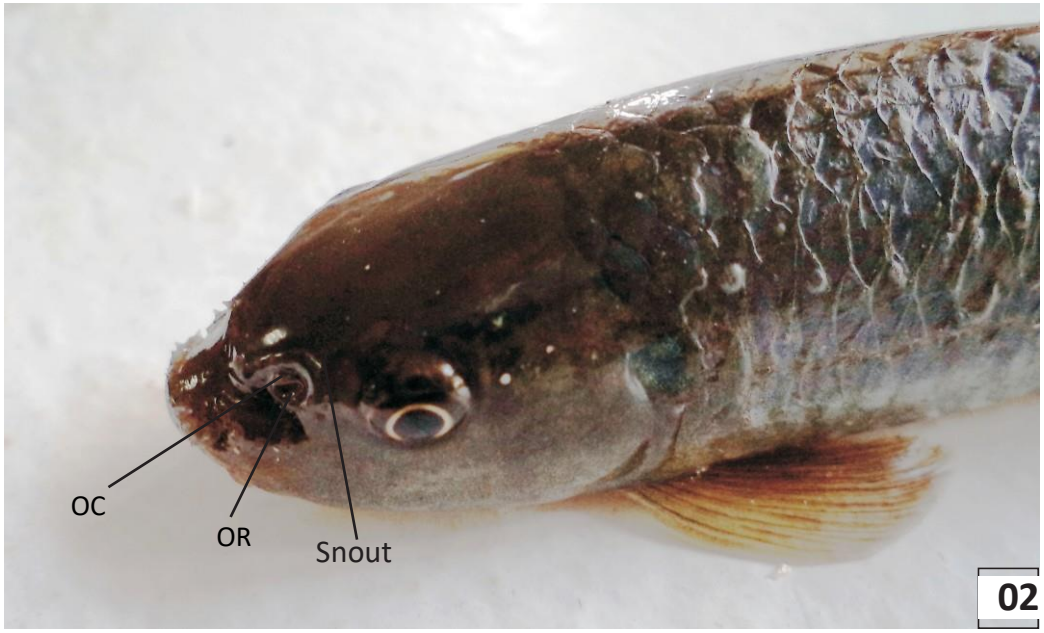
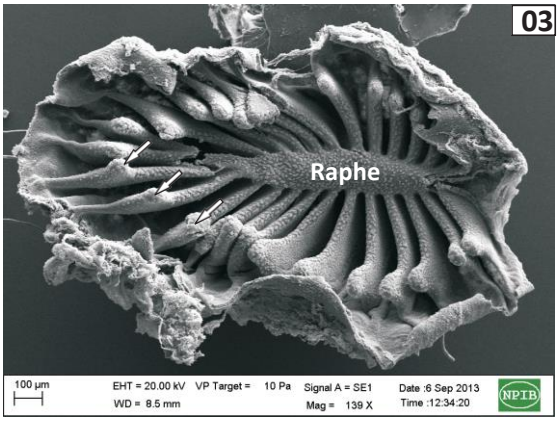
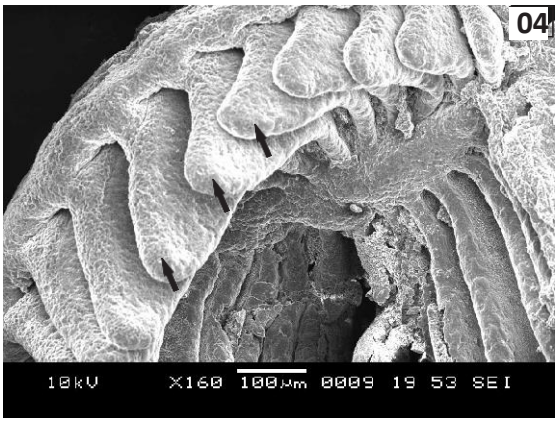
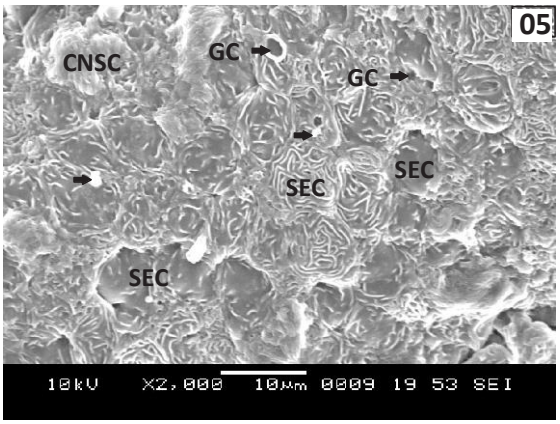


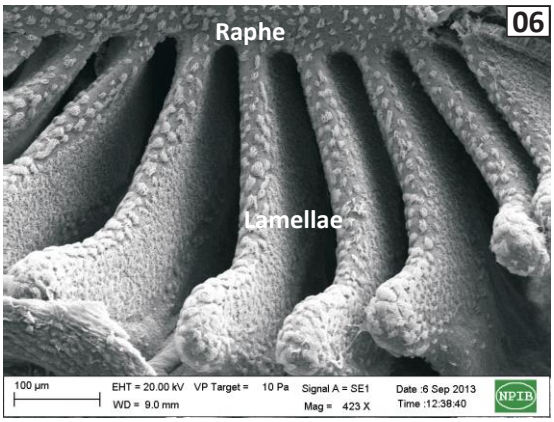
Fig. 01: Lateral view of fish *Garra mullya* (Sykes). **Fig. 02:** Lateral view showing olfactory rosette (OR) in the olfactory chamber (OC).

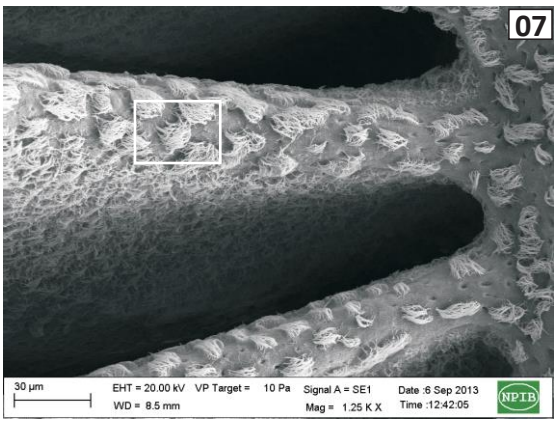
CC BY NC











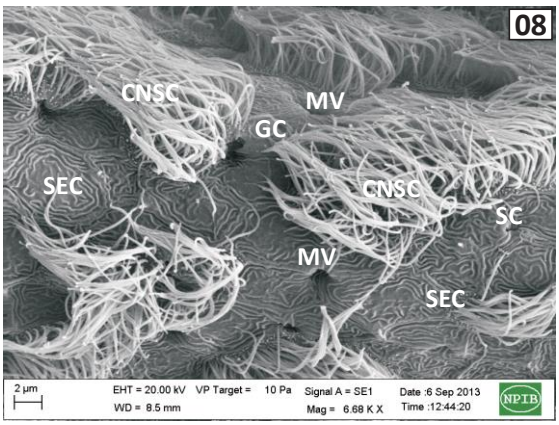


Fig. 03 & 04: Scanning electron micrograph (SEM) of olfactory epithelium (OE) of *Garra mullya.* oval shaped olfactory resette (OR) exhibits olfactory lamellae (OL) radiating from central median raphe (MR). Arrows indicate linguiform processes. **Fig. 05:** Scanning electron micrograph (SEM) of magnified median raphe exhibiting stratified epithelial cells (STC), opening of goblet cells (GC) and long ciliated non sensory cell (CNSC) in the bundles. **Note:** Mucin droplets are found over the SEC. **Fig. 06:** SEM of elongated olfactory lamellae (OL) shows basal sensory (OSA) and apical non-sensory areas (ONSA). **Fig. 07:** SEM of olfactory epithelium (OE) spread between median raphe (MR) with olfactory lamellae (OL) displays stratified epithelial cells (SEC) with intermittant patches of ciliated processes. Small rod like supporting cells (SC) are vesible. **Fig. 08:** SEM of magnified olfactory sensory area (OSA) shows SEC, microvillus receptor cells (MV), mucus secreting goblet cell (GC), rod like supporting cell (SC) and long ciliated non sensory cells (CNSC).

CC BY NC

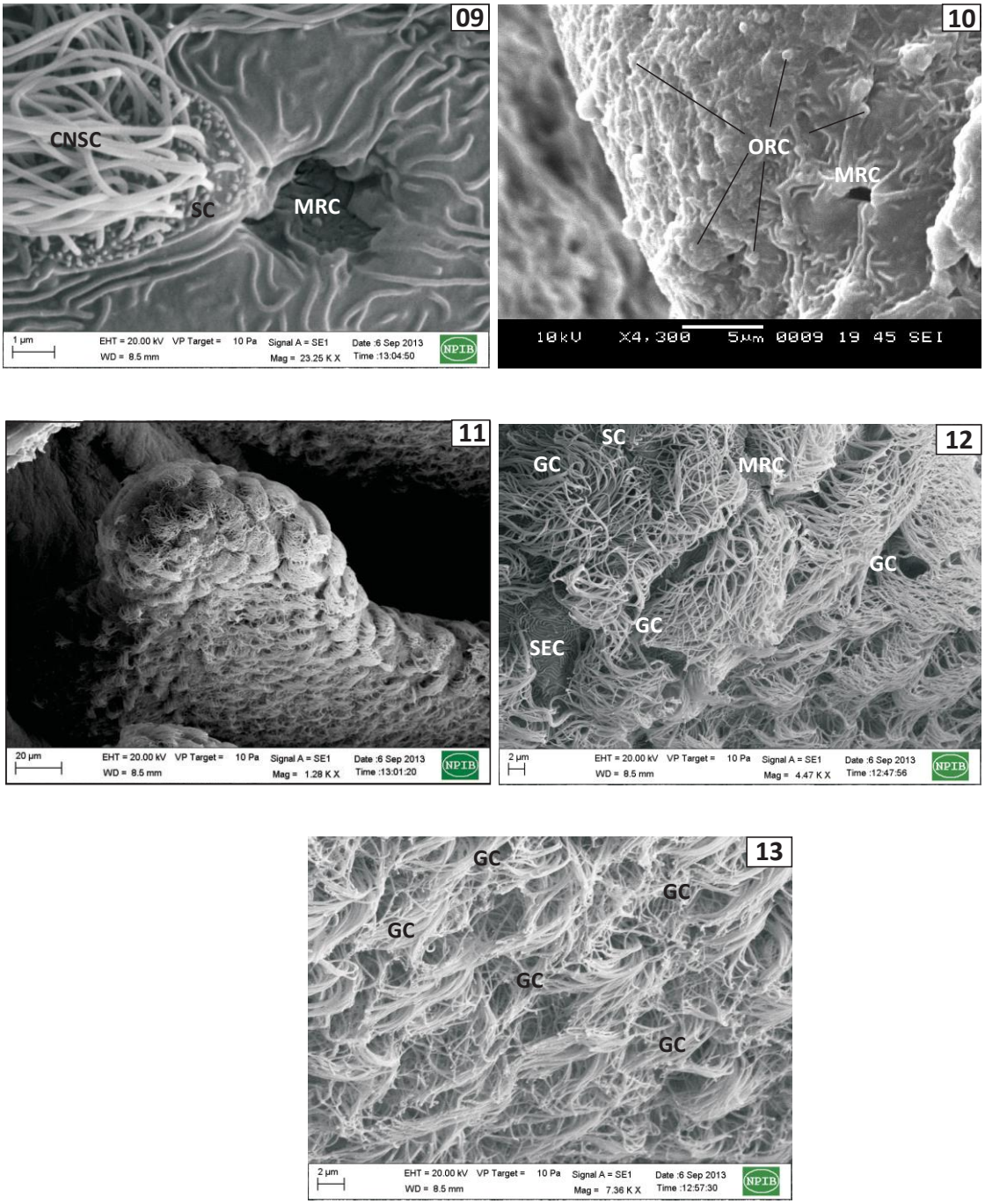


Fig. 09: SEM of further magnified olfactory sensory area (OSA) shows microvillus receptor cells (MV), SC and CNSC. **Fig. 10:** SEM of further magnified olfactory sensory area (OSA) shows ciliated receptor cells (CRC) and microvillus receptor cell (MV). **Fig. 11:** SEM of apical olfactory non-sensory area (ONSA) shows the fur of abundent long ciliated non sensory cells (CNSC). **Fig. 12:** SEM of magnified transitional region of olfactory sensory and non-sensory areas (OSA and ONSA) shows SEC, SC, MV and GC with abundent CNSC. **Fig. 13:** SEM of magnified olfactory non-sensory area (ONSA) shows
a: Stratiomyidae).

CC BY NC

International Journal of
Life Sciences
International Peer Reviewed Open Access Refereed Journal

Int. J. of Life Sciences, 2021; 9 (4):443-448
ISSN:2320-7817(p) | 2320-964X(o)

Research Article Open Access

Reproductive Phase-related Plasma Proteins in *Labeo rohita*

Suresh DVNS[1*], Bagade RS [1] and Baile VV [2]

[1]Department of Zoology, Dr Ambedkar College, Deekshabhoomi, Nagpur 440010, Maharashtra, India.
Email: sureshdvns@gmail.in, ramdasbagade63@gmail.com
[2]Ex-Professor, Post Graduate Teaching Department of Zoology, RTM Nagpur University, Nagpur 440033, Maharashtra, India.
*Corresponding author.

Manuscript details:

Received: 09.11.2021
Accepted: 25.12.2021
Published: 30.12.2021

Cite this article as:
Suresh DVNS, Bagade RS and Baile VV (2021) Reproductive Phase-related Plasma Proteins in *Labeo rohita*, *Int. J. of Life Sciences*, 9 (4): 443-448.

Available online on http://www.ijlsci.in
ISSN: 2320-964X (Online)
ISSN: 2320-7817 (Print)

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other thirdparty material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/ licenses/by/4.0/

ABSTRACT

A study of plasma content of proteins in *Labeo rohita* in the present project gives a base for the understanding of carrier proteins in the plasma specifically sex hormone-binding globulins, a type of carrier protein, which carry the sex hormones with different affinity and capacity associations. Their electrophoretic patterns in different phases of reproductive cycle of the fish will also give a preliminary idea at what molecular weight these carrier proteins might get separated in the gel for further isolation and identification. The trend of the plasma protein levels showed a significant increase in prespawning-phase of the fish breeding cycle. The values as recorded went up to 28.940 ± 0.404 mg/mL in females and 19.600 ± 0.115 mg/mL in males. The study has not only revealed the protein content of the plasma of both sexes but also kept in synchronous the records of electrophoregrams of plasma proteins of reproductive and non-reproductive phases of the cycle. Protein content in plasma increases as important estradiol-dependent proteins such as vitellogenins, eggshell proteins, which are known to be synthesized in liver, have higher or lower molecular weights and are produced in much lower amounts during the maturing phase of the fish reproduction.

Keywords: Carrier proteins, SDS-PAGE, Prespawning, Reproductive phase, *Labeo rohita*

INTRODUCTION

The disturbances in the gas exchange, nitrogenous waste excretion, acid-base and ionic balance are due to the change in water pH cause stress in fish affecting its body physiology and growth (Pickering, 1981; Jeney *et al.*, 1992). Though majority of the fish farmers in India take precautions to prevent abrupt changes in water pH in aquaculture operations, such situations may occur due to the excessive inputs of supplementary feed, manures and inorganic fertilisers to get higher

production per unit area. The three Indian major carps, catla, *Catla catla* (Ham.), rohu, *Labeo rohita* (Ham.) and mrigal, *Cirrhinus mrigala* (Ham.) account for more than 80% of the country's aquaculture production amounting to over 1.8 million ton (FAO, 2003). The optimum pH range for culture of these carps is 7.5-8.5 (Banerjea, 1967), and the majority of the Indian carp culture ponds have a pH in this range. Since, the change in water pH influences nitrogenous waste excretion, ion balance and respiratory homeostasis, we predicted there would also be altered haematology of carps (Das *et al.*, 2006). Accordingly, we studied the changes in size, shape and population of blood cells and concentrations of hemoglobin (Hb), blood sugar and serum protein which could be used as tools to indicate the stress level in these fishes during exposure to changed water pH.

A study of plasma content of proteins in *L rohita* in the present project gives a base for the study of carrier proteins in the plasma specifically sex hormone-binding globulins (a type of carrier protein) which carry the sex hormones with different affinity and capacity associations. Their electrophoretic patterns in the present study in different phases of reproductive cycle of the fish will also give a preliminary idea at what molecular weight these carrier proteins might get separated in the gel for further isolation and identification.

MATERIAL AND METHOD

Protein Assay (Hartree-Lowry Assay)

Under alkaline conditions the divalent copper ion forms a complex with peptide bonds in which it is reduced to a monovalent ion. Monovalent copper ion and the radical groups of tyrosine, tryptophan, and cysteine react with Folin reagent to produce an unstable product that becomes reduced to molybdenum/tungsten blue. *Reagent A* consists of 2 gm sodium potassium tartrate x 4 H20, 100 gm sodium carbonate, 500 ml 1N NaOH, H20 to one liter (that is, 7mM Na-K tartrate, 0.81M sodium carbonate, 0.5N NaOH final concentration). Keeps 2 to 3 months. *Reagent B*t consists of 2 gm 2 gm sodium potassium tartrate x 4 H20, 1 gm copper sulfate (CuSO4 x 5H20), 90 ml H20, 10 ml 1N NaOH (final concentrations 70 mM Na-K tartrate, 40 mM copper sulfate). Keeps 2 to 3 months. *Reagent C* consists of 1 vol Folin-Ciocalteau reagent diluted with 15 vols water. Prepare a series of dilutions of 0.3 mg/ml bovine serum albumin in the same buffer containing the unknowns, to give concentrations of 30 to 150 micrograms/ml (0.03 to 0.15 mg/ml). Final assay volume is 5 ml. Measure absorbance at 650 nm in 1 cm cuvettes. Prepare a standard curve of absorbance versus micrograms protein (or *vice versa*), and determine amounts from the curve. Determine concentrations of original samples from the amount protein, volume/sample, and dilution factor, if any.

Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis (SDS-PAGE)

Sodium dodecyl sulfate (SDS) is an anionic detergent which denatures proteins by "wrapping around" the polypeptide backbone - and SDS binds to proteins fairly specifically in a mass ratio of 1.4:1. It is usually necessary to reduce disulphide bridges in proteins before they adopt the random-coil configuration necessary for separation by size: this is done with 2-mercaptoethanol or dithiothreitol. In denaturing SDS-PAGE separations therefore, migration is determined not by intrinsic electrical charge of the polypeptide, but by molecular weight. Assemble two glass plates (one notched) with two side spacers, clamps, grease, etc. as shown by demonstrators. Stand assembly upright using clamps as supports, on glass plate. Pour some pre-heated 1% agarose onto glass plate, place assembly in pool of agarose this seals the bottom of the assembly. *Gel concentration of 12.5% in 0.25 M Tris-HCl pH 8.8 is resolving gel Gel concentration of 4.5% in 0.125 M Tris-HCl pH 6.8 is stacking gel.* Grind a little leaf material (eg. 2 grams) in a mortar, centrifuge for 3 min. Take supernatant and mix 100ul 1:1 (v:v) with SDS-PAGE disruption mix: this is 125mM Tris-HCl pH 6.8 / 10% 2-mercaptoethanol / 10% SDS / 10% glycerol, containing a little bromophenol blue. Layer samples under buffer on stacking gels. Connect up apparatus and electrophorese. Make up stain: 0.2% *Coomassie Brilliant Blue* (CBB) in 45:45:10 % methanol: water: acetic acid. Cover gel with staining solution, seal in plastic box and leave overnight on shaker (RT) or for 2 to 3 hours at 37 degree Celsius. Destain with 25% 65% 10% methanol water acetic acid mix. Rinse gel in distilled water and seal in a plastic.

RESULTS AND DISCUSSIONS

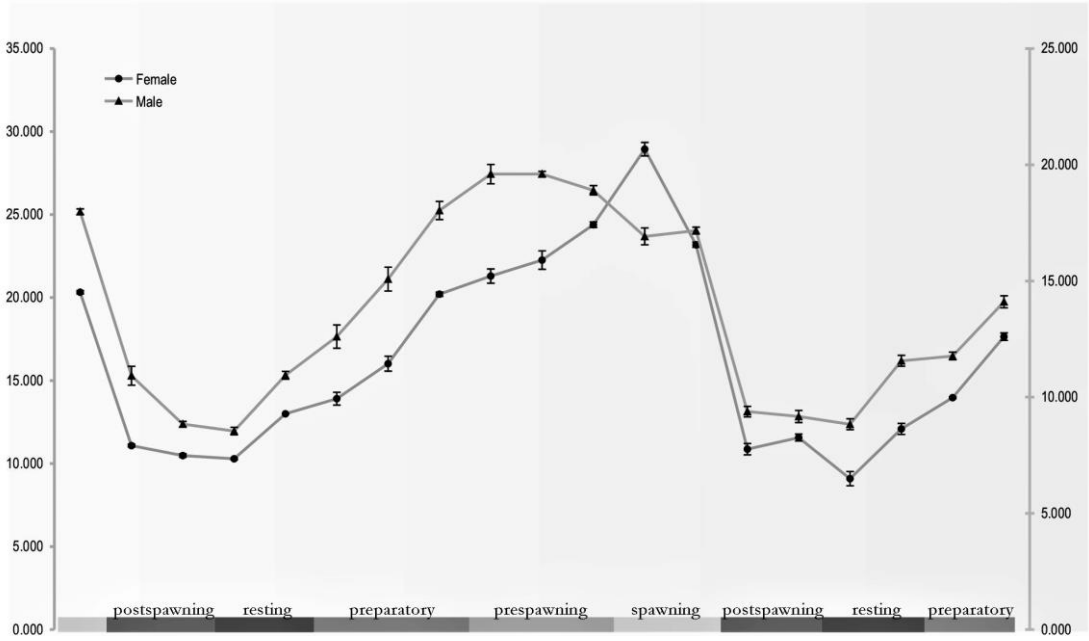
Female *Labeo rohita*

Mean readings collected of 6-8 female and male animals every month in two fortnightly batches for

eighteen months starting from August 2013 to February 2015. The plasma protein levels estimated are tabulated in Table 1 and comparative seasonal mean levels are graphically depicted in Graph 1.

Table 1: Monthly plasma protein in *Labeo rohita* during August 2013 & February '2015 (*Values in (mg/mL) ± SEM (Standard Error of Mean); *P>0.05; rest P<0.001*).

Month	(Female)		(Male)	
AUG '13	20.320	± 0.100	17.977	± 0.123
SEP '13	11.087	± 0.079 *	10.920	± 0.404 *
OCT '13	10.487	± 0.105 *	8.840	± 0.117 *
NOV '13	10.287	± 0.057	8.540	± 0.162
DEC '13	13.000	± 0.012	10.947	± 0.168
JAN '14	13.910	± 0.387	12.607	± 0.499
FEB '14	16.013	± 0.450	15.080	± 0.510
MAR '14	20.207	± 0.127	18.033	± 0.393
APR '14	21.293	± 0.431	19.600	± 0.416
MAY '14	22.260	± 0.553	19.600	± 0.115
JUN '14	24.387	± 0.173	18.900	± 0.200
JUL '14	28.940	± 0.404	16.917	± 0.363
AUG '14	23.183	± 0.156	17.167	± 0.145
SEP '14	10.867	± 0.343 *	9.380	± 0.223 *
OCT '14	11.567	± 0.208 *	9.167	± 0.260 *
NOV '14	9.093	± 0.428	8.833	± 0.233
DEC '14	12.087	± 0.330	11.567	± 0.233
JAN '15	13.973	± 0.057	11.773	± 0.165
FEB '15	17.647	± 0.226	14.100	± 0.260



Graph 1: Comparative graphical representation of seasonal mean plasma protein levels recorded in different reproductive phases of female and male *Labeo rohita.* (values are in mg/mL);

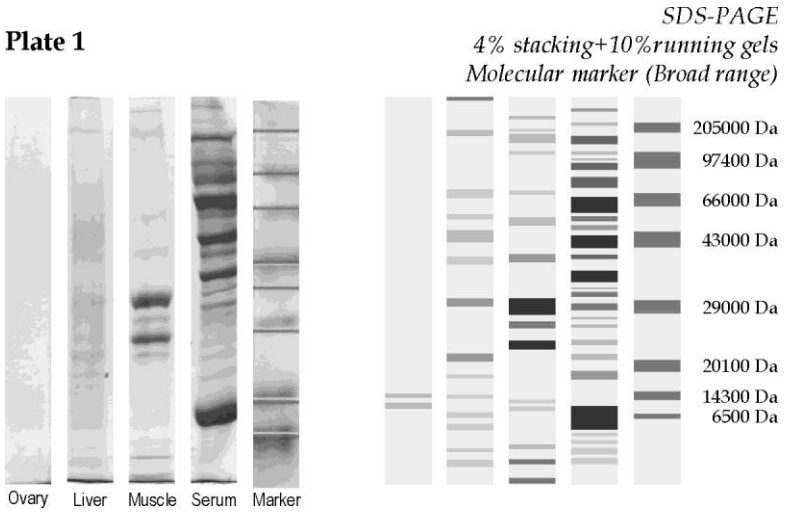


Plate 1: SDS-PAGElectrophoretic banding patterns of the samples of serum and the extract samples of ovary, liver & muscle of *L rohita* in non-reproductive phase (Nov. to Jan.). Image besides is the computer generated electrophoregram.

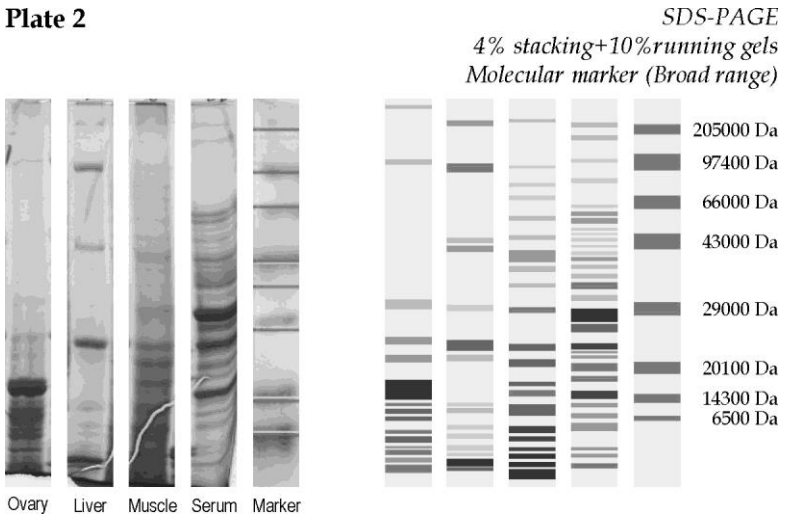


Plate 2 : SDS-PAGElectrophoretic banding patterns of the samples of serum and the extract samples of ovary, liver & muscle of *L rohita* in reproductive phase (Feb. to Aug.). Image besides is the computer generated electrophoregram.

The trend of the plasma protein levels showed a significant increase in prespawning-phase of the fish breeding cycle. The values went up to 28.940 ± 0.404 mg/mL in the month of July which subsequently reached lowest of the season in November with value 10.287 ± 0.057 mg/mL in year 2013 and 9.093 ± 0.208 mg/mL in year 2014.

Male *Labeo rohita*

Similarly, the plasma protein levels estimated in males are also tabulated in Table 1 and graphically depicted in Graph 1. The values went up to 19.600 ± 0.115 mg/mL in the month of May which subsequently reached lowest of the season in November with value 8.540 ± 0.162 mg/mL in year 2013 and 8.833 ± 0.233 mg/mL in year 2014.

Electrophoretic Patterns

The SDS-PAGE separation of plasma and few tissue levels such as ovary, liver and muscle proteins was also performed in non-reproductive (Plate 1) and reproductive (Plate 2) phases to have an idea of increased protein content during the breeding cycle of the fish that is correlated with carrier proteins and other steroid dependent proteins in the plasma.

DISCUSSION

Among the serum proteins, albumin and globulin are the major proteins, which play a significant role in the immune response. Globulins like gamma globulin are absolutely essential for maintaining a healthy immune system and contain all the immunoglobulin in the blood. A higher serum globulin level in the pre-challenge period is in agreement with Kumar *et al.* (2005) who reported a higher globulin level due to non-gelatinous carbohydrate feeding in *L. rohita* juveniles. The lowest globulin level at 2.0% n-3 PUFA supplemented groups both in the pre- and post-challenge period suggests an immunosuppressive action of high n-3 PUFA. Gelatinised carbohydrate fed groups registered lower serum protein levels, in agreement with Hemre *et al.* (1996) and Kumar *et al.* (2005). Hemre *et al.* reported a negative correlation of serum protein with dietary carbohydrate. After challenge study, reduction of serum protein may be due to vascular leaking of serum protein because of increased permeability (Quinn *et al.*, 1990; Rushmore *et al.*, 1988) along with impaired synthesis and non-specific proteolysis of serum protein (Salte *et al.*, 1993).

In view of the above discussion of the plasma proteins and other related factors like, the feed, lysozymal activity, environmental cues definitely affect the physiology of the fish more or less in a significant manner. Therefore, the plasma protein content of the both sexes was estimated in *L* rohita.

The experiments with juvenile *L. idus* presented in Allner *et al.*, (1999) study clearly show that compared to untreated fish the synthetic estrogen ethinyl estradiol causes the occurrence of an additional protein in blood. The molecular weight of this additional protein corresponds to the molecular weights of vitellogenins from other fish as reported in the literature (Tyler, 1991; Kishida *et al.*, 1992; Utarabhand and Bunlipatanon, 1996; Komatsu and Hayashi, 1997; Roubal *et al.*, 1997; Suresh *et al* 2008). This similarity justifies the assumption that the detected estrogen-dependent protein is vitellogenin. Further evidence is provided by the differences between male and mature female plasma protein spectra showing that male fish contain only very small amounts or no vitellogenin in blood. Exposure of adult male or juvenile fish to estrogens including the xenoestrogen 4-nonylphenol resulted in the same protein pattern as exhibited in plasma of mature females. This finding also supports the assumption that the estrogen-dependent protein is vitellogenin. Other estradiol-dependent proteins, for example eggshell proteins, which are also known to be synthesized in the liver, have higher or lower molecular weights and are produced in much lower amounts (Pelissero *et al.*, 1993).

According to Allner *et al.*, 1999, the advantage of the electrophoretic method is that only very low amounts of blood are required to show the induction of vitellogenin. The relative quantification of vitellogenin in relation to the entire blood protein does not depend on accurate blood volume determination which is a very time-consuming procedure when sampling a large number of fish in monitoring programs. Furthermore, the measurement of additional plasma proteins allows to distinguish specific vitellogenin induction from unspecific anabolic effects resulting in modified protein levels including vitellogenin.

CONCLUSION

Protein content in plasma increases, as important estradiol-dependent proteins, *e. g.* vitellogenins, eggshell proteins, that are known to be synthesized in the liver, have higher or lower molecular weights and are produced in much lower amounts during the maturing phase of the fish reproduction. The present study has not only revealed the protein content of the plasma of both sexes but also kept the records of the electrophoregrams of the plasma proteins of all different phases of the cycle to distinguish the sex hormone binding globulins from the electrophore-grams for further estimating/ separating/ isolating, the future objective of the study.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Allner B, Wegener G, Knacker T, Stahlschmidt-Allner P (1999) Electrophoretic determination of estrogen-induced protein in fish exposed to synthetic and naturally occurring chemicals. *Sci Total Environ* 233 (1-3), 21-31.

Banerjea SM (1967) Water quality and soil condition of fish ponds in some states of India in relation to fish production. *Indian J Fish* 14 (1&2), 115–144.

Das PC, Ayyappan S, Jena JK (2006) Haematological changes in the three Indian major carps, *Catla catla* (Hamilton), *Labeo rohita* (Hamilton) and *Cirrhinus mrigala* (Hamilton) exposed to acidic and alkaline water pH. doi:10.1016/j.aquaculture.2006.02.019

FAO (2003) Fishery Statistics. Aquaculture Production. FAO Fisheries Series No. 64, vol. 92(2). *Food and Agriculture Organisation of the United Nations* Rome pp 186.

Hemre GI, Waagbo R, Hjeltnes B, Aksnes A (1996) Effect of gelatinized wheat and maize in diets for large Atlantic salmon (Salmo salar L.) on glycogen retention, plasma glucose and fish health. *Aquacult Nutr* 2, 33-39.

Jeney Zs, Nemcsok J, Jeney G, Olah J (1992) Acute effect of sublethal ammonia concentrations on common carp (Cyprinus carpio): I. Effect of ammonia on adrenaline and noradrenaline levels in different organ. *Aquaculture* 104, 139–148.

Kishida M, Anderson TR, Specker JL (1992) Induction by *β*-estradiol of vitellogenin in striped bass, *Morone saxatilis*.: Characterization and quantification in plasma and mucus. *Gen Comp Endocrinol* 88, 29-39.

Komatsu M, Hayashi S (1997) Pharmacological dose of estradiol 17*β* induces vitellogenin synthesis in cultured hepatocytes of immature eel *Anguilla japonica*. *Fisheries Science* 63, 989-994.

Kumar S, Sahu NP, Pal AK, Choudhury D, Yengkokpam S, Mukherjee SC (2005) Effect of dietary carbohydrate on haematology, respiratory burst activity and histological changes in *L. rohita* juveniles. *Fish Shellfish Immunol* 19, 331-344.

Pelissero C, Flouriot G, Foucher JL (1993) Vitellogenin synthesis in cultured hepatocytes; an *in vitro* test for the estrogenic potency of chemicals. *J Steroid Biochem Mol Biol* 64, *263-272.*

Pickering AD (1981) The concept of biological stress. In: Pickering, A.D. (Ed.), *Stress and Fish.* Academic Press, London, pp 1–9.

Quinn BA, Crane TL, Kocal TE, Best SJ, Cameron RG, Rushmore TH, Farber E, Hayes MA (1990) Protective activity of different hepatic cytosolic glutathione *S*-transferases against DNA-binding metabolites of aflatoxin B1. *Toxicol Appl Pharmacol* 105, 351–63.

Roubal WT, Lomax DP, Willis ML, Johnson LL (1997) Purification and partial characterization of English sole, *Pleuronectes netulus* vitellogenin. *Comp Biochem Physiol* 118B, 613-622.

Rushmore TH, Harris L, Nagai M, Sharma RN, Hayes MA, Cameron RG, Murray RK, Farber E (1988) Purification and characterization of P-52 (glutathione *S*-transferase-*P* or 7-7) from normal liver and putative preneoplastic liver nodules. *Cancer Res* 48, 2805–12.

Salte R, Gjoen HM, Norberg K, Gjedrem T (1993) Plasma protein levels as potential marker traits for resistance to furunculosis. *J Fish Dis* 16, 561–8.

Suresh DVNS, Baile VV, Prasada Rao PD (2008) Annual reproductive phase-related profile of sex steroids and their carrier, SHBG, in the Indian major carp, *Labeo rohita*.*Gen Comp Endocrinol* 159 (2), 143-149.

Tyler C (1991) Vitellogenesis in salmonids. In: *Proceedings of the Fourth International Symposium on the Reproductive Physiology of Fish,* (Scott AP, Sumpter JP, Kime DE, Rolfe MS (Eds.)). University of East Anglia Norwich UK. 7, 295-299.

Utarabhand P, Bunlipatanon P (1996) Plasma vitellogenin of grouper, *Epinephelus malabaricus*.: Isolation and properties. *Comp Biochem Physiol* 115C, 101-110.

© 2021 | Published by IJLSCI

I J R B A T, Issue (X), Vol. I, Jan 2022: 111-120
A Double-Blind Peer Reviewed & Refereed Journal
OPEN ACCESS
e-ISSN 2347 – 517X
Original Article

INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE AND TECHNOLOGY

© VMS RESEARCH FOUNDATION www.ijrbat.in

PARTIAL CHARACTERIZATION OF SEX HORMONE-BINDING GLOBULIN (SHBG) IN LABEO ROHITA

DVNS Suresh* and R S Bagade
Department of Zoology, Dr Ambedkar College, Deekshabhoomi, Nagpur 440010, India.
*Corresponding author: sureshdvns@gmail.in

Communicated: 22.10.21 | Revision : 16.11.21 & 31.12.2021 Accepted: 20.01.2022 | Published: 30.01.2022

ABSTRACT:
Although much of the aspects of its biology have been well studied, there is a lack of knowledge on the reproductive endocrinology of this Indian major carp. *Labeo rohita* is the most cultivable and relished fish of India which needs an attention on its high yield production with healthy and robust fish and an exclusive knowledge about its reproductive regulations and the steroidal involvements. The serum and tissue samples were subjected to sodium dodecyl sulphate poly acrylamide gel electrophoresis (SDS-PAGE) for the separation of proteins to isolate the SHBG in the gel and then transferred to a poly vinyledene difluride (PVDF) membrane. The transferred protein band can be analyzed for the immuno confirmation of SHBG with help of anti-SHBG (DSL, Texas, USA). With increased serum graded samples, immuno-confirmation was positively observed in incremental reactions against anti-SHBG. Although albumin has not been found in fish, proteins with some of the characteristics of albumin are present. Interference of high concentrations of vitellogenins, however, may generate small changes in kDa of SHBG. The binding characteristics of SHBG remain unchanged at these reproductive stages. The possible molecular weight of the *Labeo rohita* SHBG (lrSHBG) is approximately 30254 Da. There is a poor evolutionary conservation of SHBG among species of same class.
Key words: - SHBG; SDS PAGE; Immunoblotting; *Labeo rohita*.

INTRODUCTION :

The sex-hormone binding protein (SHBG) has been characterized in plasma from several freshwater and saltwater fish species including rainbow trout (Fostier and Breton, 1975), Atlantic salmon (Lazier et al., 1985), spotted seatrout (Laidley and Thomas, 1994), goldfish (Pasmanik and Callard, 1986), Japanese eel (Chang et al., 1994), and carp (Chang and Lee, 1992; Suresh *et al.,* 2008). Recent work has also demonstrated that anadromous Arctic charr (*Salvelinus alpinus L.*) from the Svalbard Islands (Norway) exhibits a plasma protein that binds estrogens and androgens with high affinity and moderate capacity (Øvrevik et al., 2001).

Interestingly, it has been demonstrated that natural and synthetic chemicals are able to interact with fish SHBG and modulate their sex steroid binding properties (Milligan et al., 1998; Kloas et al., 2000; Tollefsen, 2002; Tollefsen et al., 2002). Recent studies also indicate that presence of chemicals in industrial effluents may interact with and modulate the properties of SHBG in fish (Hewitt et al., 2000; Pryce-Hobby et al., 2003) and thus potentially contribute to disrupt normal endocrine function (endocrine disruption) in feral fish species. Among the persistent organic pollutants found in Arctic regions, several are known or suspected endocrine disrupters.

At present, plasma SHBGs are identified in most vertebrates except birds and some mammalian species (Westphal, 1986). Best characterized is the human SHBG (hSHBG), a homodimeric glycoprotein of 90–100 kDa with a single sex steroid binding site. The hSHBG shares the same primary structure

as the human testicular androgen binding protein (ABP) which differs only with respect to the attached oligosaccharides (Hammond and Bocchinfuso, 1995). Both proteins are products of a single gene (*SHBG*), which is expressed in several tissues including liver, testis, placenta, brain, and endometrium. In fish as in humans, liver seems to be the main organ for SHBG synthesis (Foucher *et al.,* 1991; Hammond and Bocchinfuso, 1995).

As pointed out by Laidley and Thomas (1994) plasma SHBGs display considerable species variation in both affinity and specificity and clear phylogenetic patterns are not obvious. Species variation is also evident from molecular weight estimates, which for teleost SHBG alone range from 64 kDa in eel (Chang *et al.,* 1994) to 194 kDa in carp (Chang and Lee, 1992). Immunoreactive studies suggest poor evolutionary conservation of these proteins, even within classes of animals (Renoir *et al.,* 1980), which may account for some of the observed species variation. Considering this lack of uniformity, phylogenetic interpretations on SHBG distribution or characteristics would be highly uncertain even within classes of vertebrates. This work focuses on the separation of *Labeo rohita* SHBG from its blood by SDS-PAGE and confirmation thorugh immunoblotting.

Although much of the aspects of its biology have been well studied, there is a lack of knowledge on the reproductive endocrinology of this Indian major carp. *Labeo rohita* is the most cultivable and relished fish of India which needs an attention on its high yield production with healthy and robust fish and an exclusive knowledge about its reproductive regulations and the steroidal involvements.

MATERIALS AND METHODS

SDS-PAGElectrophoresis

Sodium dodecyl sulfate (SDS) is an anionic detergent which denatures proteins by "wrapping around" the polypeptide backbone - and SDS binds to proteins fairly specifically in a mass ratio of 1.4:1. It is usually necessary to reduce disulphide bridges in proteins before they adopt the random-coil configuration necessary for separation by size: this is done with 2-mercaptoethanol or dithiothreitol. In denaturing SDS-PAGE separations therefore, migration is determined not by intrinsic electrical charge of the polypeptide, but by molecular weight. Assemble two glass plates (one notched) with two side spacers, clamps, grease, etc. as shown by demonstrators. Stand assembly upright using clamps as supports, on glass plate. Pour some pre-heated 1% agarose onto glass plate, place assembly in pool of agarose this seals the bottom of the assembly. *Gel concentration of 12.5% in 0.25 M Tris-HCl pH 8.8 is resolving gel Gel concentration of 4.5% in 0.125 M Tris-HCl pH 6.8 is stacking gel.* Grind a little leaf material (eg. 2 grams) in a mortar, centrifuge for 3 min. Take supernatant and mix 100ul 1:1 (v:v) with SDS-PAGE disruption mix: this is 125mM Tris-HCl pH 6.8 / 10% 2-mercaptoethanol / 10% SDS / 10% glycerol, containing a little

CC BY NC

bromophenol blue. Layer samples under buffer on stacking gels. Connect up apparatus and electrophorese. Make up stain: 0.2% *Coomassie Brilliant Blue* (CBB) in 45:45:10 % methanol: water: acetic acid. Cover gel with staining solution, seal in plastic box and leave overnight on shaker (RT) or for 2 to 3 hours at 37 degree Celsius. Destain with 25% 65% 10% methanol water acetic acid mix. Rinse gel in distilled water and seal in a plastic.

Immunobloting

To study proteins that are expressed at very low levels, it is recommended that immunoprecipitation be followed by immunoblotting for more sensitive detection. After the above SDS-PAGElectrophoresis of protein separation samples are now subjected to the tranfere to PVDF membrane (Millipore Immobion-P #IPVH 000 10). Assemble "sandwich" for Tranfer Instrument for 1 hr at 1 amp at 4°C on a stir plate. Bigger proteins might take longer to transfer. For Transfer Instrument it's 100 V for 1 hr with cold pack and pre-chilled buffer. Incubate with primary antibody diluted in Blocking buffer for 60 min at room temperature and followed by Incubation with secondary antibody and detect with Sigma AEC kit

RESULT & DISCUSSION:

The serum and tissue samples were subjected to sodium dodecyl sulphate poly acrylamide gel electrophoresis (SDS-PAGE) for the separation of proteins to isolate the SHBG in the gel and then transferred to a polyvinyledene difluride (PVDF) membrane. The transferred protein band can be analyzed for the immuno confirmation of SHBG with help of anti-SHBG (DSL, Texas, USA).

Earlier all the tissue samples, like gonads, liver and kidney, were tried for the separation of SHBG, but later only the serum samples were tried as the quantity of protein separated from these tissue samples was insufficient for further analyses of immuno confirmation.

Plate 1 shows the SDS-PAGElectrophoresis and its computer generated image of bands separated of serum, liver, ovary and kidney at 10% running gel and 4% stacking gel combination.

Then the same electrophoresis was adopted to run the serum samples of different phases of reproductive cycle, preparatory, prespawning and spawning phases and the banding pattern shows a clear indication of increase in protein content as the fish approached the spawning phase. The suspected proteins around the 40 kDa increased significantly as the albumin-like proteins and the globulins increase during he same phase (plate 2).

Plate 3 shows the native–PAGE, which is the same electrophoretic procedure with no SDS in any of the solutions and reagents; and gels to separate the proteins in their structural existence rather than getting straightened up (primary structure) as in SDS_PAGE. These banding patterns were used usually for the transfer on PVDF membranes for immuno confirmation through Western Blot.

CC BY NC

Blot results were displayed in plate 4 where in the upper image, the portion of the gel transferred to membrane and the immuno-analyzed PVDF membrane were arranged. The analyzed gel bands with documentation software reveal the suspected band as of 30254 Da molecular weight which gives distinct reaction with anti-SHBG on membrane (right scanned image of membrane). Lower image of scanned membrane displays graded samples loaded in gel electrophoresis and then blotted for immuno-confirmation giving positive incremental reactions against anti-SHBG with increased serum samples. Thus SHBG in the major carp, *Labeo rohita* might be of molecular weight 30254 Da.

The consistent and rapid synthesis of silver nanoparticles was achieved using banana peels which is a waste material. As an alternative to conventional microbiological, physical, or chemical methods, this green synthesis method appears to be a cheaper, non-toxic, eco-friendly solution. It is also suitable for developing a biological process for large-scale production.

Crystalline, uniform, spherical, monodisperse silver nanoparticles were synthesized from banana peel extract which had an average particle size of 23.7 nm. Antimicrobial properties were demonstrated for human pathogenic bacteria tested with the synthesized nanoparticles. Additionally, they demonstrated a synergistic effect of Tetracycline on the antimicrobial activity against the Gram-positive and Gram-negative bacteria.

The biochemical properties of SHBG have already been reviewed in great detail (Petra, 1979; Petra et al., 1983; 1986). In essence, SHBGs from a variety of mammalian species appear to exist as dimeric glycoproteins of approximatetly 90 kDa (see review Hammond, 1990). Under denaturing conditions, human SHBG usually dissociates into two subunits of approximately 52 and approximately 48 kDa, and these are present in approximately a 10 :1 ratio respectively (Cheng et al., 1983). In some individuals, an additional subunit with an molecular weight of approximately 56kDa has also been identified in the same relative amount as the 52kDa subunit (Hammond and Robinson, 1984, Khan et al., 1985), similar differences in subunit size have also been observed in other species, but their relative amounts vary (Suzuki and Sinohara, 1984).

Despite variations in subunit size and electrophoretic mobility (Hammond and Robinson, 1984; Cheng et al., 1983; Khan et al., 1985; Suzuki and Sinohara, 1984; Luckock and Cavalli-Sforza, 1983), amino-terminal sequence analyze of human SHBG (Hammond and Robinson, 1984; Petra et al., 1986; Hammond et al., 1986) have detected the presence of only a single polypeptide. These studies, together with immunochemical evidence for two identical epitopes per dimer (Hammond et al., 1986), support the assumption that human SHBG is a homodimer comprised of a complex mixture of variously sized subunits, with two 52 kDa subunits forming the prominent

CC BY NC

species (Cheng et al., 1983). This therefore raises the interestmg question of whether various combinations of subunits are functionally important.

The subunit size heterogeneity of SHBG can be eliminated by complete removal of carboydrates (Denzo et al., 1989), which account for 11 to 12% of each subunit (Hammond et al., 1986). Furthermore, the presence of variable amounts of sialic acid probably contributes to the series of bands observed when SHBG is examined by isoelectrofocusing.

The binding characteristic studies in fishes of other workers reveal that the two peaks are relatively distinct suggesting that the smaller peak may consist of an albumin-like protein responsible for the low-affinity, high-capacity binding to E_2, as shown by albumin in mammals (Westphal, 1986). Although albumin has not been found in fish, proteins with some of the characteristics of albumin are present (Davidson *et al.,* 1989; Maillou and Nimmo, 1993a,b). In contrast, the E_2 binding profiles from the E_2-treated fish did not show two distinct peaks. A possible explanation for this is interference of the very high levels of vitellogenin with the later elution of smaller-molecular weight proteins including SBP and albumin off the gel filtration column. This could result in less separation between peaks of lower-molecular weight proteins.

The molecular weight of SHBG has been reported for only three teleost species to date and ranges from 64 kDa for the eel *Anguilla japonica* (Chang *et al.,* 1994) to 194 kDa for the carp (Chang and Lee, 1992). The molecular weight of rainbow trout SBP from the present study was estimated to be around 65 kDa by gel filtration after partial purification. Molecular weights of the same molecule can differ when estimated using different methods. The molecular weight of carp and eel SHBGs were both determined by HPLC after purification of the molecule, suggesting that substantial differences in the size of the SHBG of these two species are real. Estimates of spotted seatrout SHBG differed when measured by gel filtration (around 150 kDa) and native PAGE (approximately 135 kDa) in the same study (Laidley and Thomas, 1994). Gel filtration after partial purification is not an optimal method for determining molecular weight, but does provide an initial estimate for rough comparative purposes. An estimate of 65 kDa suggests that rainbow trout SBP may be more similar to eel than to common carp SHBG. In conclusion, *B*max is higher in vitellogenic than in nonreproductive female rainbow trout and black bream. This difference in trout does not appear to result directly from elevated plasma E_2 and vitellogenin levels experienced by the fish at this time. Interference of high concentrations of vitellogenin, however, may generate small changes in kDa. In greenback flounder, the binding characteristics of SHBG remain unchanged at these reproductive stages, suggesting a lesser role for SHBG in maintaining elevated plasma levels of steroids in this species

CC BY NC

Studies to conclude that the possible molecular weight of the *Labeo rohita* SHBG (lrSHBG) is approximately 30254 Da confirmed with the help of SDS-PAGE, Native-PAGE, Western Blot and anti-SHBG. Results from present studies tell about the molecular weight of the monomer of preexisting dimeric molecule of SHBG in major carp plasma as it is well known that under denaturing conditions (Cheng et al., 1983) in the procedural steps of SDS- or Native-PAGE alter the dimeric-SHBG into monomer.

The discussion on molecular weights of SHBG in different fish species compel to infer that there is a poor evolutionary conservation of it among the species of same class.

CONCLUSION:

Very recent molecular studies on fish SHBG in seabass (Miguel-Queralt_et al., 2005) and zebrafish (Miguel-Queralt__ et al., 2004) further revealed the exact molecular weight of the corresponding SHBGs and sequenced the gene responsible for its translation. The 361-residue seabass SHBG is 39894 Da and 356-residue zebrafish SHBG is 39243 Da molecular weights.

Although albumin has not been found in fish, proteins with some of the characteristics of albumin are present. Interference of high concentrations of vitellogenin, however, may generate small changes in kDa of SHBG. The binding characteristics of SHBG remain unchanged at these reproductive stages. The possible molecular weight of the *Labeo rohita* SHBG (lrSHBG) is approximately 30254 Da. There is a poor evolutionary conservation of SHBG among species of same class.

ACKNOWLEDGEMENTS

Sincere thanks to Dr Shivkumar Chauhan, PreGen Preventive Genetics Diagnostic Centre, Nagpur, India for helping in performing immunoblotting.

REFERENCES

Chang, C.-F., Lee, Y.-H., (1992): Purification of the sex steroid-binding protein from common carp (Cyprinus carpio) plasma. Comp. Biochem. Physiol., B 101, 587– 590.

Chang, C.-F., Lee, Y.-H., Yoshida, T., Sun, L.-T., (1994): Characterization of the plasma sex steroid-binding protein in eel (Anguilla japonica). Comp. Biochem. Physiol., B 108, 189– 197.

Cheng C Y,-Musto N A, Gunsalus G L, Bardin C W (1983): Demonstration of heavy and 'light protomers of human testosterone , esterdiol-binding globulin. J Steroid Biochem 19:1379.

Davidson, W. S., Bartlett, S. E., Birt, T. P., Birt, V. L., and Green, J. M. (1989): Identification and purification of serum albumin from rainbow trout (*Salmo gairdneri*). *Comp. Biochem. Physiol.* 93B, 5–9.

Denzo B J, Bell B W., Black J H. (1989): human testosterone binding globulin is a dimmer composed of two identical protomers that are

CC BY NC

differently glycosylated. Endocrinology, 124:2809

Fostier, A., Breton, B., 1975. Binding of steroids by plasma of a teleost: the rainbow trout, Salmo gairdnerii. J. Steroid Biochem. 6, 345–351.

Foucher, J. L., Niu, P. D., Mourot, B., Vaillant, C., and Le Gac, F. (1991: In vivo and in vitro studies on sex steroid binding protein (SBP) regulation in rainbow trout (*Oncorhynchus mykiss*): Influence of sex steroid hormones and of factors linked to growth and metabolism. *J. Steroid Biochem. Mol. Biol.* 39, 975–986.

Hammond GL, Robinson P A (1984): Characterization of a monoclonal antibody to human sex hormone binding globulin. FEBS Lett 168:307 .

Hammond G. L, Robinson PA, Sugino H, Ward DN, Finne J (1986): Physiochemical characteristics of human sex hormone binding globulin: evidence for two identical subunits. J Steroid Biochem 24:815.

Hammond, G. L., and Bocchinfuso, W. P. (1995). Sex hormonebinding globulin/adrogen-binding protein: Steroid-binding and dimerization domains. *J. Steroid Biochem. Mol. Biol.* 53, 543–552.

Hewitt, L.M., Parrott, J.L., Wells, K.L., Calp, M.K., Biddiscombe, S., McMaster, M.E., Munkittrick, K.R., Van Der Kraak, G.J., (2000): Characteristics of ligands for the Ah receptor and sex steroid receptors in hepatic tissues of fish exposed to bleached kraft mill effluent. Environ. Sci. Technol. 34, 4327–4334.

Khan MS, Ehrlich P, Birken, S, Rosner W (1985): Size isomers of testosterone-estradiol-binding globulin exist in the plasma of individual men and women. Steroids 45:463.

Kloas, W., Schrag, B., Ehnes, C., Segner, H., (2000): Binding of xenobiotics to hepatic estrogen receptor and plasma sex steroid binding protein in the teleost fish, the common carp (Cyprinus carpio). Gen. Comp. Endocrinol. 119, 287–299.

Laidley, C.W., Thomas, P., (1994): Partial characterization of a sex-steroid binding protein in the spotted seatrout (Cynoscion nebulosus). Biol. Reprod. 51, 982–992.

Luckock A, Cavalli-Sforza LL (1983): Detection of genetic\ariation with: radioactive'"Ugands.' V. Genetic variants of testosterone , binding globulin in human serum Am J Hum Genet 35:49.

Maillou, J., and Nimmo, I. A. (1993b): Identification and some properties of an albumin-like protein in the serum of pre-spawning Atlantic salmon (*Salmo salar*). *Comp. Biochem. Physiol.* 104B, 401–405.

CC BY NC

Miguel-Queralt S, Avvakumov G V, Blazquez M, Piferrer F, Hammond GL.(2005): Sea bass (Dicentrarchus labrax) sex hormone binding globulin: molecular and biochemical properties and phylogenetic comparison of its orthologues in multiple fish species. Mol Cell Endocrinol. 2005 Jan 14;229(1-2):21-9.

Milligan, S.R., Khan, O., Nash, M., (1998): Competitive binding of xenobiotic oestrogens to rat alpha-fetoprotein and to sex steroid binding proteins in human and rainbow trout (Oncorhynchus mykiss) plasma. Gen. Comp. Endocrinol. 112, 89–95.

Øvrevik, J., Stenersen, J., Nilssen, K., Tollefsen, K.-E., (2001): Partial ch aracterization of a sex steroid-binding protein in plasma from Arctic charr (Salvelinus alpinus L.). Gen. Comp. Endocrinol. 121, 31–39.

Pasmanik, M., Callard, G., (1986): Characteristics of a testosterone-estradiol binding globulin (TEBG) in goldfish serum. Biol. Reprod. 35, 838–845.

Petra, P.H. (1979): The serum sex steroid-binding protein. Purification, characterization and immunological properties of the human and rabbit proteins. *J Steroid Biochem* 11:245

Petra, P.H, Stanczyk FZ, Senear DF, Namkung PC, Novy MJ, Ross JBA, Turner E, 'Brown JA (1983): Current status of the molecular structure and function of the plasma sex steroid-binding protein (SBP). J Steroid Biochem 19:699 .

Petra:, P.H, Kumar S, Hayes R, Ericsson LH,' Titani K (1986): Molecular organization of the se:\ steroid-binding protein (SBP) of human plasma. J' $,teroid Biochem 24:45.

Pryce-Hobby, A.C., McMaster, M.E., Hewitt, L.M., Van Der Kraak, G., (2003): The effects of pulp mill effluent on the sex steroid binding protein in white sucker (Catostomus commersoni) and longnose sucker (C. catostomus). Comp. Biochem. Physiol., C 134, 241– 250.

Renoir, J.-C., Mercier-Bodard, C., and Baulieu, E.-E. (1980): Hormonal and immunological aspects of the phylogeny of sex steroid binding plasma protein. *Proc. Natl. Acad. Sci. USA* 77, 4578–4582.

Suresh, DVNS, Baile, V.V., Prasada Rao P.D. (2008): Annual reproductive phase-related profile of sex steroids and their carrier, SHBG, in the Indian major carp, Labeo rohita. *Gen Comp Endocrinol* 159 (2), 143-149.

Suzuki Y, Sinohara' H (1984): Subunit structure of sex-steroid binding plasma proteins from ,inan, cattle, dog,.l!nd rabbit. J Biochem 96:751.

CC BY NC

Tollefsen, K.-E., (2002): Interaction of estrogen mimics, singly and in combination, with plasma sex steroid-binding proteins in rainbow trout (Oncorhynchus mykiss). Aquat. Toxicol. 56, 215– 222.

Tollefsen, K.E., Meyes, J.F.A., Frydenlund, J., Stenersen, J., (2002): Environmental estrogens interact with and modulate the properties of plasma sex steroid-binding proteins in Atlantic salmon (Salmo salar).Mar. Environ. Res. 54, 697–701

Westphal, U. (1986): Sex steroid-binding protein (SBP). *In* "Steroid–Protein Interactions II," Monographs on Endocrinology, pp. 198–264. Springer-Verlag, New York.

EXPLANATION OF FIGURES

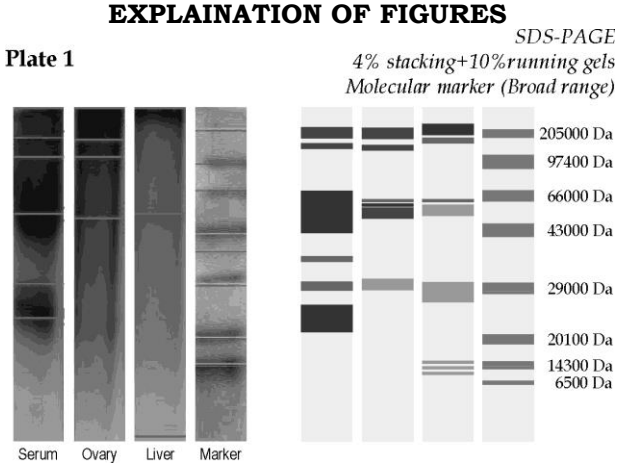


Plate 1. SDS-PAGElectrophoretic banding patterns of the samples of serum and the extract samples of ovary and liver of L rohita. Image besides is the computer generated electrophoregram showing bands more clear to visualize

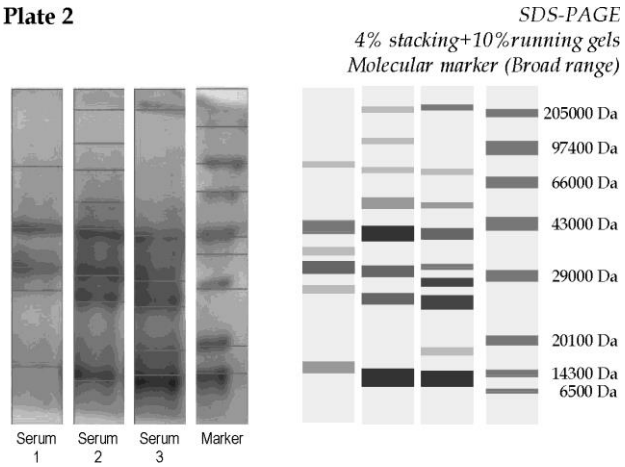


Plate 2. SDS-PAGElectrophoretic banding patterns of the samples of serum of preparatory, prespawning and spawning phases of reproductive cycle of L rohita. Image besides is the computer generated electrophoregram.

CC BY NC

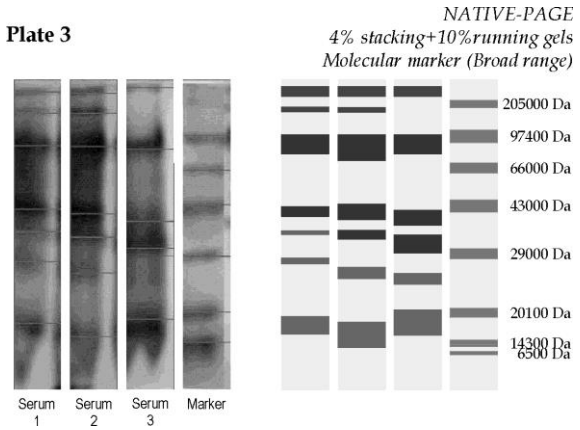


Plate 3. NATIVE--PAGElectrophoretic banding patterns of serum samples of preparatory, prespawning & spawning phases of reproductive cycle of L rohita. Image besides is computer generated electrophoregram of the same.

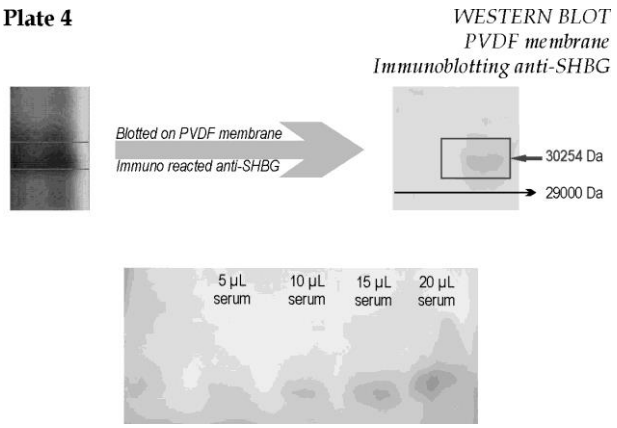


Plate 4. Right side image is the positive reacted blot PVDF membrane against anti-SHBG and confirming the band as SHBG band. Below scanned PVDF membrane image showing the graded serum samples with SHBG immunoconfirmation.

CC BY NC

Pranali D. Khadseet al /J. Pharm. Sci. & Res. Vol. 14(9), 2022, 918-920

ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Phytochemical Screening and antibacterial activity of leaves extract of Sterculia urens Roxb.

Pranali D. Khadse, Ratnnadeep C. Sawant*
Department of Chemistry, Dr. Ambedkar College, Deekshabhoomi, Nagpur (MS)- 440010
*E-mail: rcsawant@dacn.in

Abstract
The leaves of Sterculia urens Roxb was studied for phytochemical screening and antimicrobial activity. The ethanolic solvent extract was used to screen the secondary metabolites and test the antimicrobial effect of extract on microorganisms. The phytochemical analysis showed the presence of phenols, tannins, flavonoids, steroids, terpenoids, alkaloids, volatile oils. The extracts were subjected for Antimicrobial test using agar well disc diffusion method showed the significant zone of inhibition that is comparable to standard antibiotic in terms of inhibition.

Key Words: Sterculia urens Roxb, Solvent extraction, Phytochemical screening, Antibacterial, Agar well diffusion

INTRODUCTION

Plants provide practically everything that ordinary people need in their daily lives, including food, housing, medications, clothes, and livelihood [1]. Man is fully reliant on indigenous flora in one form or another in the present era. As a source of medication, natural compounds have an advantage over synthetic counterparts. Plant secondary metabolites have a range of functions and can be utilised as medications. In recent years, plant-based secondary metabolites have been used in a variety of Ayurvedic and traditional treatments. Herbal treatments have become increasingly popular due to their perceived safety. Sterculia urens Roxb. was previously classified as a member of the Sterculiaceae family, but is now classified as a member of the Malvaceae (Sterculioideae) family [2] and commonly known as the cacao family, which is found all throughout the world [3].

Table 1 Sterculia urens Roxb.

Kingdom	: Plantae
Sub-kingdom	: Tracheobionta (Vascular plant)
Super-division	: Spermatophyta (Seed plant)
Division	: Magnoliophyta (Flowering plants)
Class	: Magnoliopsida (Dicotyledons)
Sub-class	: Dilleniidae
Order	: Malvales
Family	: Sterculiaceae (Cacao family)
Genus	: Sterculia
Species	: urens

The Sterculiaceae family is an angiosperm family that was named after the genus Sterculia. Because of the foul odour of some plant species' blossoms, the generic name was given in the Latin word "stercus," which truly means "manure or filth." Sterculia urens is a desert-adapted deciduous forest tree endemic to Asia, particularly the tropical Indian subcontinent, Northern and Central India, the Indian west coast, and the dry forest regions of Burma and Sri Lanka [4]. This tree can withstand harsh temperatures and grow in areas with limited water supplies, such as 10–40 °C and 500–1900 mm of annual rainfall, respectively [5]. Gulu, kadaya, karaya, katera, kuteera, teklej, semla katilo, kullo, mucara, ghost tree, kovela, tapsi, India gum, and so on are some of the traditional names for Stercilua urens. Classification system given by Cronquist [7] is given in table 1.

MATERIALS AND METHODS:

Collection of Sample

Fresh Sterculia urens leaves were collected in Kanppa, Taluka Nagbhid, District Chandrapur, Maharashtra, India's "Panzadi Forest." The plant materials were carefully cleaned with distilled water and shade dried until all water molecules had disappeared and the plant components were completely dry. Following drying, the plant material was ground into a fine powder using a mechanical blender and placed into airtight packages with adequate labelling for use.

Preparation of Extract

The Soxhlet device was set up according to the instructions [8]. Individual thimbles were filled with twenty-five grammes (25 g) of dried and fresh Sterculia urens leaves powder. In a separate round bottom flask, 250 mL ethanol was taken. The solvent-filled round bottom flask was positioned on the heating element or above the burner (with water bath). A syphon was installed in the mouth of the round bottom flask (containing lateral thimble). On or until the solvent in the extractor's syphon tube became colourless, a reflux condenser was connected. The leaves' extract was collected in a flask with a circular bottom. The extract was then placed in a beaker and heated at 30-40 degrees Celsius until all of the solvent had evaporated. The dried extract was stored at 40°C in the refrigerator for future use in phytochemical analysis and antibacterial properties, among other things.

Phytochemical Screening:

Using standardised methodologies for phytochemical analysis of plant extracts, a quantitative assay for the presence of plant primary and secondary metabolites was performed [9].

Test for Phenols

A.$FeCl_3$ test: Crude extract was mixed with 2mL of 2% solution of $FeCl_3$. A blue-green or black coloration indicated the presence of phenols [10].

B.Liebermann's test: Small amount of extract and few crystals of sodium nitrite were taken in a dry test tube and heated gently for a minute. It was cooled and slowly at 0.5 mL conc. H_2SO_4 was added properly. A deep green or blue color was developed. The mixture was diluted with distilled water. The solution turned red. Then the excess of dilute NaOH solution was added. The mixture again became green or blue indicating the presence of phenols.

Test for Tannins

A. Gelatin Test: 5 gm powdered plant material was extracted by boiling in 100 mL of distilled water. The extract was filtered after 30 min. 2 mL of 2% gelatin was added to 5 ml of filtrate. Curdy white precipitate foam indicated the presence of tannin [11].

B. Ferric Chloride Test: To the filtrate, 5 drops of 5% ferric chloride solution was added. The formation of black or green-black coloration indicated the presence of tannin.

C. Potassium Iodide Test: To the filtrate, few drops of a saturated solution of potassium iodide were added if pink color forms which changes to brown on standing, indicating the presence of tannin like gallic and ellagic acid.

Test for Flavonoids

A. Shinoda Test: Crude extract was mixed with few fragments of magnesium ribbon and concentrated HCl was added dropwise. The pink scarlet color appeared after a few minutes which indicated the presence of flavonoids [12].

B. Alkaline Reagent Test: Crude extract was mixed with 2mL of 2% solution of NaOH. An intense yellow color was formed which turned colorless with the addition of a few drops of diluted acid which indicated the presence of flavonoids.

Test for Steroids

A. Salkowski's Test: Extracts were treated with chloroform and filtered. The filtrates were treated with a few drops of conc. Sulphuric acid, shaken, and allowed to stand. The appearance of the golden yellow color indicated the presence of triterpenes [13].

B. Liebermann Burchard's Test: Extracts were treated with chloroform and filtered. The filtrates were treated with a few drops of acetic anhydride, boiled, and cooled. Concentrated sulphuric acid was added carefully along the sides of the test tube. The formation of a brown ring at the junction indicated the presence of phytosterols.

Test for Terpenoids

Terpenoids are a group of the complex compound composed of 5-carbon units called isoprene. The crude extract was dissolved in 2mL of chloroform and evaporated to dryness. To this, 2mL of concentrated H_2SO_4 was added and heated for about 2 minutes. A grayish color indicated the presence of terpenoids [14].

Test for Alkaloids

A. Mayer's Test: Filtrates were treated with Mayer's reagent (Potassium Mercuric iodide). Formation of a yellow cream precipitate indicated the presence of alkaloids [15].

B. Wagner's Test: Filtrates were treated with Wagner's reagent (Iodine in potassium iodide). The formation of a brown or reddish-brown precipitate indicated the presence of alkaloids.

Test for Volatile Oil

The presence of volatile oil was tested in petroleum ether. 2 mL of extract was evaporated on a porcelain dish. The aromatic smell of residue indicated the presence of volatile oil [16].

RESULTS AND DISCUSSION:

Preliminary Phytochemical Screening

Table 2 shows preliminary phytochemical screening of ethanolic extract. Phenols, flavonoids, steroids, alkaloids, volatile oils, and other compounds were discovered in an ethanolic extract of Sterculia urens leaves.

Table 2: Phytochemical screening of crude ethanolic extract of *Sterculia urens* leaves.

Phytochemicals	Ethanolic extract
Phenols	+ve
Tannins	-ve
Flavonoids	+ve
Steroids	+ve
Terpenoids	-ve
Alkaloids	+ve
Volatile oils	+ve

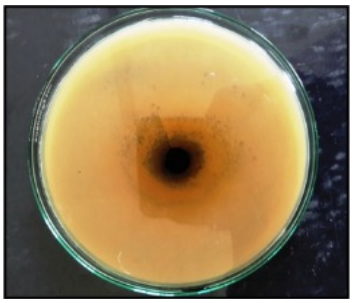
Where + shows presence and - shows absence of phytochemical activities.

Antibacterial activity [17] of the ethanol extract and silver nanoparticles from the leaf of S. urens

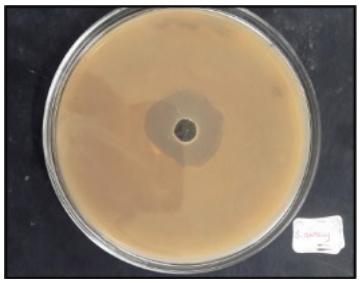
The antibacterial activity of S.urens dry powdered leaves ethanol extracts has a higher zone of inhibition in Staphylococcus aureus (26 mm) and a similar zone of inhibition in Pseudomonas aeruginosa (25 mm). In vitro experiments showed that ethanolic extracts of Strculia urens leaf had inhibitory action against both gram positive and gram negative bacteria. The findings suggest that chemical components found in ethanolic extracts of Sterculia urens leaf have antibacterial action. The ethanolic leaf extract of Sterculia urens exhibited promising results against all bacteria tested in this study. The ethanolic leaf extract of Sterculia urens showed significant antimicrobial activity (Table 3).

Table 3. Zone of inhibition of extract of leaf of S. urens

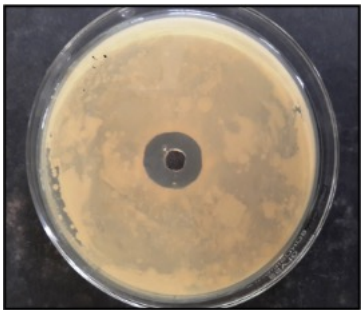
	Microorganisms	Zone of Inhibition (ZI) (In mm)
		100 ul
1.	Escherichia coli	21 mm
2.	Staphylococcus aureus	26 mm
3.	Salmonella typhae	19 mm
4.	Pseudomonas aeruginosa	25 mm
5.	Proteus mirabilis	23 mm



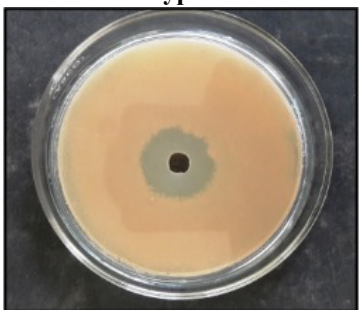
E. coli



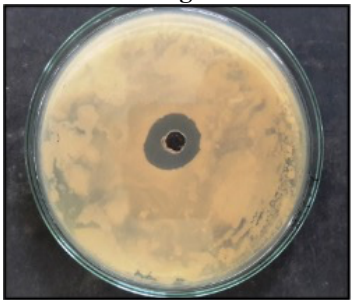
S. aureus



S. typhae



P. aeruginosa



P. mirabilis

Figure 1. Showing zone of inhibition of ethanol extract of the leaf of S. urens against various microorganisms

CONCLUSION:

The findings demonstrated that the Sterculia urens tested contained medicinally significant components. Antimicrobial testing revealed a considerable zone of inhibition comparable to that of a typical antibiotic. Natural products have long attracted the interest of the world due to its fewer side effects, lower cost, and superior medicinal properties. As a result, extracts from these plants could be considered a promising source of therapeutics. Traditional medicine is strongly recommended for these plants, and it is urged that more research be done to extract, purify, and define the active ingredients responsible for the activity of these plants' metabolites. Furthermore, deeper research into the likely mechanism of action of these extracts is urged. As a result, future research should focus on utilizing this plant as one of the greatest medicinal plants for managing pathogenic microorganisms.

REFERENCES

1. Dhiman M, Singh A, Sharma MM. A review on Sterculia urens Roxb.: a boon to the livelihood for tribal people and industry. Industrial Crops and Products. 2019 Apr 1;130:341-51.
2. Lujan-Medina GA, Ventura J, Ceniceros AC, Ascacio JA, Valdés DB, Aguilar CN. Karaya gum: general topics and applications. Macromolecules Indian J. 2013;9:111-6.
3. Abd Al-Rahman AY. A Pharmacognostical Study of Certain Sterculia Species (Family: Sterculiaceae). CU Theses. 2017.
4. Nussinovitch A. Plant gum exudates of the world: sources, distribution, properties, and applications. CRC Press; 2009 Dec 21.
5. Roecklein JC, Leung PS, editors. A profile of economic plants. Transaction Publishers; 1987.
6. Davidson RL. Handbook of water-soluble gums and resins. 1980 Jun 5.
7. Cronquist A, Takhtadzhi͡an AL. An integrated system of classification of flowering plants. Columbia university press; 1981.
8. De Castro ML, Priego-Capote F. Soxhlet extraction: Past and present panacea. Journal of chromatography A. 2010 Apr 16; 1217 (16):2383-9.
9. Shaikh JR, Patil MK. Qualitative tests for preliminary phytochemical screening: An overview. International Journal of Chemical Studies. 2020 Mar;8(2):603-8.
10. Prakash, V., Saxena, S., Gupta, S., Saxena, A.K., Yadav, R. and Singh, S.K., Preliminary Phytochemical screening and Biological Activities of Adina cardifolia. *Journal of Microbial & Biochemical Technology*, *2015*.
11. Ayoola, G.A., Coker, H.A.B., Adesegun, S.A., Adepoju-Bello, A.A., Obaweya, K., Ezennia, E.C. and Atangbayila, T.O., Phytochemical screening and antioxidant activities of some selected medicinal plants used for malaria therapy in Southwestern Nigeria. Trop J Pharm Res, 2008, 7(3), pp.1019-1024.
12. Edeoga, H.O., Okwu, D.E. and Mbaebie, B.O., Phytochemical constituents of some Nigerian medicinal plants. African journal of biotechnology, 2005, 4(7), pp.685-688.
13. Rathore SK, Bhatt SH, Dhyani S, Jain A. Preliminary phytochemical screening of medicinal plant Ziziphus mauritiana Lam. fruits. International Journal of Current Pharmaceutical Research. 2012;4(3):160-2.
14. Singh, M.P. and Saxena, S., Phytochemical analysis and antimicrobial efficacy of methanolic extract of some medicinal plants at Gwalior region. *Journal of Pharmacy Research*, 2011, *4*.
15. Tadhani, M. and Subhash, R., Preliminary studies on Stevia rebaudiana leaves: proximal composition, mineral analysis and phytochemical screening. J. Med. Sci, 2006, 6(3), pp.321-326.
16. Sanni MO, Gringarten AC. Well test analysis in volatile oil reservoirs. InSPE annual technical conference and exhibition 2008 Sep 21. OnePetro.
17. Boyanova L, Gergova G, Nikolov R, Derejian S, Lazarova E, Katsarov N, Mitov I, Krastev Z. Activity of Bulgarian propolis against 94 Helicobacter pylori strains in vitro by agar-well diffusion, agar dilution and disc diffusion methods. Journal of medical microbiology. 2005 May 1;54(5):481-3.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

c0006

6

Nanoparticles for sustainable agriculture: innovative potential with current and future perspectives AU:1

Subhash Rupchand Somkuwar[1], Ratnnadeep C. Sawant[1,2], Prashant P. Ingale[3], Dhanraj T. Masram[4], Rupali Ramesh Chaudhary[5]

[1]DEPARTMENT OF BOTANY, DR. AMBEDKAR COLLEGE DEEKSHABHOOMI, NAGPUR, MAHARASHTRA, INDIA [2]DEPARTMENT OF CHEMISTRY, DR. AMBEDKAR COLLEGE DEEKSHABHOOMI, NAGPUR, MAHARASHTRA, INDIA [3]DEPARTMENT OF ZOOLOGY, SAIBABA COLLEGE PARSEONI, NAGPUR, MAHARASHTRA, INDIA [4]DEPARTMENT OF CHEMISTRY, UNIVERSITY OF DELHI, DELHI, INDIA [5]DEPARTMENT OF BOTANY, SANT GADGE MAHARAJ COLLEGE HINGNA, NAGPUR, MAHARASHTRA, INDIA

Chapter outline

6.1 Introduction 1
6.2 Nanopesticides: agro-based formulations for pest control 2
6.3 Nanofertilizers: recent trends and prospect in agriculture system 4
6.4 Nanoparticles: uptake, translocations, and plant growth 6
6.5 Recent advances in nanoparticles for plant protection 7
6.6 Nanomaterials as agents to smart monitoring 8
6.7 Nanoparticles for managing the agricultural postharvest waste 9
6.8 Future perspective 10
6.9 Conclusion 10
References 10

s0010 6.1 Introduction

p0060 The mother earth is in the midpoint of the sixth mass extinction of life. Researchers have estimated that approximately 180–190 birds, amphibians, insects, mammals, and plant species become globally and locally extinct daily. This rate is almost 1000-fold more than that of the natural extinction rate due to global climate change and anthropogenic activities. Taking such burning issues into consideration and to promote strategic action plan, the period 2011–20 was

Biogenic Sustainable Nanotechnology. DOI: https://doi.org/10.1016/B978-0-323-88535-5.00013-5
© 2022 Elsevier Inc. All rights reserved.

Pratap-Singh-BSN-1633138 978-0-323-88535-5 00013

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

declared as the United Nations (UN) Decade on biodiversity; 2020 as the international year of plant health; and 2021–30 as the UN Decade on ecosystem restoration.

p0065 In the period of global climate shifting, agriculture sectors are facing several unusual challenges. Very few number of cultivated crop species are available on which global agriculture is heavily dependent, which indicates to optimize productivity within a relatively narrow range of environmental variations (Kukal & Irmak, 2018). Climatic extremities cause a huge loss of crop production. To combat the effects of such extreme events, mitigation strategies are required alongside the global drivers of agricultural production (Dhankher & Foyer, 2018; Nutan et al., 2020; Schewe et al., 2019). The recent ongoing advancements in the field of plant and agri-biosciences have the potential to address these challenges (Bailey-Serres et al., 2019) as far as food and nutritional security is concerned but not the environmental safety.

p0070 Recent advancement in nanotechnologies research supports the pathogens, pesticides, and toxins, tracking–tracing–monitoring system that can assure food quality (Sahoo et al., 2021). Nanotechnology will positively lead sustainable agriculture (Prasad et al., 2017), with the formulation and fabrication of more sophisticated nanoagrochemicals, with a lower impact on the environment and human health. Technological innovations in nanoengineering demonstrate multidisciplinary relevance in targeted agrochemical delivery system that is still under progressive development. Moreover, these unique properties and diverse applications of nanomaterials (NMs) prove to be the novel material for the future (Chouke et al., 2022). Thus the cross-pollination of biological ideas and environmental conditions with nanotechnology has significantly increased their potential to identify, develop, and design innovative tools for agricultural uses that possibly help one to satisfy the ever-increasing food demand and environmental sustainability in the age of negative environmental externalities.

s0015 6.2 Nanopesticides: agro-based formulations for pest control

p0075 Agrochemical technology is classically meant to improve crop health and restrict pests that compromise crop yields. The unscientific and overuses of pesticides to control pests adversely affect crop productivity (Bombo et al., 2019), which leads to pathogen resistance, biodiversity loss, and affect nitrogen fixation, and increasing chances of bioaccumulation of pesticides in agri-ecosystem. Approximately, half of the applied pesticides saturate in farmlands that contaminate the aquatic bodies. Agrochemicals-based nanoparticles (NPs) enhance overall contact with the crop pest that makes them more competent due to their higher total surface area occupancy (Osorio-Echavarría, 2021; Pérez-Iglesias, 2019; Umekar et al., 2021; Vigneshwaran, 2006). In the modern farming the nanocarrier strategies are significantly used to reduce pesticides application rates and overcome environmental imbalance (Kah & Hofmann, 2014; Kah et al., 2018). Agrochemical-based nanopesticides formulations find wider application over chemical pesticide formulations. Bioinspired NMs formulations with pesticidal activities (nanobiopesticides) are sustainably and effectively used to protect crops against the target pests with improved stability and absorption rate (Borgatta et al., 2018; de Oliveira et al., 2019). It also minimizes adverse environmental consequences and maintains health and integrity of agro-ecosystem.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

p0080 Nanopesticides are nanoengineered materials are employed in plant protection that increases leaf coverage and stability and reduces the quantities with minimal application losses. In general, nanopesticides formulations can be classified into dendrimers, liposome, metallic and bimetallic NPs (e.g., copper, copper oxide, silver, zinc oxide, silicon dioxide, manganese dioxide, and titanium dioxide), and dynamic encapsulating components such as polymeric NPs, nanoemulsion, lipid NPs, and nanotubes. Several nanosized materials, namely, ceramic, silica, metal, lipids, polymers, copolymers, and carbon, are used to investigate pesticidal efficacies in nanocarrier-mediated formulations (Agostini et al., 2012; Bratovcic, 2020; Chaud et al., 2021; Chaudhary et al., 2019; Chouke et al., 2019; Elmer et al., 2018; Guilger-Casagrande et al., 2019; Lakshmeesha et al., 2020; Shukla et al., 2020). Carbon nanotubes can be used as a biosensor with systemic-release-system for agrochemical pesticide and fertilizer. The carbon nanotubes increase the biomass of the plants, seed germination, and the length of shoot and root (Sarlak et al., 2014), but due to reactive oxygen species (ROS) it leads to cell death (Vithanage et al., 2017). RNAi technologies are designed for gene silencing in insect having multidrug-resistance capacity (Parsons et al., 2018). Due to sequence-specific endogenous RNAi, a novel genetic material delivery—nonencapsulated system is used as pest control strategies (Fletcher et al., 2020).

p0085 Recently in agriculture sector, formulation and designing of emulsion-based nanopesticide carriers is a subject of research interest for the systemic release of agrochemicals. The mesoporous silica NPs loaded with azoxystrobin showed more loading content, pH-driven controlled release, and better fungicidal effect in the tomato plant (Xu et al., 2018). Several emulsion-based nanopesticide formulations are designed for pest and weed control (Hazra & Purkait, 2019; Mustafa & Hussein, 2020). The nanoencapsulation of neem and citronella oil biopesticides is used for better efficacy and to improve water solubility using spontaneous emulsification technique. It showed an excellent fungicidal activity (Ali et al., 2017). Adopting the same scientific approach, Hasheminejad et al. (2019) prepared a clove oil encapsulated chitosan-based NPs effective against fungi along with prolonged release of the active ingredient. β-Cyclodextrin encapsulated chitosan NPs, coloaded with linalool, and carvacrol, enhanced insecticidal activity against cotton bollworm and red spider mite (Campos et al., 2018). Liposomes-mediated nanocarriers are designed for easy release of active compound and to preserve it from thermal degradation and photodegradation. Liposome-based nanocarriers can extend the period for the delivery of active agrochemical ingredients, depending on specific properties and types of the compounds used (Bang et al., 2011; Huang et al., 2018; Hwang et al., 2011; Jampílek & Kráľová, 2017).

p0090 Synthesis of environmentally safe and cost-effective metallic NPs is generally recognized. Due to a large surface area, metallic NPs have a broad spectrum of action against plants pathogens due to its antimicrobial biochemical behavior and have negligible risk of resistance development (Keller et al., 2017; Malandrakis et al., 2021; Santos et al., 2021). However, pulmonary inflammation (Worthington et al., 2013), immune response, and bioaccumulation on living organisms have been recognized with the exposure copper NPs coating with polysaccharides (Zhang et al., 2012). Silver NPs sulfidate rapidly in the reducing environments that would minimize cytotoxicity and environmental toxicity of AgNPs

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

(Potbhare et al., 2020a). The nanopesticide formulations can control crop pathogens by increasing their water solubility and bioavailability, and also avoid their environmental degradation (Yadav et al., 2020). The potential of nanopesticides in the pest control in consonance with environmental stimuli can avoid the early complexation and restrain the sulfidation reaction (Agostini et al., 2012; Gao et al., 2021). The effect of nanopesticides formulations in the environment, consumers, workers, and other all associated in the agriculture chain is poorly known (Huang et al., 2015). Depending on the material used, it can produce a toxic effect in plant, human, and other vertebrate classes (Potbhare et al., 2020b).

p0095 To understand the toxicity and ability of the NPs to interact with the human biomolecules, more research is being conducted by various researchers. However, enhanced toxicological risk is likely to be associated with nanotechnology-based agrochemicals that can threaten ecosystems and human health (Mustafa & Hussein, 2020; Yadav et al., 2020). Despite lot many advances achieved in nanopesticide formulations for pest control, still direct interactions of NMs between plant products and environment need to be extensively evaluated in terms of bioaccumulation, bioavailability, toxicity, and public health (Chaud et al., 2021; Kah et al., 2019; Lowry et al., 2019; Pascoli et al., 2018; Sanzari et al., 2019; Tiple et al., 2020). The good sides of nanopesticides in crops are understood well, while its negative impacts such as retention time, reactivity, bioaccumulation levels, degradation time, and pollination behavior and food safety are poorly understood. More scientific research on nanopesticides and financial support is needed to understand its linkages and interaction with biochemical pathways. Meanwhile, it is needed to formulate the best possible long-term strategies on the selection of specific nanopesticides materials for synthesis that would get a very negligible genotoxic effect. In that way, nanopesticides usage policy can satisfy the agricultural pest control demand and thereby safeguard agri-workers' health and ecosystems.

s0020 6.3 Nanofertilizers: recent trends and prospect in agriculture system

p0100 The development of world economy and abundance of victuals for a better living depends predominantly on agriculture. The current global climate change poses great adverse challenges, for agriculture sector, namely, soil contamination/erosion, less production of crops owing to pests (De La Torre-Roche et al., 2020; Kah et al., 2019; Lowry et al., 2019; Pouratashi & Iravani, 2012), incessant use of pesticides and fertilizers, resulting in environmental contamination (Lowry et al., 2019; Sonkusare et al., 2020; Zhao et al., 2020). Sustainable strengthening is a design associated with a production of crop that aims to enhance the yield without adverse ecological impact whilst cultivating the same farming region (Baulcombe et al., 2009). This measure supports an outline to review the finest alternative to farming considering all the relevant factors (Garnett & Godfray, 2012). To hand out these relevant issues, novel techniques and strategies are continuously progressing. NP-based agricultural product introduction is one such step taken for revolutionizing modern agricultural practices. Nanofertilizers contain macro- and microelements required for crop

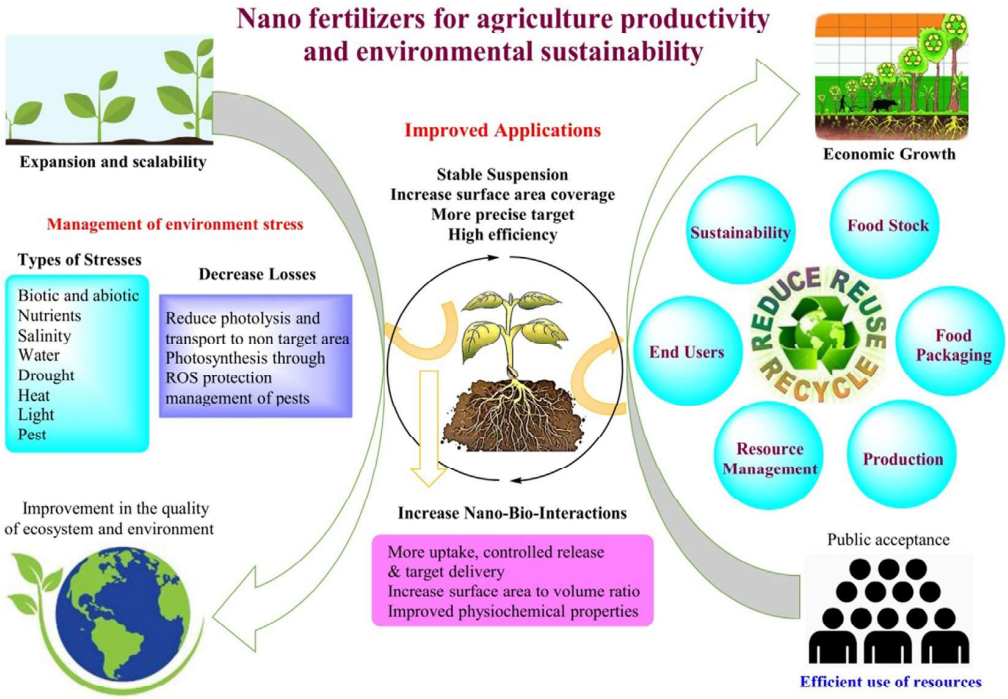
To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

growth and development that are supplied in a controlled manner. NPs (Jeevanandam et al., 2018) and nanoengineering improve crop production and assure sustainability with enhancing the competence of input and minimize significant losses. The engineered NMs act as an exclusive carrier of agrochemicals aid with site-targeted controlled release of nutrients support high-tech agriculture system. Intelligent nanofertilization system finds application in control nutrients discharge in soil that benefits to reduce leaching with an improved uptake of nutrients by crops and extenuating eutrophication (Liu & Lal, 2015) by restricting the nitrogen enrichment to groundwater. NMs reduce nutrient losses and improve utility by rising solubility, increasing resistance against hydrolysis and photodegradation by offering precise and proscribed discharge toward objective organisms (Mishra & Singh, 2015; Nuruzzaman et al., 2016; Sonkusare et al., 2018; Usman et al., 2020), and curtail the expenditure to exploit better output on products for crop fortification.

p0105 Innovation in agri-biosciences greatly promotes the research on NPs that plays a diverse role in agricultural system as nutritional supplements and soil monitoring tool, and as nanocapsules to carry slow and constant release of nanofertilizers and nanopesticides, or even uses in genes transfer to plant target sites (Gnanamangai et al., 2017; Kamle et al., 2020; Ma et al., 2018) (Fig. 6.1). Nanofertilizers have been proposed as a sustainable agricultural tool for the next 30 years due to the feasibility of slow-release means of nitrogen and phosphorus that results in rise of crop production by up to 30% with minimal inputs (Kah et al., 2018; Kalia et al., 2019) (Fig. 6.1). Nanofertilizers are applied in smaller quantities compared to traditional fertilizers that could be crucial development in the environment protection (Adisa et al., 2019), in terms of reducing runoff, leaching, and gas emissions (Manjunatha et al., 2016). Nanosized ammonia, urea, ammonium humate, plant wastes, and peat particles are being employed to prepare nanosized fertilizers (Taiz & Zeiger, 2010; Wan et al., 2010) (Fig. 6.1). Applications of P, Zn, Fe, and Mg NPs remarkably improve (three to four times) nutrient use efficiency by facilitating a slow-release nutrients thus help crops for required nutrient uptake (Jyothi & Hebsur, 2017; Kalia & Sharma, 2019; Manjunatha et al., 2016). Incredible boost was observed in organic acid and phosphorous uptake in the rhizospheric zone of plants after an application of nanophosphorous (Tarafdar & Adhikari, 2015). Similarly, it is observed that nanostructured 2D clays can enhance nutrients uptake efficiency (Lazaratou et al., 2020).

p0110 Foliar NPs improved seed germination (Zhao et al., 2020), increased shelf life of agricultural produce, improved absorption and assimilation of foliar fertilizer (García-López et al., 2019), and reduced damage by abiotic stresses (Elsheery et al., 2020). Foliar application of one or many NPs collectively accelerates the activity of antioxidative enzymes and improves resistance against stress (Ei et al., 2020; Faizan et al., 2021; Gao et al., 2020; Ogunkunle et al., 2020). It is demonstrated in growth chamber experiments that the ability of the amorphous-calcium−phosphate nanofertilizer to enhance quality and yields of the wheat grains (Ramírez-Rodríguez et al., 2020a, 2020b). N-doped nanofertilizers may open a bright future for urban and vertical farming in soilless (hydroponic) conditions (Beacham et al., 2019) (Fig. 6.1), and a new way to enhance output, mainly in arid and densely populated areas with limited lands (Sambo et al., 2019). In brief, fertilizers encapsulated with NPs have broad outlook for preparing plant-nutrient supplements with more use efficacy.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.



f0010 **FIGURE 6.1** Schematic representation of efficient use of nanofertilizers for agriculture productivity and environmental sustainability.

s0025 6.4 Nanoparticles: uptake, translocations, and plant growth

p0115 It is evident that the use of NPs influences the growth and development of plant that comprises seedling vigor, photosynthesis process, and growth of plant parts such as roots and shoots. Lv et al. (2015) and Su et al. (2019) comprehensively reviewed and explained the uptake, transport, and fate of NMs. Physiological and structural variations in plants show variations in uptake patterns of various classes of NMs, such as TiO_2 and carbon-coated Au (Gandhare et al., 2016; Larue et al., 2012). Uptake of NMs depends upon the mode of exposure and the ability of plants (Schwab et al., 2016). Soil organic matter, humic acid, mycorrhizal fungi, and bacteria enhances the uptake and access of NPs to plants (Feng et al., 2013; Navarro et al., 2012). NMs change the confirmation of cell membrane proteins with the help of their energy and surface charge (Juárez-Maldonado et al., 2019; Pérez-de-Luque, 2017). Usually, plasmodesma develops cytoplasmic connections to assist the movement of NPs between adjacent cells during translocation (Dietz & Herth, 2011). Wang et al. (2012) reported the translocation of CuO NPs from roots to shoots and wise versa through vascular tissues. The negatively charged plant cell-walls component act as the surface for positively charged NPs (Meychik et al., 2005; Santiago et al., 2013; Zeng et al., 2017).

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

p0120 Related to the previous observation, surface charge-dependent uptake of Au NPs in roots and its translocation from roots to shoots was investigated (Milewska-Hendel et al., 2019). They also observed that negatively charged NPs support both transport pathways (symplastic and apoplastic) into the vascular system. More root surface areas in tomato and lettuce plants were observed when treated with positively charged cerium oxide NPs, while improved root to shoot movements were observed with neutral and negatively charged cerium oxide NPs (Spielman-Sun et al., 2019). NPs are mostly deposited on the cell wall of the guard cells or subsidiary cells of stomata or stomatal opening when entering through the stomata that was proved by Fe_3O_4 NPs, through transmission electron microscopy studies (Cai et al., 2020). In the view of above context, Li et al. (2020) also observed a biotransformation of Ag NO_3 applied with AgNPs (24.8–38.6 nm) within *Lactuca sativa* leaves. Su et al. (2020) observed that NPs (ZnO and Cu) affect seed germination in Mung bean plant (Raja et al., 2019). Rahman et al. (2020) examine the seed germination and growth-enhancement effect in a pea plant with the polyvinyl–pyrrolidone-protected platinum NPs treatment. Chitosan-based NPs show positive effect on seed germination and growth of wheat even at a very lower concentration (Li et al., 2019).

p0125 Govea-Alcaide et al. (2016) tracked Fe_3O_4 NPs in plant tissues by applying magnetic properties. Raliya et al. (2016) quantified the AuNPs by using inductively coupled plasma mass spectrometry (ICP-MS) to observe the uptake pathway and saturation in *Citrullus lanatus* plants. When garlic leaves were treated with TiO_2 NPs, it is observed that of chlorophyll content and photosynthetic rate were enhanced (Bharti et al., 2018). Mozhayeva and Engelhard (2020) suggested that single-particle ICP-MS (SP-ICP-MS) analysis serves as a promising and reliable method for the detection, characterization, and quantification of NMs. Earlier, with the help of single particle inductively coupled plasma mass spectrometry (SP-ICP-MS) technique, Keller et al. (2018) quantified the uptake of CuONPs in various edible plants, while Wojcieszek et al. (2019) used SP-ICP-MS and electrospray ionization (ESI) tandem MS to confirm the fate of ZnO NPs inside the edible plant lettuce. Nath et al. (2018) used SP-ICP-MS, scanning electron microscopy, and energy-dispersive x-ray spectroscopy (EDS) to study simultaneous uptake, retention, and distribution of Cu, Ag, and ZnO NPs in *Arabidopsis thaliana*, while Deng et al. (2017) utilized the SP-ICP-MS, electron microscopy, and ICP-optical emission spectroscopy (OES) techniques to understand the size, distribution, and uptake of TiO_2 NPs in rice. NPs caused injury to the plant when applied with higher dose. Yuan et al. (2018) observed the increased plant growth and extra gain of chloroplast content in *Capsicum annuum* when treated with lower concentrations of Fe NPs.

s0030 6.5 Recent advances in nanoparticles for plant protection

p0130 Plant grows ubiquitously in nature in diverse habitat; therefore they tolerate environmental extremities. Plant shows various kinds of stress responses against biotic and abiotic stresses. Depending on the stress, it modifies stress-responsive gene regulation and produces antioxidative enzymes that play a significant role in protecting the plants from stresses (Rejeb et al., 2014; Sharifi et al., 2020). SiO_2 NPs improve the water use efficacy, enhance transpiration rate, accelerate carbonic anhydrase activity, and increase chlorophyll content in the *Cucurbita pepo* against abiotic stress (Siddiqui & Al-Whaibi, 2014).

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

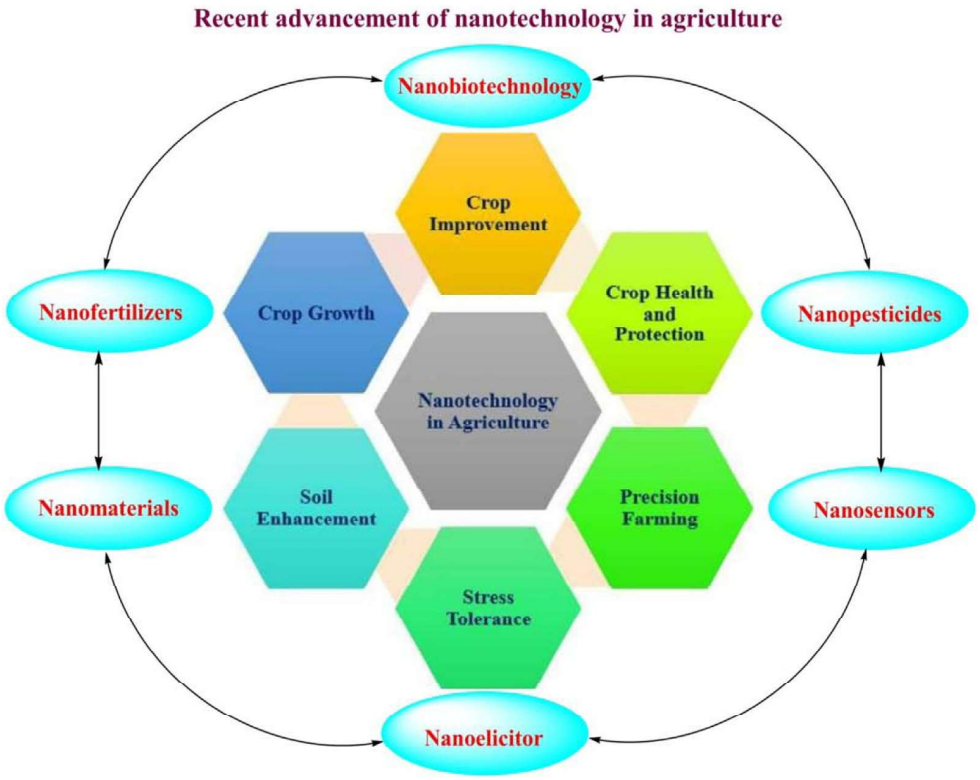
p0135 Abiotic stress minimizes the photosynthetic efficacy of the plant that led to influence the additional ROS production with an oxidation of biomolecules (Wakeel et al., 2020). Nanoceria (CeO NPs) showed extensive linkages with positive and negative plant health and growth conditions (Milenković et al., 2019). Nano-Ce acts as an antioxidative agent that regulates ROS by scavenging pathways (Chaudhary et al., 2020; Collin et al., 2014) (Fig. 6.2) and improves the resistance against a range of abiotic plant stresses. Si NPs can interact with plants directly or indirectly by conferring morphological and physiological changes (Babajani et al., 2019) (Fig. 6.2) to afford tolerance against drought stress (Ashkavand et al., 2015) and under saline environment at various concentrations by maintaining osmotic and ionic balance that enhance the antioxidant system, along with increased levels of various phytopropanoids (Soleymanzadeh et al., 2020). Interestingly, it is observed that the application of SiNPs in strawberry plants leads advance structure and thickness of epicuticular wax as compared to salt-stressed plants (Avestan et al., 2019) (Fig. 6.2).

p0140 The enzymatic and nonenzymatic defense mechanism can be triggered by the TiO_2 NPs against stress in plants. Karamian et al. explained that methyl jasmonate, salicylic acid, and TiO_2 NPs reduce drought stress in medicinal plants. TiO_2 NPs-treated plants show higher chlorophyll content and biomass by maintaining the osmotic balance and antioxidant enzymes pathways (Karamian et al., 2020). TiO_2 NPs regulate the synthesis of glutamate dehydrogenase and glutamine synthase thereby accumulates more nutrients and essential oil content in plants (Ahmad et al., 2018) under normal conditions. This concludes that aromatic plants can be protected against the stress by changing essential oil synthesis profile and composition (Gohari et al., 2020). TiO_2 NPs enhances the accumulation of osmolytes by recovering the hydration status of the plant. It can increase the activity of the nitrate reductase enzyme that induces proline and glycine betaine synthesis that leads to nitric oxide production (Khan et al., 2020).

s0035 6.6 Nanomaterials as agents to smart monitoring

p0145 Agro-nanotechnology is an emerging field where the reduction of biotic stress is a novel sustainable approach employed for improving plant growth (Khan et al., 2021) and overall health. Khot et al. (2012) stated that Au, SiO_2, ZnO, and TiO_2 carbon nanotubes and NPs can accelerate the nutrients and elemental uptake and improve the plant development. Nanosensors may be connected with self-directed sprinkling controllers for estimating soil—water tension in real time. This attribute offers management of sustainable irrigation on the basis of drying soil (de Medeiros et al., 2001). Nanosensors are sensitive and cost-effective, which perform quick operation in detecting various targets related to food qualities. Moreover, nanosensors are amongst one of the emerging technologies that might challenge the estimation of food safety and quality, being capable of providing a smart monitoring of food ingredients and impurities. A nanosensor plays a significant role in intelligent packaging along with monitoring the food and checking of the integrity of the packages during transport, storage, and display in markets (Vanderroost et al., 2014). Furthermore, nanosensors can be employed in monitoring physical parameters of agri-produce such as freshness, decomposition, and to trace out pathogens and toxins.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.



f0015 **FIGURE 6.2** Application of nanotechnology-based nanofertilizers and nanopesticides to improve crop growth, protection, yield, and productivity. Nanosensors can greatly contribute to precision farming. Nanomaterial-mediated gene transfer to organelles/cell can be used for crop improvement.

s0040 6.7 Nanoparticles for managing the agricultural postharvest waste

p0150 Recent literature has highlighted that nanotechnology offers a variety of applications in the agricultural postharvest waste management. The aerogel is a very hydrophilic nanoscale cellulosic material that has diverse applications in postharvest management. Agricultural waste has more amount of lignocellulose that can be used to prepare nanocomposites (Othman, 2014), nanocellulose (Shahabi-Ghahafarrokhi et al., 2015), nanohemicellulose, nanolignin, nanopectin, and nanoxylan. A cellulose biopolymer is the most abundant component of cell wall of the tree. Nano- and holocellulose aerogels are employed widely as adsorption materials owing to the nanofibrillar structure with some unique properties (Dai & Fan, 2013; Muñoz-García et al., 2015). Rice and wheat husks waste can be used to produce value-added nanoproducts to tackle the agricultural disposal problem (Kaur et al., 2016) by utilizing electrospinning technique (Ramakrishna et al., 2006). The rice husk is an excellent material for

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

nano- and microsilica that can be utilized to extract silica. The nanosilica in conjugation with valid amycin has been effectively used to control the delivery of water-soluble pesticides (Liu et al., 2006). Huang et al. (2015) reported that the nanosilica conjugates promote plant growth and act against mildew diseases.

s0045 6.8 Future perspective

p0155 Nanotechnology has diverse and promising applications in different domains of the agriculture practices and agriculture-based processing industries. However, most of the information is gathered mainly from laboratory experiments performed by various researchers. The application and practical relevance of NPs-based agrochemicals need to be investigated in details with basic understanding by their impact on socioenvironment-related toxicity. Hence, there is a prerequisite to execute bulky trials of novel NP-based agrochemicals to encourage further investigations for understanding long-term food security and environment safety. Furthermore, it is very essential to prepare specific regulatory guidelines and a list of eco-friendly NP-based novel agrochemicals available for sale to get approval and support from consumers.

s0050 6.9 Conclusion

p0160 Recently, prodigious challenges we are facing due to a growing global population, climate sifting, and outbreak of plant pathogens. The introduction of NPs can significantly contribute to addressing these burning issues. To enhance crop production, unscientific use of chemical pesticides and fertilizers, causing a desertification of agri-soil, affects natural environment and leads to biodiversity loss. As nanotechnology is a promising research field in the current times when broad spectrum research is being conducted in terms of optimizing efficiency of nanofertilizers, nanocarriers, nanosensors, fuel additives, and NMs-mediated genetic engineering. Likewise, eco-sustainable innovations in agri-biosciences are also essential to explore and promote agriculture-based industry and socioenvironment safety. The scientific use of NPs-based agrochemicals provides better application that can result in a system safer for farmers as well as consumers for future environmental sustainability. A nanotechnology contributes in waste reduction and improves efficiency, while nanocarriers and nanosensors technology encourages the precision agriculture. Furthermore, cutting edge research is needed on efficient use of agriculture waste to convert that waste into value-added nanoproducts.

References

AU:2

Adisa, I. O., et al. (2019). Recent advances in nano-enabled fertilizers and pesticides: A critical review of mechanisms of action. *Environmental Science: Nano*, *6*(7), 2002–2030.

Agostini, A., et al. (2012). Dual enzyme-triggered controlled release on capped nanometric silica mesoporous supports. *ChemistryOpen*, *1*(1), 17–20.

Ahmad, B., et al. (2018). Efficacy of titanium dioxide nanoparticles in modulating photosynthesis, peltate glandular trichomes and essential oil production and quality in *Mentha piperita* L. *Current Plant Biology*, *13*, 6–15.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

Ali, E. O. M., et al. (2017). Antifungal activity of nano emulsions of neem and citronella oils against phytopathogenic fungi, *Rhizoctonia solani* and *Sclerotium rolfsii*. *Industrial Crops and Products*, *108*, 379—387.

Ashkavand, P., et al. (2015). Effect of SiO_2 nanoparticles on drought resistance in hawthorn seedlings. *Forest Research Papers*, *76*(4), 350—359.

Avestan, S., et al. (2019). Application of nano-silicon dioxide improves salt stress tolerance in strawberry plants. *Agronomy*, *9*(5), 246.

Babajani, A., et al. (2019). Differential growth, nutrition, physiology, and gene expression in *Melissa officinalis* mediated by zinc oxide and elemental selenium nanoparticles. *Environmental Science and Pollution Research*, *26*(24), 24430—24444.

Bailey-Serres, J., et al. (2019). Genetic strategies for improving crop yields. *Nature*, *575*(7781), 109—118.

Bang, S. H., et al. (2011). Influence of chitosan coating on the liposomal surface on physicochemical properties and the release profile of nanocarrier systems. *Journal of Microencapsulation*, *28*(7), 595—604.

Baulcombe, D., et al. (2009). *Reaping the benefits: Science and the sustainable intensification of global agriculture*. The Royal Society.

Beacham, A. M., Vickers, L. H., & Monaghan, J. M. (2019). Vertical farming: A summary of approaches to growing skywards. *The Journal of Horticultural Science and Biotechnology*, *94*(3), 277—283.

Bharti, A. S., et al. (2018). Steady state and time resolved laser-induced fluorescence of garlic plants treated with titanium dioxide nanoparticles. *Spectroscopy Letters*, *51*(1), 45—54.

Bombo, A. B., et al. (2019). A mechanistic view of interactions of a nanoherbicide with target organism. *Journal of Agricultural and Food Chemistry*, *67*(16), 4453—4462.

Borgatta, J., et al. (2018). Copper based nanomaterials suppress root fungal disease in watermelon (*Citrullus lanatus*): Role of particle morphology, composition and dissolution behavior. *ACS Sustainable Chemistry & Engineering*, *6*(11), 14847—14856.

Bratovcic, A. (2020). Biosynthesis of green silver nanoparticles and its UV-vis characterization. *International Journal of Innovative Science, Engineering and Technology*, *7*, 170—176.

Cai, L., et al. (2020). Foliar exposure of Fe_3O_4 nanoparticles on *Nicotiana benthamiana*: Evidence for nanoparticles uptake, plant growth promoter and defense response elicitor against plant virus. *Journal of Hazardous Materials*, *393*, 122415.

Campos, E. V. R., et al. (2018). Carvacrol and linalool co-loaded in β-cyclodextrin-grafted chitosan nanoparticles as sustainable biopesticide aiming pest control. *Scientific Reports*, *8*(1), 1—14.

Chaud, M., et al. (2021). Nanopesticides in agriculture: Benefits and challenge in agricultural productivity, toxicological risks to human health and environment. *Toxics*, *9*(6), 131.

Chaudhary, R. G., et al. (2019). Metal/metal oxide nanoparticles: Toxicity, applications, and future prospects. *Current Pharmaceutical Design*, *25*(37), 4013—4029.

Chaudhary, R. G., Chouke, P. B., Bagade, R., Potbhare, A. K., & Dadure, K. M. (2020). Molecular docking and antioxidant activity of *Cleome simplicifolia* assisted synthesis of cerium oxide nanoparticles. *Materials Today: Proceedings*, *29*, 1085—1090.

Chouke, P., et al. (2019). Green fabrication of zinc oxide nanospheres by *Aspidopterys cordata* for effective antioxidant and antibacterial activity. *Advanced Materials Letter*, *10*, 355—360.

Chouke, P. B., Potbhare, A. K., Meshram, N. P., Rai, M. M., Dadure, K. M., Chaudhary, K., Rai, A. R., Desimone, M. F., Chaudhary, R. G., & Masram, D. T. (2022). Bioinspired NiO nanospheres: Exploring *in vitro* toxicity using Bm-17 and *L. rohita* liver cells, DNA degradation, docking, and proposed vacuolization mechanism. *ACS Omega*, *7*(8), 6869—6884.

Collin, B., et al. (2014). Environmental release, fate and ecotoxicological effects of manufactured ceria nanomaterials. *Environmental Science: Nano*, *1*(6), 533—548.

Dai, D., & Fan, M. (2013). Green modification of natural fibres with nanocellulose. *RSC Advances*, *3*(14), 4659—4665.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

De La Torre-Roche, R., et al. (2020). Seed biofortification by engineered nanomaterials: A pathway to alleviate malnutrition? *Journal of Agricultural and Food Chemistry*, *68*(44), 12189–12202.

de Medeiros, G. A., et al. (2001). The influence of crop canopy on evapotranspiration and crop coefficient of beans (*Phaseolus vulgaris* L.). *Agricultural Water Management*, *49*(3), 211–224.

de Oliveira, J. L., et al. (2019). Association of zein nanoparticles with botanical compounds for effective pest control systems. *Pest Management Science*, *75*(7), 1855–1865.

Deng, Y., et al. (2017). Multiple method analysis of TiO_2 nanoparticle uptake in rice (*Oryza sativa* L.) plants. *Environmental Science & Technology*, *51*(18), 10615–10623.

Dhankher, O. P., & Foyer, C. H. (2018). Climate resilient crops for improving global food security and safety. *Plant, Cell & Environment*, *41*, 877–884.

Dietz, K.-J., & Herth, S. (2011). Plant nanotoxicology. *Trends in Plant Science*, *16*(11), 582–589.

Ei, H. H., et al. (2020). Impact of selenium, zinc and their interaction on key enzymes, grain yield, selenium, zinc concentrations, and seedling vigor of biofortified rice. *Environmental Science and Pollution Research*, *27*(14), 16940–16949.

Elmer, W., et al. (2018). Effect of metalloid and metal oxide nanoparticles on Fusarium wilt of watermelon. *Plant Disease*, *102*(7), 1394–1401.

Elsheery, N. I., et al. (2020). Foliar application of nanoparticles mitigates the chilling effect on photosynthesis and photoprotection in sugarcane. *Plant Physiology and Biochemistry*, *149*, 50–60.

Faizan, M., et al. (2021). Role of zinc oxide nanoparticles in countering negative effects generated by cadmium in *Lycopersicon esculentum*. *Journal of Plant Growth Regulation*, *40*(1), 101–115.

Feng, Y., et al. (2013). The role of metal nanoparticles in influencing arbuscular mycorrhizal fungi effects on plant growth. *Environmental Science & Technology*, *47*(16), 9496–9504.

Fletcher, S. J., et al. (2020). A perspective on RNAi-based biopesticides. *Frontiers in Plant Science*, *11*, 51.

Gandhare, N., Chaudhary, R. G., Meshram, V. P., Gharpure, M. P., Chauke, P., Tanna, J. A., & Juneja, H. D. (2016). An efficient and effective in vitro-callus production in *Bacopa monnieri* by using copper nanoparticles. *Research Journal of Pharmaceutical Biology and Chemical Sciences*, *7*, 12–17.

Gao, M., et al. (2020). Effects of foliar application of graphene oxide on cadmium uptake by lettuce. *Journal of Hazardous Materials*, *398*, 122859.

Gao, Y., et al. (2021). Dual stimuli-responsive fungicide carrier based on hollow mesoporous silica/hydroxypropyl cellulose hybrid nanoparticles. *Journal of Hazardous Materials*, *414*, 125513.

García-López, J. I., et al. (2019). Foliar application of zinc oxide nanoparticles and zinc sulfate boosts the content of bioactive compounds in habanero peppers. *Plants*, *8*(8), 254.

Garnett, T., & Godfray, C. (2012). *Sustainable intensification in agriculture. Navigating a course through competing food system priorities* (p. 51) Oxford: Food Climate Research Network and the Oxford Martin Programme on the Future of Food, University of Oxford.

Gnanamangai, B. M., et al. (2017). Biosynthesised silver and copper nanoformulation as foliar spray to control bird's eye spot disease in tea plantations. *IET Nanobiotechnology*, *11*(8), 917–928.

Gohari, G., et al. (2020). Titanium dioxide nanoparticles (TiO_2 NPs) promote growth and ameliorate salinity stress effects on essential oil profile and biochemical attributes of *Dracocephalum moldavica*. *Scientific Reports*, *10*(1), 1–14.

Govea-Alcaide, E., et al. (2016). Tracking iron oxide nanoparticles in plant organs using magnetic measurements. *Journal of Nanoparticle Research*, *18*(10), 1–13.

Guilger-Casagrande, M., et al. (2019). Biosynthesis of silver nanoparticles employing *Trichoderma harzianum* with enzymatic stimulation for the control of *Sclerotinia sclerotiorum*. *Scientific Reports*, *9*(1), 1–9.

Hasheminejad, N., Khodaiyan, F., & Safari, M. (2019). Improving the antifungal activity of clove essential oil encapsulated by chitosan nanoparticles. *Food Chemistry*, *275*, 113–122.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

Hazra, D. K., & Purkait, A. (2019). Role of pesticide formulations for sustainable crop protection and environment management: A review. *Journal of Pharmacognosy and Phytochemistry*, *8*, 686–693.

Huang, B., et al. (2018). Advances in targeted pesticides with environmentally responsive controlled release by nanotechnology. *Nanomaterials*, *8*(2), 102.

Huang, S., et al. (2015). Nanotechnology in agriculture, livestock, and aquaculture in China. A review. *Agronomy for Sustainable Development*, *35*(2), 369–400.

Hwang, I. C., et al. (2011). Insecticidal effect of controlled release formulations of etofenprox based on nano-bio technique. *Journal of the Faculty of Agriculture, Kyushu University*, *56*(1), 33–40.

Jampílek, J., & Kráľová, K. (2017). *Nanopesticides: Preparation, targeting, and controlled release. New pesticides and soil sensors* (pp. 81–127). Academic Press.

Jeevanandam, J., et al. (2018). Review on nanoparticles and nanostructured materials: History, sources, toxicity and regulations. *Beilstein Journal of Nanotechnology*, *9*(1), 1050–1074.

Juárez-Maldonado, A., et al. (2019). Nanoparticles and nanomaterials as plant biostimulants. *International Journal of Molecular Sciences*, *20*(1), 162.

Jyothi, T. V., & Hebsur, N. S. (2017). Effect of nanofertilizers on growth and yield of selected cereals—A review. *Agricultural Reviews*, *38*(2).

Kah, M., & Hofmann, T. (2014). Nanopesticide research: Current trends and future priorities. *Environment International*, *63*, 224–235.

Kah, M., et al. (2018). A critical evaluation of nanopesticides and nanofertilizers against their conventional analogues. *Nature Nanotechnology*, *13*(8), 677–684.

Kah, M., Tufenkji, N., & White, J. C. (2019). Nano-enabled strategies to enhance crop nutrition and protection. *Nature Nanotechnology*, *14*(6), 532–540.

Kalia, A., & Sharma, S. P. (2019). Nanomaterials and vegetable crops: Realizing the concept of sustainable production. *Nanoscience for sustainable agriculture* (pp. 323–353). Cham: Springer.

Kalia, A., Sharma, S. P., & Kaur, H. (2019). Nanoscale fertilizers: Harnessing boons for enhanced nutrient use efficiency and crop productivity. *Nanobiotechnology applications in plant protection* (pp. 191–208). Cham: Springer.

Kamle, M., et al. (2020). Nanotechnological interventions for plant health improvement and sustainable agriculture. *3 Biotech*, *10*(4), 1–11.

Karamian, R., Ghasemlou, F., & Amiri, H. (2020). Physiological evaluation of drought stress tolerance and recovery in *Verbascum sinuatum* plants treated with methyl jasmonate, salicylic acid and titanium dioxide nanoparticles. *Plant Biosystems—An International Journal Dealing with all Aspects of Plant Biology*, *154*(3), 277–287.

Kaur, T., et al. (2016). Synthesis of biogenic silicon/silica (Si/SiO_2) nanocomposites from rice husks and wheat bran through various microorganisms. *Materials Research Express*, *3*(8), 085026.

Keller, A. A., et al. (2017). Comparative environmental fate and toxicity of copper nanomaterials. *NanoImpact*, *7*, 28–40.

Keller, A. A., Huang, Y., & Nelson, J. (2018). Detection of nanoparticles in edible plant tissues exposed to nano-copper using single-particle ICP-MS. *Journal of Nanoparticle Research*, *20*(4), 1–13.

Khan, M., et al. (2021). Agro-nanotechnology as an emerging field: A novel sustainable approach for improving plant growth by reducing biotic stress. *Applied Sciences*, *11*(5), 2282.

Khan, M. N., et al. (2020). Nitric oxide is involved in nano-titanium dioxide-induced activation of antioxidant defense system and accumulation of osmolytes under water-deficit stress in *Vicia faba* L. *Ecotoxicology and Environmental Safety*, *190*, 110152.

Khot, L. R., et al. (2012). Applications of nanomaterials in agricultural production and crop protection: A review. *Crop Protection*, *35*, 64–70.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

Kukal, M. S., & Irmak, S. (2018). Climate-driven crop yield and yield variability and climate change impacts on the US Great Plains agricultural production. *Scientific Reports*, *8*(1), 1–18.

Lakshmeesha, T. R., et al. (2020). Biofabrication of zinc oxide nanoparticles from *Melia azedarach* and its potential in controlling soybean seed-borne phytopathogenic fungi. *Saudi Journal of Biological Sciences*, *27*(8), 1923–1930.

Larue, C., et al. (2012). Comparative uptake and impact of TiO_2 nanoparticles in wheat and rapeseed. *Journal of Toxicology and Environmental Health. Part A*, *75*(13–15), 722–734.

Lazaratou, C. V., Vayenas, D. V., & Papoulis, D. (2020). The role of clays, clay minerals and clay-based materials for nitrate removal from water systems: A review. *Applied Clay Science*, *185*, 105377.

Li, R., et al. (2019). Effects of chitosan nanoparticles on seed germination and seedling growth of wheat (*Triticum aestivum* L.). *International Journal of Biological Macromolecules*, *126*, 91–100.

Li, W.-Q., et al. (2020). Integration of subcellular partitioning and chemical forms to understand silver nanoparticles toxicity to lettuce (*Lactuca sativa* L.) under different exposure pathways. *Chemosphere*, *258*, 127349.

Liu, R., & Lal, R. (2015). Potentials of engineered nanoparticles as fertilizers for increasing agronomic productions. *Science of the Total Environment*, *514*, 131–139.

Liu, X.-M., et al. (2006). Preparation and testing of cementing and coating nano-subnanocomposites of slow/controlled-release fertilizer. *Agricultural Sciences in China*, *5*(9), 700–706.

Lowry, G. V., Avellan, A., & Gilbertson, L. M. (2019). Opportunities and challenges for nanotechnology in the agri-tech revolution. *Nature Nanotechnology*, *14*(6), 517–522.

Lv, J., et al. (2015). Accumulation, speciation and uptake pathway of ZnO nanoparticles in maize. *Environmental Science: Nano*, *2*(1), 68–77.

Ma, C., et al. (2018). Uptake of engineered nanoparticles by food crops: Characterization, mechanisms, and implications. *Annual Review of Food Science and Technology*, *9*, 129–153.

Malandrakis, A. A., Kavroulakis, N., & Chrysikopoulos, C. V. (2021). Copper nanoparticles against benzimidazole-resistant *Monilinia fructicola* field isolates. *Pesticide Biochemistry and Physiology*, *173*, 104796.

Manjunatha, S. B., Biradar, D. P., & Aladakatti, Y. R. (2016). Nanotechnology and its applications in agriculture: A review. *Journal of Farm Science*, *29*(1), 1–13.

Meychik, N. R., Nikolaeva, J. I., & Yermakov, I. P. (2005). Ion exchange properties of the root cell walls isolated from the halophyte plants (*Suaeda altissima* L.) grown under conditions of different salinity. *Plant and Soil*, *277*(1), 163–174.

Milenković, I., et al. (2019). Interaction of carbohydrate coated cerium-oxide nanoparticles with wheat and pea: Stress induction potential and effect on development. *Plants*, *8*(11), 478.

Milewska-Hendel, A., et al. (2019). Effect of nanoparticles surface charge on the *Arabidopsis thaliana* (L.) roots development and their movement into the root cells and protoplasts. *International Journal of Molecular Sciences*, *20*(7), 1650.

Mishra, S., & Singh, H. B. (2015). Biosynthesized silver nanoparticles as a nanoweapon against phytopathogens: Exploring their scope and potential in agriculture. *Applied Microbiology and Biotechnology*, *99*(3), 1097–1107.

Mozhayeva, D., & Engelhard, C. (2020). A critical review of single particle inductively coupled plasma mass spectrometry—A step towards an ideal method for nanomaterial characterization. *Journal of Analytical Atomic Spectrometry*, *35*(9), 1740–1783.

Muñoz-García, R. O., et al. (2015). A novel polyacrylamide-based hydrogel crosslinked with cellulose acetate and prepared by precipitation polymerization. *Química Nova*, *38*(8), 1031–1036.

Mustafa, I. F., & Hussein, M. Z. (2020). Synthesis and technology of nanoemulsion-based pesticide formulation. *Nanomaterials*, *10*(8), 1608.

Nath, J., et al. (2018). Synthesis and characterization of isotopically-labeled silver, copper and zinc oxide nanoparticles for tracing studies in plants. *Environmental Pollution*, *242*, 1827–1837.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

Navarro, D. A., Bisson, M. A., & Aga, D. S. (2012). Investigating uptake of water-dispersible CdSe/ZnS quantum dot nanoparticles by *Arabidopsis thaliana* plants. *Journal of Hazardous Materials*, *211*, 427–435.

Nuruzzaman, M. D., et al. (2016). Nanoencapsulation, nano-guard for pesticides: A new window for safe application. *Journal of Agricultural and Food Chemistry*, *64*(7), 1447–1483.

Nutan, K. K., et al. (2020). Integrating the dynamics of yield traits in rice in response to environmental changes. *Journal of Experimental Botany*, *71*(2), 490–506.

Ogunkunle, C. O., et al. (2020). Cadmium toxicity in cowpea plant: Effect of foliar intervention of nano-TiO_2 on tissue Cd bioaccumulation, stress enzymes and potential dietary health risk. *Journal of Biotechnology*, *310*, 54–61.

Osorio-Echavarría, J., et al. (2021). Synthesis of silver nanoparticles using white-rot fungus Anamorphous *Bjerkandera* sp. R1: Influence of silver nitrate concentration and fungus growth time. *Scientific Reports*, *11* (1), 1–14.

Othman, S. H. (2014). Bio-nanocomposite materials for food packaging applications: Types of biopolymer and nano-sized filler. *Agriculture and Agricultural Science Procedia*, *2*, 296–303.

Parsons, K. H., et al. (2018). Guanidinium-functionalized interpolyelectrolyte complexes enabling RNAi in resistant insect pests. *Biomacromolecules*, *19*(4), 1111–1117.

Pascoli, M., et al. (2018). State of the art of polymeric nanoparticles as carrier systems with agricultural applications: A minireview. *Energy, Ecology and Environment*, *3*(3), 137–148.

Pérez-de-Luque, A. (2017). Interaction of nanomaterials with plants: What do we need for real applications in agriculture? *Frontiers in Environmental Science*, *5*, 12.

Pérez-Iglesias, J. M., et al. (2019). Biomarkers at different levels of organisation after atrazine formulation (SIPTRAN 500SC®) exposure in *Rhinella schneideri* (Anura: Bufonidae) neotropical tadpoles. *Environmental Pollution*, *244*, 733–746.

Potbhare, A., et al. (2020a). *Rhizoctonia solani* assisted biosynthesis of silver nanoparticles for antibacterial assay. *Materials Today: Proceedings*, *29*, 939–945.

Potbhare, A., et al. (2020b). Bioinspired graphene-based silver nanoparticles: Fabrication, characterization and antibacterial activity. *Materials Today: Proceedings*, *29*, 720–725.

Pouratashi, M., & Iravani, H. (2012). Farmers' knowledge of integrated pest management and learning style preferences: Implications for information delivery. *International Journal of Pest Management*, *58*(4), 347–353.

Prasad, R., Bhattacharyya, A., & Nguyen, Q. D. (2017). Nanotechnology in sustainable agriculture: Recent developments, challenges, and perspectives. *Frontiers in Microbiology*, *8*, 1014.

Rahman, M. S., et al. (2020). Effects of poly (vinylpyrrolidone) protected platinum nanoparticles on seed germination and growth performance of *Pisum sativum*. *Nano-Structures & Nano-Objects*, *21*, 100408.

Raja, K., et al. (2019). Biogenic ZnO and Cu nanoparticles to improve seed germination quality in blackgram (*Vigna mungo*). *Materials Letters*, *235*, 164–167.

Raliya, R., et al. (2016). Quantitative understanding of nanoparticle uptake in watermelon plants. *Frontiers in Plant Science*, *7*, 1288.

Ramakrishna, S., et al. (2006). Electrospun nanofibers: Solving global issues. *Materials Today*, *9*(3), 40–50.

Ramírez-Rodríguez, G. B., et al. (2020a). Engineering biomimetic calcium phosphate nanoparticles: A green synthesis of slow-release multinutrient (NPK) nanofertilizers. *ACS Applied Bio Materials*, *3*(3), 1344–1353.

Ramírez-Rodríguez, G. B., et al. (2020b). Reducing nitrogen dosage in triticum durum plants with urea-doped nanofertilizers. *Nanomaterials*, *10*(6), 1043.

Rejeb, I. B., Pastor, V., & Mauch-Mani, B. (2014). Plant responses to simultaneous biotic and abiotic stress: Molecular mechanisms. *Plants*, *3*(4), 458–475.

Sahoo, M., et al. (2021). Nanotechnology: Current applications and future scope in food. *Food Frontiers*, *2*(1), 3–22.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

Sambo, P., et al. (2019). Hydroponic solutions for soilless production systems: Issues and opportunities in a smart agriculture perspective. *Frontiers in Plant Science*, *10*, 923.

Santiago, M., Pagay, V., & Stroock, A. D. (2013). Impact of electroviscosity on the hydraulic conductance of the bordered pit membrane: A theoretical investigation. *Plant Physiology*, *163*(2), 999–1011.

Santos, T. S., et al. (2021). Entomopathogenic fungi biomass production and extracellular biosynthesis of silver nanoparticles for bioinsecticide action. *Applied Sciences*, *11*(6), 2465.

Sanzari, I., Leone, A., & Ambrosone, A. (2019). Nanotechnology in plant science: To make a long story short. *Frontiers in Bioengineering and Biotechnology*, *7*, 120.

Sarlak, N., Taherifar, A., & Salehi, F. (2014). Synthesis of nanopesticides by encapsulating pesticide nanoparticles using functionalized carbon nanotubes and application of new nanocomposite for plant disease treatment. *Journal of Agricultural and Food Chemistry*, *62*(21), 4833–4838.

Schewe, J., et al. (2019). State-of-the-art global models underestimate impacts from climate extremes. *Nature Communications*, *10*(1), 1–14.

Schwab, F., et al. (2016). Barriers, pathways and processes for uptake, translocation and accumulation of nanomaterials in plants—Critical review. *Nanotoxicology*, *10*(3), 257–278.

Shahabi-Ghahafarrokhi, I., et al. (2015). Preparation and characterization of nanocellulose from beer industrial residues using acid hydrolysis/ultrasound. *Fibers and Polymers*, *16*(3), 529–536.

Sharifi, M., et al. (2020). Antioxidant properties of gold nanozyme: A review. *Journal of Molecular Liquids*, *297*, 112004.

Shukla, G., Gaurav, S. S., & Singh, A. (2020). Synthesis of mycogenic zinc oxide nanoparticles and preliminary determination of its efficacy as a larvicide against white grubs (Holotrichia sp.). *International Nano Letters*, *10*, 131–139.

Siddiqui, M. H., & Al-Whaibi, M. H. (2014). Role of nano-SiO_2 in germination of tomato (*Lycopersicum esculentum* seeds Mill.). *Saudi Journal of Biological Sciences*, *21*(1), 13–17.

Soleymanzadeh, R., et al. (2020). Selenium nanoparticle protected strawberry against salt stress through modifications in salicylic acid, ion homeostasis, antioxidant machinery, and photosynthesis performance. *Acta Biologica Cracoviensia s. Botanica*, *62*(1), 33–42.

Sonkusare, V., Chaudhary, R. G., Bhusari, G., Rai, A. R., & Juneja, H. D. (2018). Microwave-mediated synthesis, photocatalytic degradation and antibacterial activity of α-Bi_2O_3 Microflower/γ-Bi_2O_3 microspindle. *Nano-Structures & Nano-Objects*, *13*, 121–131.

Sonkusare, V. N., Chaudhary, R. G., Mondal, A., Bhusari, G., Mishra, R. K., Potbhare, A. K., Abdala, A., & Juneja, H. D. (2020). Mesoporous octahedron-shaped tricobalt tetraoxide nanoparticles for photocatalytic degradation of toxic dyes. *ACS Omega*, *5*, 7823–7835.

Spielman-Sun, E., et al. (2019). Nanoparticle surface charge influences translocation and leaf distribution in vascular plants with contrasting anatomy. *Environmental Science: Nano*, *6*(8), 2508–2519.

Su, Y., et al. (2020). Delivery, fate, and mobility of silver nanoparticles in citrus trees. *ACS Nano*, *14*(3), 2966–2981.

Su, Y., et al. (2019). Delivery, uptake, fate, and transport of engineered nanoparticles in plants: A critical review and data analysis. *Environmental Science: Nano*, *6*(8), 2311–2331.

Tarafdar, J. C., & Adhikari, T. (2015). Nanotechnology in soil science. In R. J. Rattan, J. C. Katyal, B. S. Dwivedi, A. K. Sarkar, T. Bhattacharyya, et al. (Eds.), *Soil Science: An Introduction* (pp. 775–807). New Delhi: Indian Society of Soil Science.

Taiz, L., & Zeiger, E. (2010). *Plant physiology* ((5th ed.), pp. 67–86). Sunderland, MA: Sinauer Associates Inc.

Tiple, A., Chaudhary, R. G., Singh, N. B., Badwaik, V. J., & Padwad, S. V. (2020). A review on nanotoxicology: Aquatic environment and biological system. *Materials Today: Proceedings*, *29*, 1246–1250.

Umekar, M. S., Bhusari, G. S., Potbhare, A. K., Mondal, A., Kapgate, B. P., Desimone, M. F., & Chaudhary, R. G. (2021). Bioinspired reduced graphene oxide based nanohybrids for photocatalysis and antibacterial applications. *Current Pharmaceutical Biotechnology*, *22*(13), 1759–1781.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

Umekar, M. S., Chaudhary, R. G., Bhusari, G. S., Mondal, A., Potbhare, A. K., & Sami, M. (2020). Phytoreduced graphene oxide-titanium dioxide nanocomposites using *Moringa oleifera* stick extract. *Materials Today: Proceedings*, *29*(3), 709–714. AU:3

Usman, M., et al. (2020). Nanotechnology in agriculture: Current status, challenges and future opportunities. *Science of the Total Environment*, *721*, 137778.

Vanderroost, M., et al. (2014). Intelligent food packaging: The next generation. *Trends in Food Science & Technology*, *39*(1), 47–62.

Vigneshwaran, N., et al. (2006). Biomimetics of silver nanoparticles by white rot fungus, *Phaenerochaete chrysosporium*. *Colloids and Surfaces B: Biointerfaces*, *53*(1), 55–59.

Vithanage, M., et al. (2017). Contrasting effects of engineered carbon nanotubes on plants: A review. *Environmental Geochemistry and Health*, *39*(6), 1421–1439.

Wakeel, A., Xu, M., & Gan, Y. (2020). Chromium-induced reactive oxygen species accumulation by altering the enzymatic antioxidant system and associated cytotoxic, genotoxic, ultrastructural, and photosynthetic changes in plants. *International Journal of Molecular Sciences*, *21*(3), 728.

Wan, A., Gao, Q., & Li, H. (2010). Effects of molecular weight and degree of acetylation on the release of nitric oxide from chitosan-nitric oxide adducts. *Journal of Applied Polymer Science*, *117*(4), 2183–2188.

Wang, Q., et al. (2012). The impact of cerium oxide nanoparticles on tomato (*Solanum lycopersicum* L.) and its implications for food safety. *Metallomics*, *4*(10), 1105–1112.

Wojcieszek, J., et al. (2019). Elucidation of the fate of zinc in model plants using single particle ICP-MS and ESI tandem MS. *Journal of Analytical Atomic Spectrometry*, *34*(4), 683–693.

Worthington, K. L. S., et al. (2013). Chitosan coating of copper nanoparticles reduces in vitro toxicity and increases inflammation in the lung. *Nanotechnology*, *24*(39), 395101.

Xu, C., et al. (2018). Emulsion-based synchronous pesticide encapsulation and surface modification of mesoporous silica nanoparticles with carboxymethyl chitosan for controlled azoxystrobin release. *Chemical Engineering Journal*, *348*, 244–254.

Yadav, R. K., et al. (2020). Expanding the horizons of nanotechnology in agriculture: Recent advances, challenges and future perspectives. *Vegetos*, *33*(2), 203–221.

Yuan, J., et al. (2018). New insights into the cellular responses to iron nanoparticles in Capsicum annuum. *Scientific Reports*, *8*(1), 1–9.

Zeng, Y., Himmel, M. E., & Ding, S.-Y. (2017). Visualizing chemical functionality in plant cell walls. *Biotechnology for Biofuels*, *10*(1), 1–16.

Zhang, H., et al. (2012). Use of metal oxide nanoparticle band gap to develop a predictive paradigm for oxidative stress and acute pulmonary inflammation. *ACS Nano*, *6*(5), 4349–4368.

Zhao, L., et al. (2020). Nano-biotechnology in agriculture: Use of nanomaterials to promote plant growth and stress tolerance. *Journal of Agricultural and Food Chemistry*, *68*(7), 1935–1947.

To protect the rights of the author(s) and publisher we inform you that this PDF is an uncorrected proof for internal business use only by the author(s), editor(s), reviewer(s), Elsevier and typesetter MPS. It is not allowed to publish this proof online or in print. This proof copy is the copyright property of the publisher and is confidential until formal publication.

Asian Journal of Chemistry; Vol. 33, No. 11 (2021), 2525-2547

ASIAN JOURNAL OF CHEMISTRY

https://doi.org/10.14233/ajchem.2021.23373

REVIEW

Review on Synthesis Route of Quinazoline Based Hybrid Derivatives

PRAVIN DEHARKAR*, SHRIDHAR SATPUTE and DEEPA PANHEKAR

Department of Chemistry, Dr. Ambedkar College, Deekshabhoomi, Nagpur-440010, India

*Corresponding author: E-mail: pdeharkar@gmail.com

Received: 16 June 2021; *Accepted*: 16 July 2021; *Published online*: 20 October 2021; AJC-20531

Quinazolines are amidst the most significant pharmacological compounds in natural and medicinal chemistry, with a wide variety of pharmacological things, including antifungal, antibacterial, anti-inflammatory, anti-HIV, anticancer and analgesic activity. Designing innovative quinazolines, studying possible techniques to synthesize quinazolines, examining diverse features of quinazolines and looking for prospective uses of quinazolines have all become more important in the last two decades due to their multiple possible applications. The current review paper discusses the synthesis of quinazolines using the multi-component synthetic technique that is environmentally friendly, mild and atom-efficient. The discussion is separated into sections based on the key processes used to construct quinazoline scaffolds to provide an efficient approach for a more significant grasp. The most recent references have also been taken into account. The review should prove useful in future research on quinazoline synthesis and developing a more promising synthetic technique.

Keywords: Bicyclic compounds, Pyrimidine, Amidines, Nitriles, Synthesis, Green chemistry, Quinazolines, Quinazolinones.

INTRODUCTION

4(3*H*)-Quinazoline, quinazolinone and even its metabolites represent an effective combination among fused heterocycles which may be found in over 100 biologically active alkaloids [1]. In terms of synthesis, the first 4(3*H*)-quinazolinone molecule (Fig. 1a) was synthesized in 1869 using anthranilic acid and cyanogens [2]. Early in 1950s, febrifugine is an alkaloid which has been clarified (Fig. 1b). A traditional Chinese herbal treatment component for malaria patients [3] sparked a vigorous investigation of physiologically active chemicals that included Series. Meantime in 1951, developed methaqualone (Fig. 1c) as a drug based on 4(3*H*)-quinazolinone [4], which has muscle relaxant and sedative properties. However, as a side effect, it causes photosensitization (methaqualone's commercialization was stopped in 1984). Various commercial medicines with 4-quinazolinone moiety are utilized as hypnotics/sedatives [5].

Cancer has also been treated with 4(3*H*)-quinazolinone derivatives. Raltitrexed (Fig. 1d) (brand name: Tomudex) is an antimetabolite medication used in cancer treatment as an example. Since 1998, it has also been used to treat colorectal cancer and malignant mesothelioma. In Canada and a few European nations, raltitrexed has been approved for usage. An antiviral, anti-inflammatory, anticancer, antimicrobial, antitumor, cholinesterase inhibitor, a protein kinase inhibitor, antifolate and many other functional biological characteristics are found in the 4(3*H*)-quinazolinone systems [6]. These chemicals are biosynthetically generated from anthranilic acid and isolated from a various plant, bacterial and animal taxa. Vasicine (peganine), the first quinazoline alkaloid, was discovered in 1888 by Adhatodavasica. Chrysogine, febrifugine and isofebrifugine are some additional isolated quinazoline alkaloids synthesized [7].

More than 200 naturally occurring alkaloids contain important classes of a fused heterocyclic compound of quinazoline. Indolquinazolinones are primarily found in blue dye-producing plants such as *Polygonum tinctorium* Lour, *Strobilanthes cusia isatis tinctoria* and others. These chemicals have been identified from *Fusarium lateritium* Nees, *Bacillus cereus* 041381, the entomopathogenic fungus *Isaria farinose*, *Streptomyces* species, *Chaetomium* species IFB-EO15, *Aspergillus nidulans* MA-143 and *Penicilium aurantiogriseum* in microorganisms [8]. The heterocyclic category of the quinazoline nucleus is

This is an open access journal, and articles are distributed under the terms of the Attribution 4.0 International (CC BY 4.0) License. This license lets others distribute, remix, tweak, and build upon your work, even commercially, as long as they credit the author for the original creation. You must give appropriate credit, provide a link to the license, and indicate if changes were made.

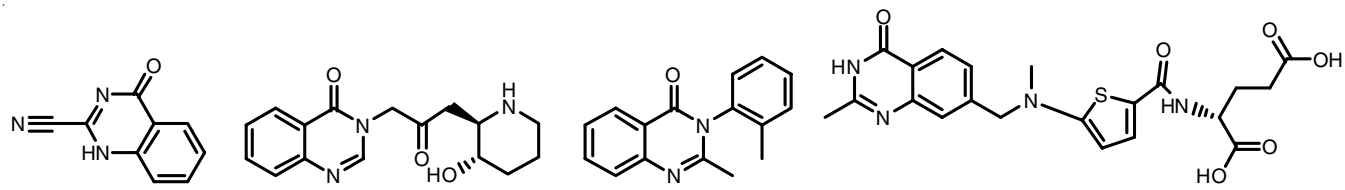
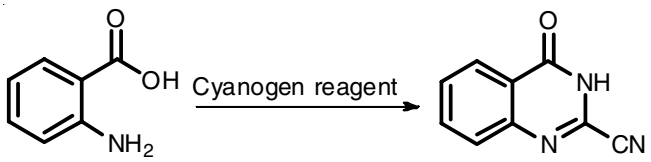


Fig. 1. Chemical structures of 4(3*H*)-quinazolinone molecule and its important derivatives

composed of 2 merged six-membered aromatic rings, *viz*. a pyrimidine ring and a benzene ring. $C_8H_6N_2$ is its chemical formula. Gabriel [9] synthesized the fused bicyclic compound of quinazoline in 1903. Its last name was benzo-1,3-diazine. One of its variants, however, was discovered considerably earlier [10]. It may be classified into three types depending on where the oxo or keto group is located (Fig. 2) [11].

The four quinazolinone compounds as shown above (Fig. 2) are still the most common, either as natural products or as intermediates in diverse biosynthetic pathways [12]. anthranilamide or various esters, Anthranilic acid and anthranilonitrile (isatoicanhydride) anthranilates were used to create this structure. Simultaneously, with nitriles or anthranilonitrile, 2(1*H*)-quinazolinone is primarily a benzamide product [13]. Quinazolines and quinazozolinones are heterocyclic compounds made up of 2 six-membered aromatic rings merged, benzene and pyrimidine [14].

In light of the significance of quinazolinones, several functional synthesized techniques had been established to produce Guiry's complete evaluation of methods for creating 4(3*H*)-quinazolinones up to the year's conclusion in 2004 [15-17]. In 2006, Eguchi published a review of bioactive quinazolinone-based natural alkaloids [18-20]. Following then, a few related studies of quinazolinone synthesis were also published [21]. Carbonylations can introduce carbon into quinazolinones and the carbonylative synthesis of chalcones is the focus of the present research. Consequently, we attempt to provide an overview of the synthetic methods and techniques for highly functionalized 4(3*H*)-quinazolinones that have recently been described. Griess synthesized the whole first quinazoline analog *via* cyanogens reaction with anthranilic acid in 1869 (**Scheme-A1**).

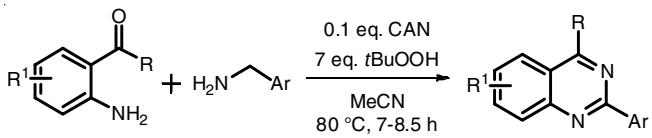


Scheme: A1: Anthranilic acid was used to synthesize 2-cyano-3,4-dihydro-4-oxoquinazoline

Quinazolines were categorized as disubstituted, trisubstituted, 2,3-fused and 3,4-fused derivatives based on the substitution of quinazoline. For 2,3-substituted and 2,3,4-substituted derivatives, the majority of the literature is accessible. Quinazolines were primarily synthesized using anthranilic acid as a starting material to produce various substituted quinazolines in three or four stages, depending on quinazoline substitution. Quinazolinones are biologically active in a variety of ways. As an example, CNS depressants [21], antimicrobials [22], antibacterials [23], analgesics [24], antifungals [25], anticancer [26], antiulcer [27], anticonvulsant [28], dengue virus inhibitors, human Pin1 inhibitors [29], antihypertensive, sedative, anesthetic, tranquilizing, muscle relaxant [30], antipyretic, antitubercular, antiparkinsons [31], *etc*. Antimicrobial compounds have been described using substitution at quinazolin-4(3*H*)-one's C-2 and C-3 locations [32,33]. Quinazolinone derivatives were utilized as an orally accessible Ghrelin receptor antagonist to treat obesity and diabetes. Quinazolines' biological significance: Anticancer drugs EGFR inhibitors (epidermal growth factor receptor) contain 4-aminoquinazolines [34]. Quinazoline and quinazolinone moieties were found in certain commercially available medicines. Antimicrobial agents have been reported when quinazolin-4(3*H*)-one are substituted at C-2 as well as C-3 positions.

Synthetic routes of modified quinazolines: Synthesis of 2-ary1-4-substituted quinazolines using 2-aminobenzophenone and benzyl amines in acetonitrile using ceric ammonium nitrate (CAN) catalyzed-TBHP obtained with 80-85% yields (**Scheme-I**) [35].

The tandem process followed by sp^3, C-H functionalization gave 70-75% yields of 2-phenylquinazolines from benzylic amines and 2-aminobenzophenone (**Scheme-II**) [36].



Scheme-I: Synthesis of 2-phenylquinazolines using 2-aminobenzophenone and benzyl amines catalyzed by ceric ammonium nitrate (CAN)

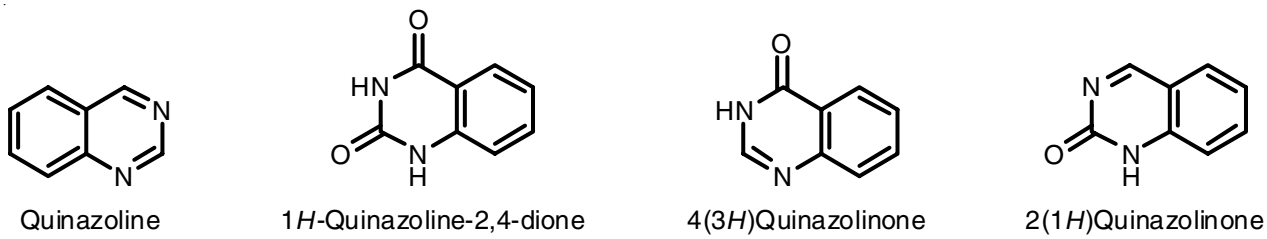
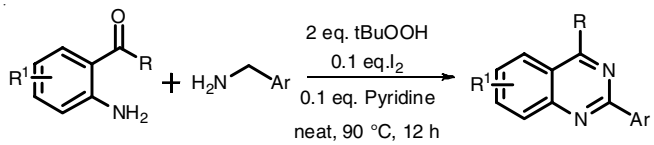
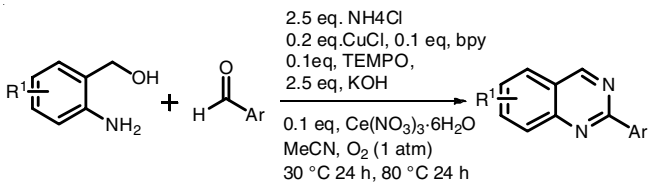


Fig. 2. Chemical structures of four different quinazolinone compounds having different location of oxo or keto group



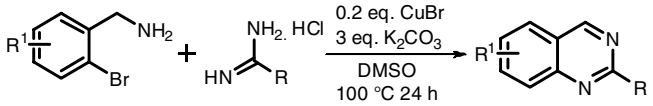
Scheme-II: Synthesis of 2-phenylquinazolines using 2-aminobenzophenone and benzylic amines

The use of $Ce(NO_3)_3$ and ammonium chloride in a copper-catalyzed cascade reaction to synthesize quinazolines from (2-aminophenyl-1)methanol and aryl aldehydes gave 72-76% excellent yields (**Scheme-III**) [37].



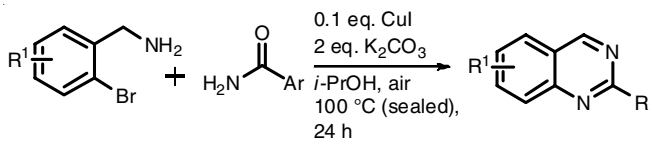
Scheme-III: Synthesis of quinazolines using aldehydes and (2-aminophenyl)-methanol in a copper-catalyzed pathway

The copper-catalyzed cascade technique synthesizes quinazolines from substituted amide hydrochloride and (2-bromophenyl)methylamine. Intramolecular nucleophilic substitution, followed by intermolecular *N*-arylation and aerobic oxidation (72-76% yields) were performed sequentially (**Scheme-IV**) [38].



Scheme-IV: Synthesis of quinazolines from amidine hydrochlorides and substituted (2-bromophenyl)methylamines

Using widely accessible substituted amides and (2-bromophenyl)methylamine as starting material, a copper-catalyzed approach without ligands was used to synthesize quinazoline analogs. The cascade process, which comprises sequential aerobic oxidation and Ullmann-type coupling, allowed for a quick synthesis of quinazoline derivatives (yields 72-76%) (**Scheme-V**) [39].

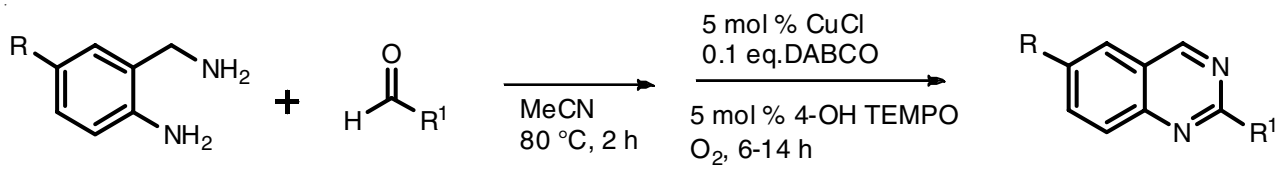


Scheme-V: Synthesis of quinazoline using substituted amide and (2-bromophenyl)methylamine

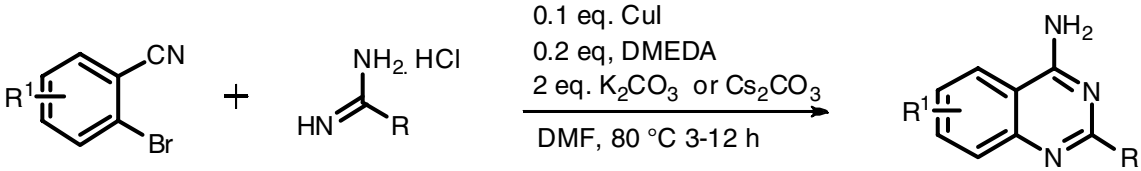
Using CuCl/DABCO and 4-HO-TEMPO as catalysts and O_2 as final oxidants, a one-pot reaction of 2-aminobenzylamine or 2-aminobenzyl alcohol with aldehydes permitted practical workup of aerobic oxidative synthesis to produce 2-substituted quinazoline derivatives having 72-76% yields (**Scheme-VI**) [40].

Copper-catalyzed reactions with DMEDA and K_2CO_3 in DMF solvent shows substituted 2-bromobenzonitriles with amidines and perhaps even guanidine give 72-76% 2,4-diaminoquinazoline and 4-aminoquinazoline derivatives (**Scheme-VII**) [41]. A palladium-catalyzed reaction followed by intramolecular aryl C-H amidation with isocyani de insertion produces 73-78% yields of 4-amino-2-alkyl(aryl)quinazoline derivatives utilizing pure reactant *N*-arylamidines with isonitriles (**Scheme-VIII**) [42].

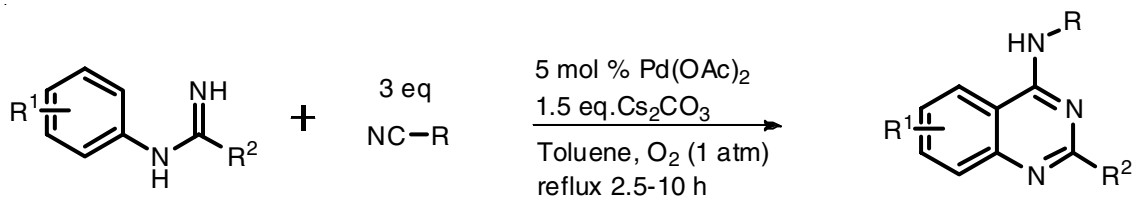
Synthesis of 4(3*H*)-quinazolinone and its derivative: The most popular technique for making 4(3*H*)-quinazolinone was Niementowski quinazolinone synthesis. The Niementowski



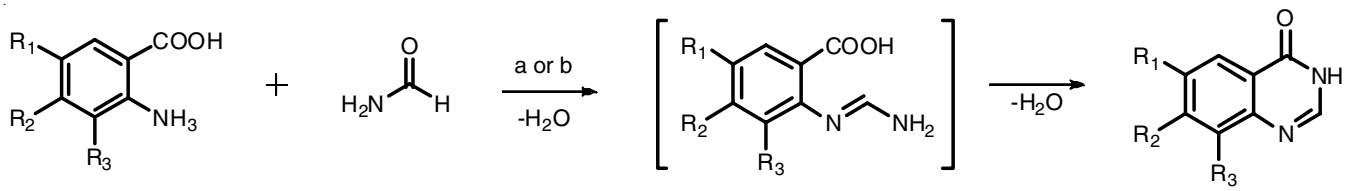
Scheme-VI: Synthesis of 2-substituted quinazolines from 2-aminobenzyl-amines and aldehydes



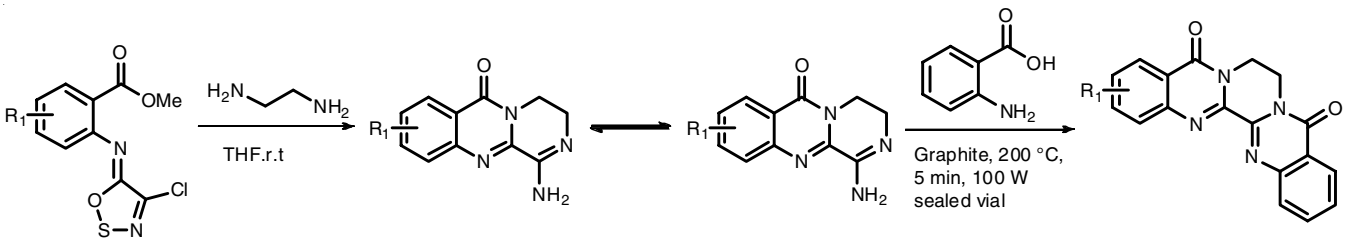
Scheme-VII: Synthesis of 4-aminoquinazoline using amidines from substituted 2-bromo-benzonitriles



Scheme-VIII: Synthesis of 4-amino-2-alkyl(aryl)quinazolines analogs using *N*-arylamidines and isonitriles



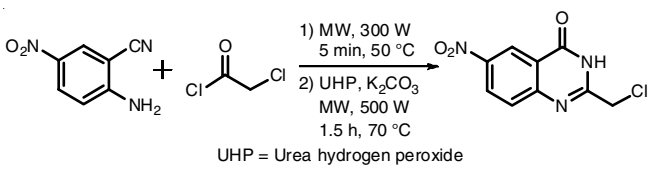
Scheme-IX: Synthesis of quinazoline analogs using anthranilic acid analogs and *o*-amidobenzamide in a microwave-assisted Niementowski method



Scheme-X: Synthesis of new pentacyclic heterocyclic quinazoline analogs using a microwave-assisted Niementowski method

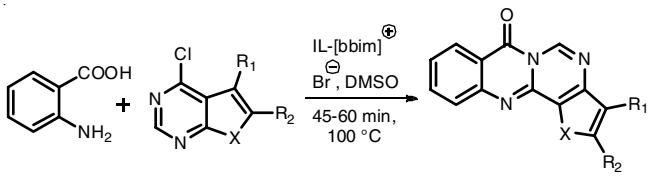
reaction shows anthranilic acid analogs fusing an *o*-amidobenzamide precursor at 130-150 ºC with amides (**Scheme-IX**). In these circumstances, the reaction has a variable yield. Low yields (35-40%) were often difficult to eliminate, even with the recrystallization process or column chromatography, since they were accompanied by a complex combination of carbonaceous compound sand impurities. To address these issues, Besson *et al.* [43] used microwave irradiation to re-investigate the Niementowski synthesis process of the 4(3*H*)-quinazolinone and increased up to 72-76% yields while reducing reaction time. Microwave irradiation techniques were used to develop better, more efficient strategies for making novel merged quinazolinone derivatives shown in **Scheme-X** [44,45].

Instead of 2-substituted derivatives, Desai & Desai [46] used a microwave-assisted Niementowski technique to make 2,3-disubstituted or 3-substituted-4(3*H*)-quinazolinone analogs. This method is non-toxic to the environment and does not require a solvent reaction. In a quinazoline series, Vanelle *et al.* [47] investigated novel anticancer drug precursors. The Niementowski reaction may be carried out efficiently and quickly, yielding the precursor 2-chloromethyl-6-nitroquinazolin-4(3*H*)-one by observing 72-76% as good yields (**Scheme-XI**). This molecule was used as a starting point for creating numerous novel quinazolines with different substituents at position-2.



Scheme-XI: Syntheis of 2-substituted quinazolines using urea hydrogen peroxide

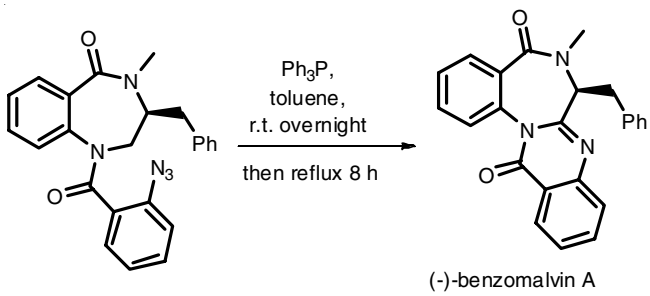
Srinivasan *et al.* [48] described a novel, fast and flexible Niementowski technique of fused 4(3*H*)-quinazolinone analogs (**Scheme-XII**). In this synthetic route, an ionic liquid and DMSO were used. With a simple workup process, isolated yields ranging from 83 to 92% were obtained. The increased reactivity



Scheme-XII: Synthesis of enhanced quinazolinones by Niementowski method

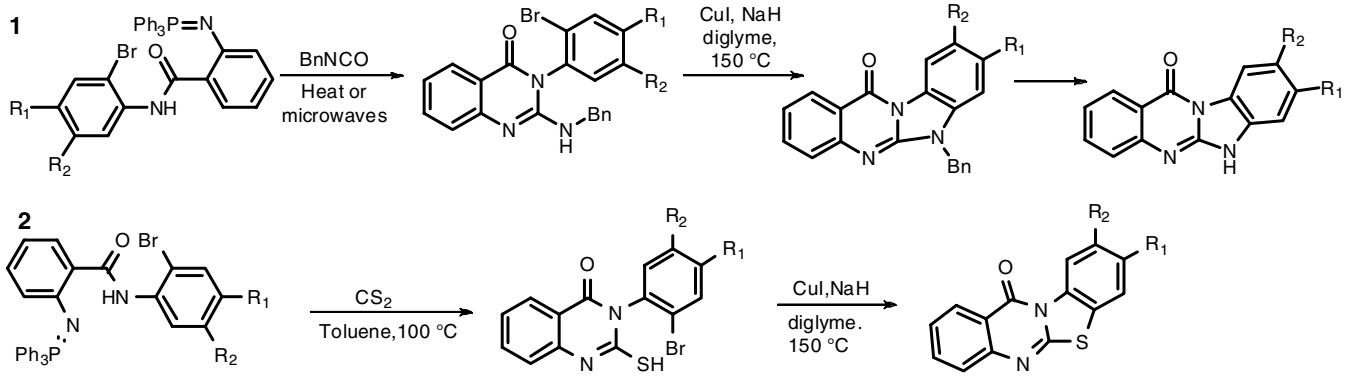
was attributed to the ionic liquid's intrinsic Brønsted acidity and DMSO's high polarity.

The Aza-Wittig procedure to synthesize 4(3*H*)-quinazolinone analogs is based on iminophosphoranes (Eguchi protocol) and has shown to be a reliable method for building heterocyclic nitrogen compounds. The tandem aza-Wittig/cyclization technique was used to incorporate several 2-substituted quinazolinone analogs, initiating functional iminophosphorane relevance and an amide group. The complete convergent synthesis of (-)-benzomalvin-A [49] is a successful, straightforward use of the aza-Wittig technique. The iminophosphorane coupled mostly with imide carbonyl mechanism provides the desired product in an organization resulting from 80-82% as the final play to (-)-benzomalvin-A, used as a microbial spray neurokinin adrenergic receptors. (**Scheme-XIII**).



Scheme-XIII: Synthesis of (-)-benzomalvin

Molina *et al.* [50] developed an effective technique for producing the not generally accessible angular or linear tetracyclic ring structure containing quinazolinone analogs (**Scheme-XIV**)



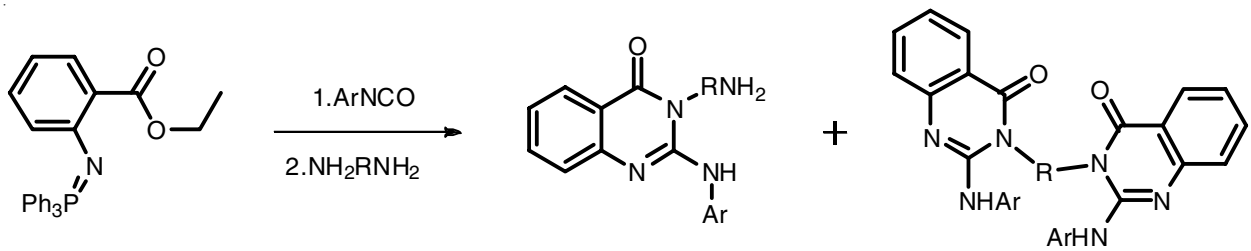
Scheme-XIV: Synthesis of merged tetracyclic quinazolinone analogs

by combining aza-Witting methods CuI-catalyzed hetero-arylation process. *N*-(*o*-substituted-aryl)carboxamide with (aryl-imino) phosphoranes substituents in respective *ortho*-positions was used in the technique. After an aza-Witting reaction/reductive process, the availability of nitrogen functioning in the *N*-aryl anomeric group favours heterocyclization. Iminophosphoranes also interacted with carbon disulfide in an aza-Witting-type reaction to create substituted aryl isothiocyanates.

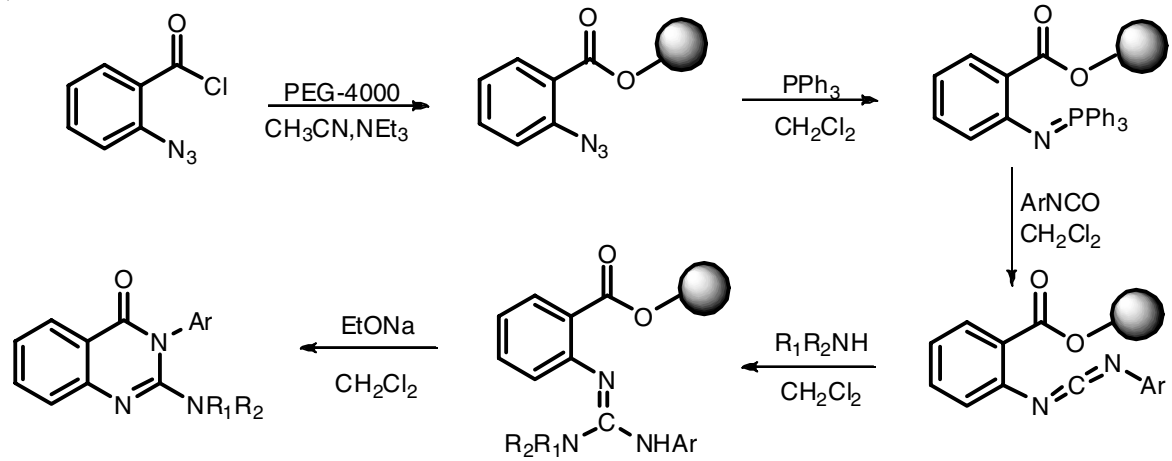
A basic method for synthesizing new 3,3′-disubstituted *bis*-2-arylaminoquinazolin-4(3*H*)-ones and 3-aminoalkyl-2-arylaminoquinazolin-4(3*H*)-ones have been described by the Wu *et al*. [51] using a tandem aza reaction shown in **Scheme-XV**: Witting reaction of 1-aryl-3-(2-ethoxy-carbonyl phenyl) carbodiimides as well as primary diamines in favourable response circumstances, excellent selectivity, produce 81-87% yields, conveniently available starting materials and simple product isolation are all advantages of this technique.

Such polymer-supported catalysts in medicinal chemistry save purification and workup time by allowing for easy filtering. There have been various solid-phase methods to quinazolinones developed so far. In 2006, Vogtle & Marzinzik [52] conducted a review of the relevant literature. Ding *et al*. [53] reported a successful collateral synthesis of 4(3*H*)-quinazolinone analog using polyethylene glycol (PEG) assisted aza-Witting reaction (**Scheme-XVI**). As a soluble polymer basis, commercially available difunctional PEG-4000 was used. This technique of synthesis might be used with a variety of secondary amines and isocyanates. The materials were created in a high-yielding manner as 88-92 % yields.

Since last decade, the synthesis of 4(3*H*)-quinazolinone from 2-aminobenzoic acid *via* a benzoxazinone intermediate has become a standard technique. Chenard *et al.* [54] described a succinct SAR algorithm for detecting piriqualone CP-465,022. An allosteric site allows a powerful opponent to engage with



Scheme-XV: Synthesis of quinazoline analog using tandem aza reaction



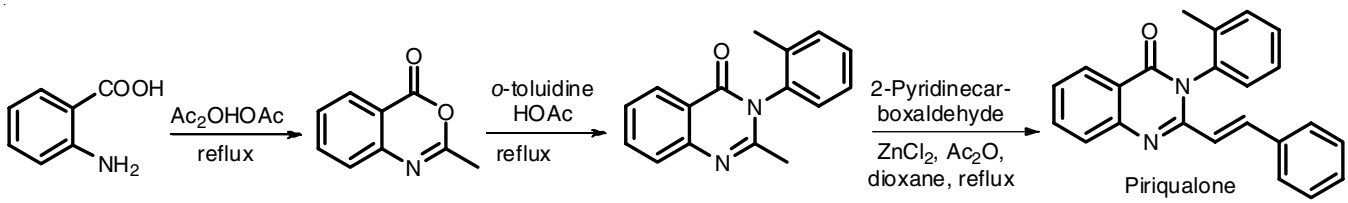
Scheme-XVI: Synthesis of 4(3*H*)-quinazolinone analog using polymer-supported catalyst PEG-4000

the receptor. Three stages are involved in the synthesis of piriqualone (**Scheme-XVII**). In the existence of acetic acid, first 2-aminobenzoic acid permutes to benzoxazin-4-one in warm ethanoic anhydride. Then, *ortho*-toluidine ring was reacted with an appropriate aniline component refluxing in ethanoic acid. Finally, the target compounds were obtained by condensing pyridine-2-carboxaldehyde with 2-methyl-3-aryl-quinazolin-4-one to produced 87-90% yields.

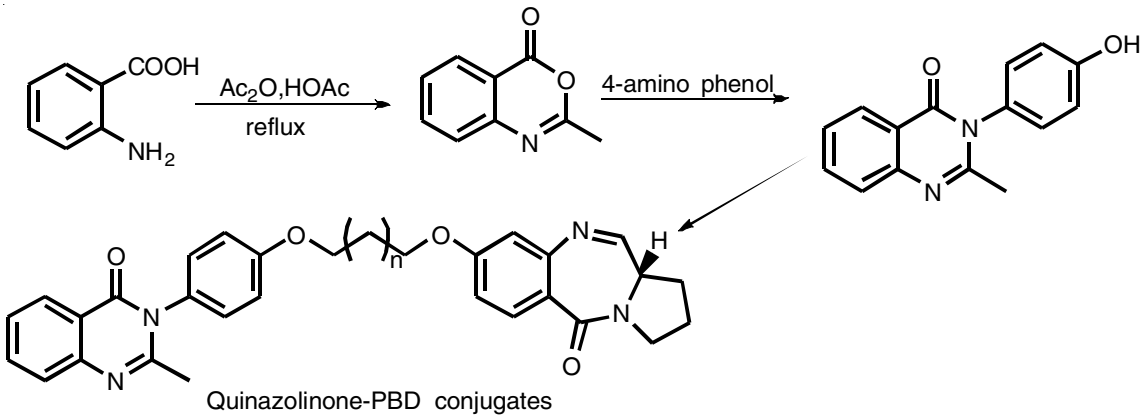
Kamal *et al*. [55] synthesized a series of novel quinazolinone-hybrids pyrrolobenzodiazepine analogs (**Scheme-XVIII**) with high yields (91-93%), showing condensation of 5-hydroxy-2-aminobenzoic acid with ethanoic anhydride produces benzoxazinones in the first synthesis method. They also synthesized various methaqualone analogs and 3-diarylethynequinazolinones using this technique (a new senescence inducers class).

Liu *et al*. [56] devised a microwave-assisted technique to synthesize 2,3-disubstituted quinazolin-4-(3*H*)-ones. A crucial stage is a one-pot synthesis, a two-step reaction cascade involving carboxylic acid, anthranilic acid and amines. It provides an efficient route to the required heterocycles. Liu *et al*. [57] reported a microwave-assisted three-component one-pot pyrazino-[2,1-*b*]quinazoline-3,6-dione framework (**Scheme-XIX**). A variety of synthesized alkaloids represent the critical biological roles.

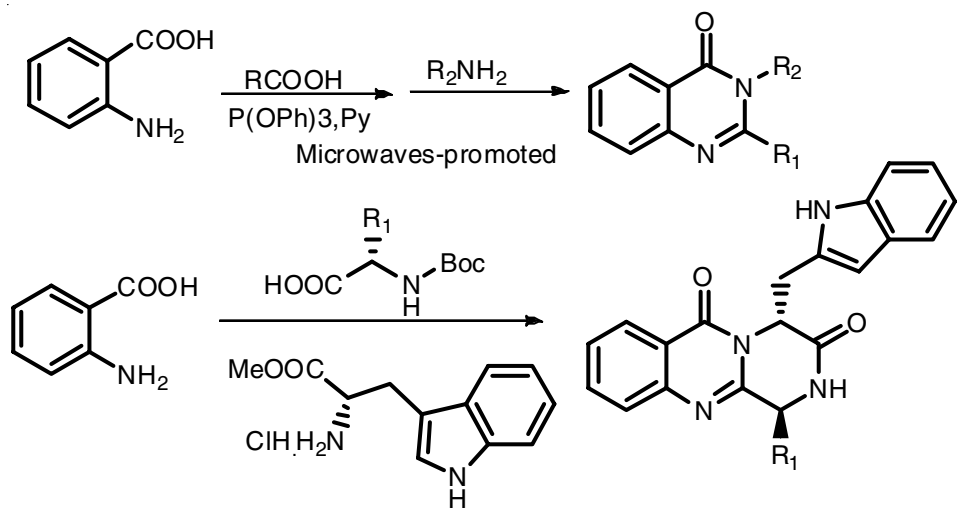
Güngör *et al.* [58] synthesized a novel family of 3-aryl-quinazolines. Even though compounds of general formula were discovered using various techniques depending on the type and locations of the substituents, the majority of them were synthesized using a benzoxazinone precursor. Giridhar *et al.* [59] synthesized and evaluated some 2,3-diaryl-4(3*H*)quina-



Scheme-XVII: Synthesis of piriqualone by reacting pyridine-2-carboxaldehyde and methyl-3-aryl-quinazolin-4-one



Scheme-XVIII: Synthesis of pyrrolobenzodiazepine (PBD) conjugates connected to quinazolinones

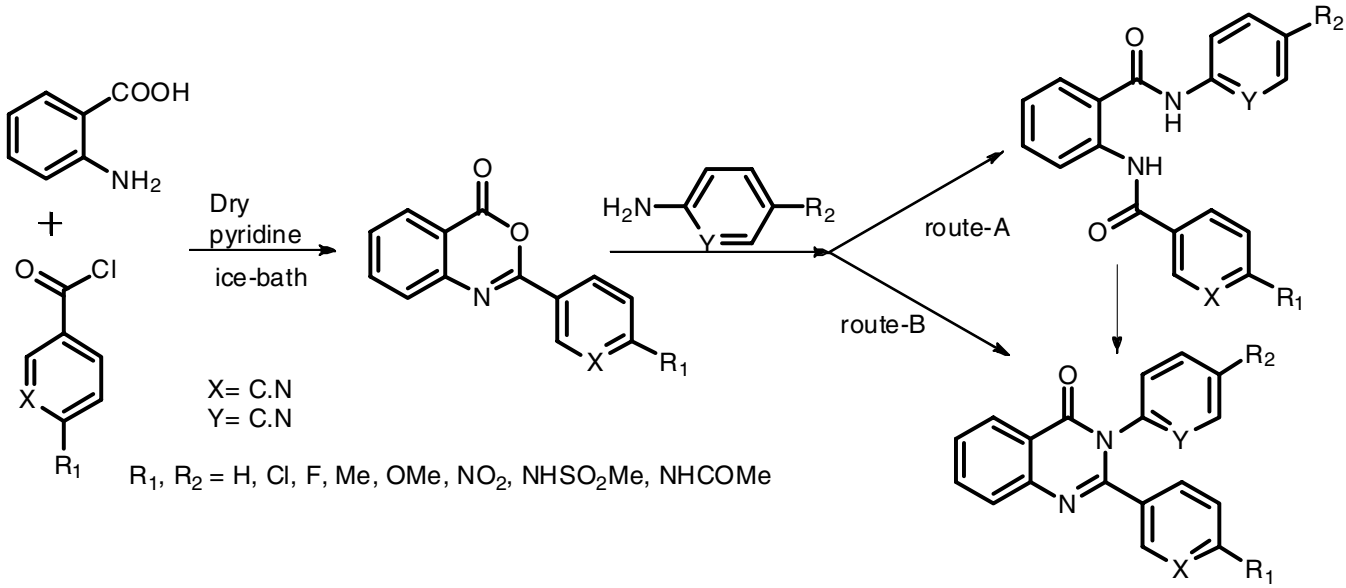


Scheme-XIX: Microwave-assisted quinazolinone analog synthesis using benzoxazinone intermediate

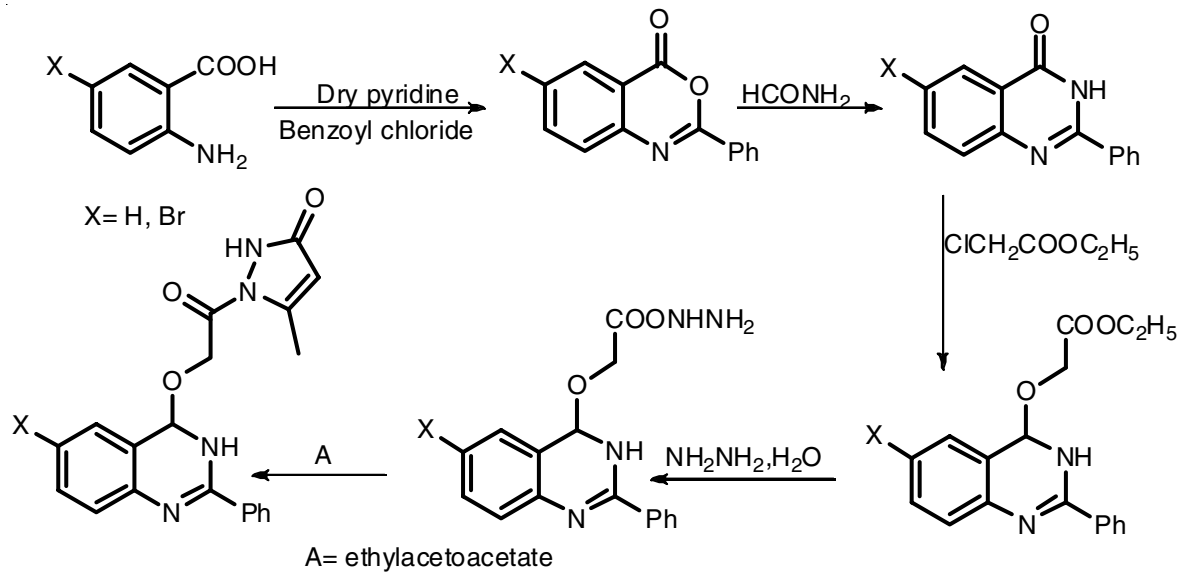
zolinones (**Scheme-XX**) potential anti-inflammatory activity. The reaction of 2-phenyl-3,1-benzoxazin-4(3*H*)-one with 2-aminopyridine produces diamide under favourable conditions (below 100 ºC). But the cyclized product 4(3*H*)-quinazolinone analog was isolated at higher temperatures (≤ 200 ºC) (through route B). This assertion only applied to compounds with pyridyl rings in the amines components or 3,1-benzoxazin-4(3*H*)-one. Anhydrous $ZnCl_2$ was used as a catalyst to cyclize the quinazolinones that resulted (route A). Boyapati *et al.* [60] presented novel quinazolinones' synthesis with replacement of OCH_2CONH_2 (oxy methyl carbamide) group at the 4th position (**Scheme-XXI**) for the development of novel antibacterials which have been shown to exhibit increased biological activity.

Anthranilic acid was cyclized with benzyl chloride at 0-5 ºC in pyridine to provide bentranil, which was used to make the required compounds. The resulting intermediate is then converted to the better foundation quinazolinone-2-phenyl-4(3*H*) [61] *via* a formamide, increasing biological activity. Anthranilic acid was cyclized with benzene carbonyl chloride in pyridine at 0-5 ºC to provide bentranil, which was used to make the required compounds. The resulting intermediate was then converted to more consistent 2-phenyl-4(3*H*) quinazolinone *via* a reaction with formamide. Gupta *et al.* [62] reported the synthesis and biological evaluation of various new quinazolin-4(3*H*)-ones derivatives (**Scheme-XXII**) as anticonvulsants. Condensation of anthranilic acid with benzene carbonyl chloride in the basic medium presence of pyridine is the initial step. 3-Amino-2-phenyl-1*H*-quinazolin-4-one was produced by treating the obtained 2-phenylbenzo[*d*][1,3]oxazin-4-one with hydrazine hydrate. Using a similar method, Alagarsamy & Saravanan [63] synthesized 18 novel quinazolin-4-(3*H*)-one derived pyrazole analogs.

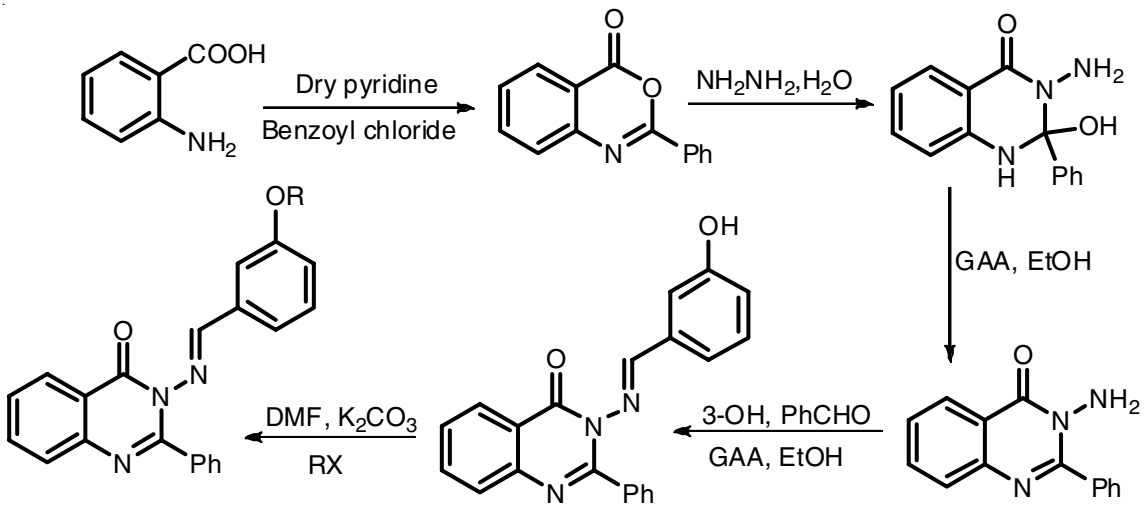
Anthranilic acid, amines and *ortho*-esters or formic acid are all condensed in one pot, a kind of multi-component reaction



Scheme-XX: Synthesis of 2,3-diaryl-4(3*H*)-quinazolinones using 2-aminobenzoic acid and dry pyridine

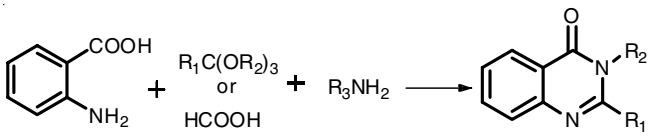


Scheme-XXI: Synthesis of 4-substituted quinazolines using anthranilic acid and benzoyl chloride followed by formamide



Scheme-XXII: Synthesis of quinazolinones derivatives

(MCR), to produce 4(3*H*)-quinazolinones analog (**Scheme-XXIII**). This condensation is known to be affected by several acid catalysts. The condensation was catalyzed by $FeCl_4$ with high to outstanding outputs of 4(3*H*)-quinazolinones. According to Khosropour *et al.* [64], this technique is notable for its moderate reaction conditions (room temperature), visible reaction, better yields with primary amines, anilines improved rates and simplicity of use. This method also has several advantages like stability, reusability and non-toxicity of the catalyst and ionic liquid. Hamdi *et al.* [65] reported that the microwave irradiation combined with Keggin-type heteropolyacids ($H_3PW_{12}O_4Os_{13}H_2O$) allowed for a solvent-free, fast condensation process.

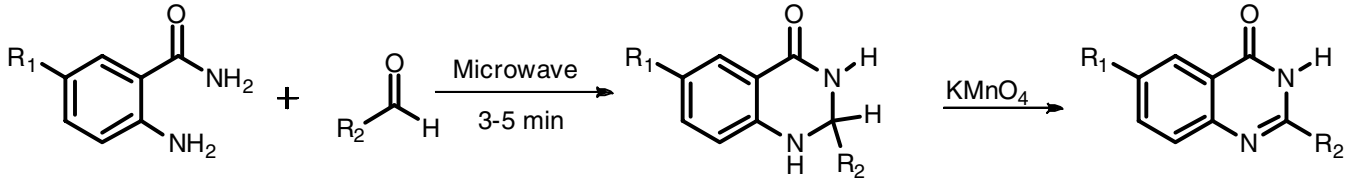


Scheme-XXIII: Synthesis of quinazoline analog using 2-aminobenzoic acid, amines and *o*-esters or formic acid under one pot condensation reaction

The reaction time was 10 times faster than the traditional approach (microwave irradiation takes 13 min, but conventional heating takes 120 min). Heravi *et al.* [66] used Keggin-type heteropolyacids as efficient, reusable and environmentally acceptable heterogeneous inorganic catalysts to develop a simple multi-component synthesis process for 4-arylamino-quinazolines from the reaction of 2-aminobenzamide, *ortho*-ester and substituted anilines. In a similar work, Heravi *et al.* [67] presented another method for producing 4(3*H*)-quinazolinones from the reaction of 2-amino-benzamide, acyl chlorides and ($H_{14}[NaP_5W_{30}O_{11}]$) or SiO_2 in the presence of a catalytic amount under ultrasonic irradiation. Wang *et al.* [68] demonstrated that $SrCl_2S_6H_2O$ is an excellent and recyclable catalyst for the one-pot condensation of anthranilic acid, *ortho*-esters and amines to generate 4(3*H*)-quinazolinone derivatives in good yields at room temperature under solvent-free conditions. The technique has many benefits, including a detailed workup, moderate conditions, a commercially accessible catalyst and a generally clean procedure that shows a new method for making 2-substituted-2-quinazolin-4(3*H*)-one. In 2011, Huang *et al.* [69] used the condensation process of modified 2-amino-benzamide *ortho*-esters to create ones and their derivatives. The reaction happens without an organic solvent and a basic or acidic catalyst, which is unusual. To understand the mechanism of action and study the drug metabolism of 4(3*H*)-quinazolinones, Saemian *et al.* [70] synthesized quinazolin-4(3*H*)-ones [4-14C] from 2-aminobenzoic acid-[carboxy-14C] formic acid and amine. In absence of a solvent or other dehydrating agents, the process was performed in the microwave.

Synthesis of 4(3*H*)-quinazolines and their analogs *via* oxidative heterocyclization: Bakavoli *et al.* [71] generated 4(3*H*)-quinazolines in one pot by oxidative heterocyclization of aldehydes with *o*-aminobenzamides in the presence of $KMnO_4$ with microwave irradiation (**Scheme-XXIV**). They also reported the oxidative cyclo-condensation of various aldehydes with *o*-aminobenzamides mediated by I_2/KI [72]. The desired 4(3*H*)-quinazolines were generated in high to excellent yields of 93-96% in boiling water or ethanol-water.

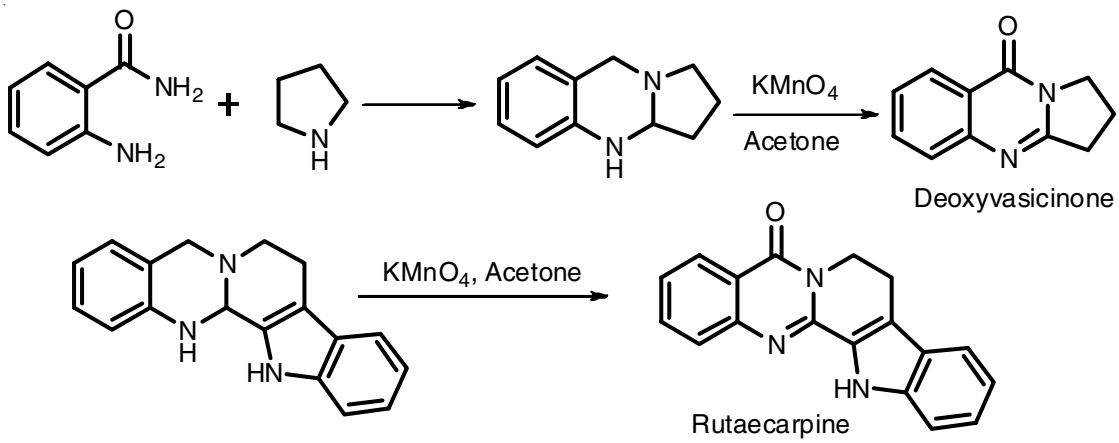
Seidal *et al.* [73] reported that $KMnO_4$ was used to synthesize deoxyvasicinone and rutaecarpine. In turn, *o*-amino benzaldehyde condensation and simple secondary amines (**Scheme-**



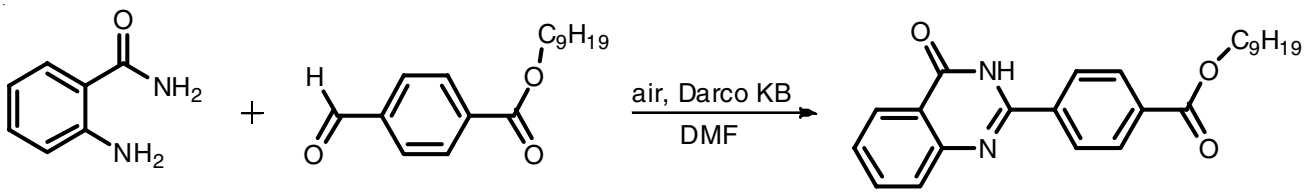
Scheme-XXIV: Microwave activated oxidative heterocyclization for the synthesis of quinazoline analog

XXV) resulted in enhanced oxidation of aminals. Later Seidal *et al.* [74] proved that quinazolinone alkaloids analogs could be generated from their respective aminals who used a copper(II) acetate/O_2 potassium iodide/acetic acid/*tert*-butyl hydroperoxide system. It was discovered that combining CH_3COOH with O_2 and catalytic Cu(II) salts inhibited dihydroquinazoline over oxidation, making it accessible to these structures beneath mild conditions. By oxidative coupling of aromatic/aliphatic aldehydes with 2-aminobenzamide or 2-aminobenzylamines, Hioki *et al*. [75] discovered a solid-phase combinatorial synthesis 2-aryquinazolinones and 2-aryl/alkyl quinazoline. Darco KB, a catalyst based on a kind of activated carbon, was developed (**Scheme-XXVI**). Mulakayala *et al.* [76] described a practical and convenient process using $InCl_3$-catalyzed condensation of 2-aminobenzamides with aromatic aldehydes to produce quinazolinone analog (**Scheme-XXVII**). $InCl_3$ has more excellent operational simplicity, water stability, robust resistance to nitrogen and oxygen-containing compounds, with a functional group than traditional Lewis acids. It is frequently used in catalytic quantities. The researchers recently disclosed an intriguing quinazolinone synthesis method by mixing aldehydes with 2-aminobenzamide using a simple catalyst-free condition [77]. Aromatic aldehydes containing halogen or electron-withdrawing (EWG) functional groups are acceptable and give the required compound having good to exceptional yields. Because heterocycles have fascinating biological properties, As substrates, various heterocyclic aromatic aldehydes were employed. The related 2-heterocyclic substituted quinazolinones were quickly produced and yielded well. Even aliphatic aldehydes provided high yields of complimentary alkyl substituted products when reacting with 2-aminobenzamide, which was difficult in the prior approach. They also used a zinc-catalyzed oxidation method to take advantage of stable alcohol's reactivity in quinazolinone analog synthesis. As predicted, a one-pot with one-step method produced acceptable to outstanding yields for various targeted products.

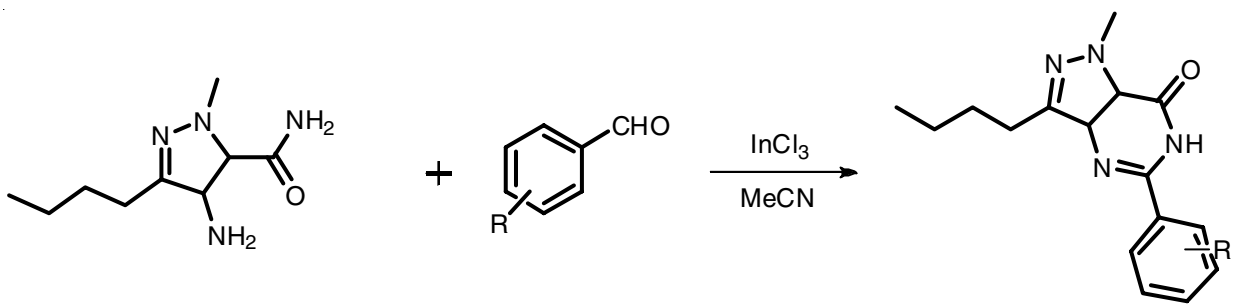
Utilizing a hydrogen transfer method to synthesize quinazolinones and *N*-alkylation of alcohols with amines alcohols has shown to be a helpful technique for forming C-N bonds. This domino reaction chain starts with the dehydrogenation of the alcohol *in situ* to create the corresponding aldehyde or ketone. The *N*-alkylated amine was formed due to further imine production, followed by reduced hydrogen (**Scheme-XXVIII**) [78]. Fang & Zhou [79] used this approach to synthesize natural



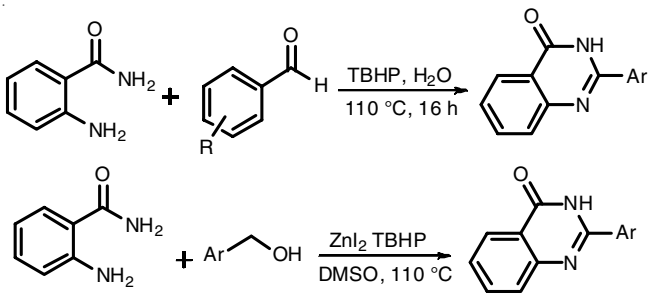
Scheme-XXV: Synthetic route of deoxyvasicinone and rutaecarpine



SchemeXXVI: Darco KB catalyzed oxidative heterocyclization for the synthesis of quinazoline analog

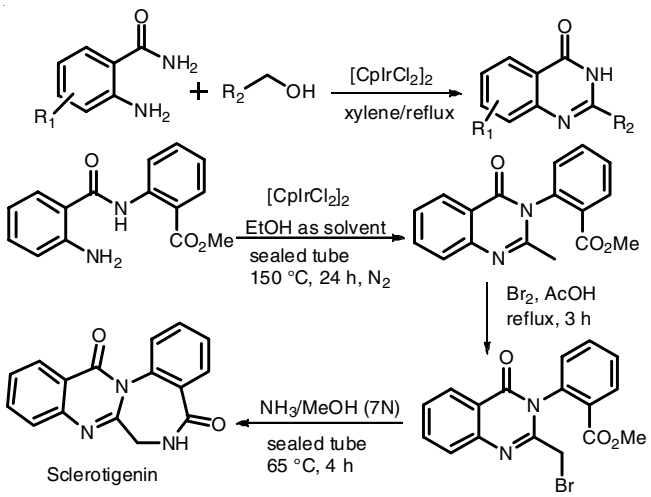


Scheme-XXVII: Synthesis of the design quinazoline analog using $InCl_3$ as catalyst

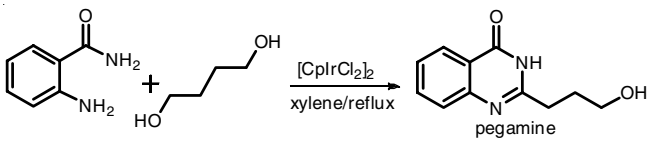


Scheme-XXVIII: Oxidative synthesis of quinazolinone

products like sclerotigenin and pegamine, which was very handy for them. Yokoyama *et al*. [80] described a Pd-catalyzed cascade reactivity of benzyl alcohols with *o*-aminobenzamides (**Scheme-XXIX**) to produce 4-phenylquinazolinones. A mechanism was postulated that was very distinct from the Ir-catalyzed hydrogen transfer process. In aqueous environments, benzyl alcohols are oxidatively added to Pd(0) to form the (h3-benzyl) palladium complex, which is required for both C-H activation *via* benzyl transfer (**Scheme-XXX**).

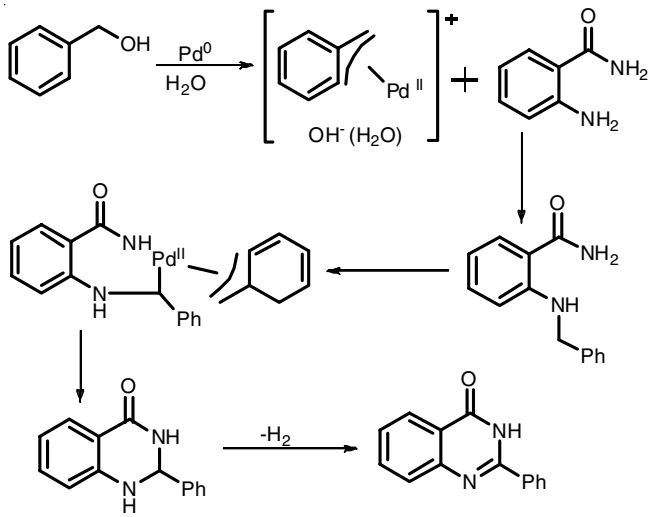


Scheme-XXIX: Synthesis of quinazolinones using an Ir-catalyzed reaction between *o*-aminobenzamides and primary alcohols



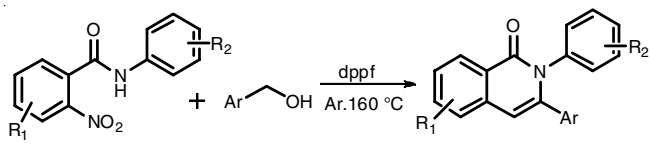
Scheme-XXX: Synthesis of quinazolinones using an Ir-catalyzed reaction between *o*-aminobenzamides.and primary dialcohols

In addition, following C-H activation reactions necessitate the use of an oxidant susceptible to recast palladium to a high oxidation state. In the system, benzyl alcohols help to regenerate Pd(II) species into toluene. Typically, the amino group was created by reducing the matching nitro group with a stoichiometric quantity of hydrogen or acid/metal. It is preferable to employ commercially accessible and affordable nitroarenes and alcohol as starting materials to synthesize quinazolinones. The alcohol may potentially serve two roles in this simple transformation: a hydrogen supply for an alkylating reagent and nitro reduction based on catalytic hydrogen transfer. Deng *et al*. [81] reported that non-toxic iron might be used as a catalyst to synthesize a series of 2,3-dialkyl/arylquinazolinones from alcohols and nitrobenzamides (**Scheme-XXXI**). Halogens and some other activist groups have been well-tolerated together under process conditions.



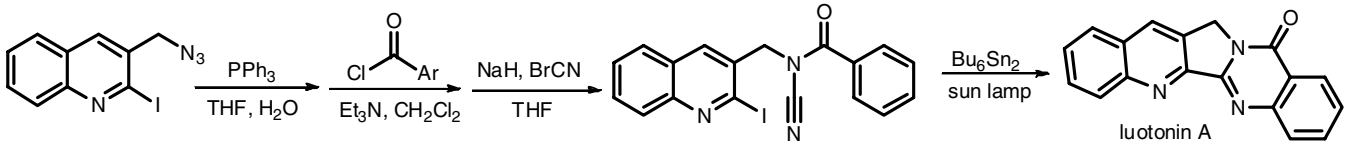
Scheme-XXXI: Synthesis of quinazolinones using Pd-catalyzed processes with benzyl alcohol

Radical chain reaction formed quinazolinones analog: Malacria *et al.* [82,83] described an excellent radical cascade method for the complete synthesis of luotonin-A utilizing *N*-acyl cyanamides (**Scheme-XXXII**). This method may make pyrimidones fused with aryl, alkyl, heteroaryl or heteroaryl moieties. According to a comprehensive mechanistic investigation, the rearomatization-induced radical migration of carbon substituents or a hydrogen atom of the cyclohexadienyl radical was the fundamental characteristic of the reaction, according to a comprehensive mechanistic investigation [84]. Through molecular oxygen-induced oxidative radical structural rearrangement synthesizing 5-aryl-4,5-dihydro-1,2,4-oxadiazoles (**Scheme-XXXIII**), Chiba *et al*. [85,86] established a simple synthesis of physiologically quinazolinone compounds that are active. The product selectivity was achieved by varying the reaction temperature and the solvents and inorganic bases used. This atom and step-economical permitted the straightforward synthesis of quinazolinone centers under tin-free aerobic radical circumstances.

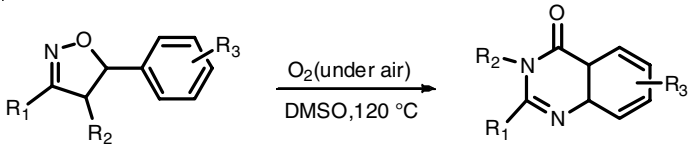


Scheme-XXXII: Synthesis of 2,3-diarylquinazolinones using a Fe-catalyzed reaction

***N*-Arylation catalyzed by transition metals toward quinazolinone synthesis:** Ullmann *N*-arylations catalyzed by transition metals is an integral approach with various applications in synthesizing many different compounds. In this respect, Fu *et al*. [87] reported effective copper-catalyzed *N*-arylations



THF was used as a solvent in the complete synthesis of luotonin-A.

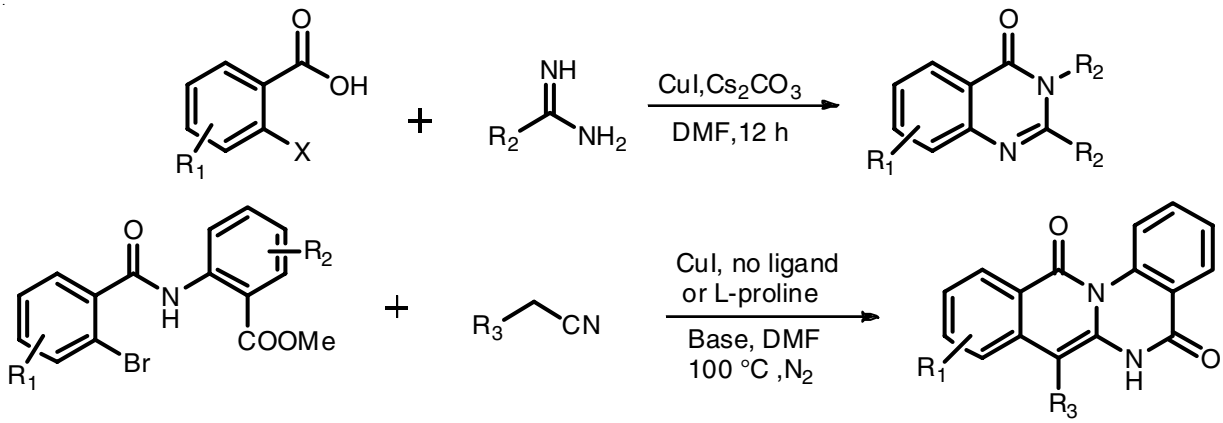


Scheme-XXXIII: Syntheisis of quinazolinones *via* oxidative radical molecular transformation of oxadiazoles analogs

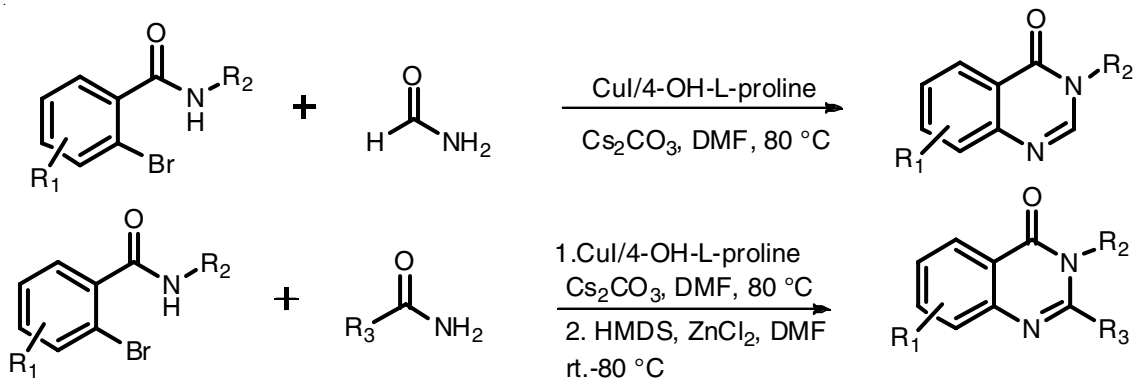
to produce quinazolinone derivatives. They showed that without the need for a ligand or additive, coupling reactions of 2-bromo or 2-iodobenzoic acid derivatives with amidines might be carried out effectively at 25 ºC (**Scheme-XXXIV**). Even non-active substrates like guanidines or 2-chlorobenzoic acid can be readily transformed into the corresponding quinazolinone analogs in the presence of CuI at 80 ºC. This is the first time, *N*-heterocycles have been synthesized at room temperature using ligand-free copper catalysis. Fu *et al*. [88] disclosed an iron-catalyzed cascade synthesis of quinazolinone derivatives and 1,2,4-benzothiadiazine 1,1-dioxide. Using widely accessible amino acids as nitrogen-containing motifs, the same group described a unique and valuable domino approach for building quinazolinones [89]. Using a copper-catalyzed method, Fu *et al*. [90] succeeded in producing isoquinolino[2,3-*a*]quinazolinones. The process includes an Ullman-type *C*-arylation, intramolecular addendum of CN with NH and a nucleophilic attack of amino on the ester group. Under microwave irradiation, Liu *et al*. [91] devised a practical in H_2O and DMF, Fe-catalyzed formulation of different quinazolinone moiety. This is the first time Fe-catalyzed C-N coupling has been reported in aquatic settings, resulting in *N*-heterocycles. Later, Liu *et al*. [92] also reported a microwave irradiated Fe/Cu co-catalyzed production of 2-methylquinazolin-4(3*H*)-one.

To meet the challenges of sustainable organic transformation pathways, Wang *et al.* [93] reported an efficient, reusable and magnetically recoverable Fe_3O_3 nanoparticle supported Cu(I) catalyst and its application cascade reactions of substituted 2-halobenzoic acid and 2-bromocycloalk-1-enecarboxylic acids with amidines to synthesize quinazolinone moiety and bicyclic pyrimidinone. Decanting the sample solution under the influence of an applied magnet is an effective and straightforward way to recover the catalyst and reused it in the process over ten times with no noticeable loss of activity. Ma *et al*. [94] reported a fast and straightforward method for building substituted quinazolinones. Conveniently accessible amides may be used as nucleophiles in coupling reactions with *N*-substituted *o*-bromobenzamides, resulting in 2,3-disubstituted or 3-substituted quinazolinone calmer condensative cyclization by HMDS/$ZnCl_2$ (**Scheme-XXXV**). The formal synthesis of 3-[2-(hydroxymethyl)-4-methoxyphenyl]-6-methoxyquinazolin-4-one and methaqualone has been demonstrated using this protocol. Li *et al.* [95] were motivated to develop a modular synthesis of 3*H*-pyrido[3,4-*d*]pyrimidin-4-one (**Scheme-XXXVI**), an orally active Ca-sensing receptor (CaR) antagonist currently being investigated for the treatment of osteoporosis. The intended product was obtained on the first try utilizing CuI-mediated conditions; however, despite all optimization efforts, the reaction only reaches a 50% conversion rate at best, even without ligands. They soon moved to palladium-catalyzed techniques and reported that the system was produced by the Xantphos/$Pd_2(dba)_3$ complete conversion and a pure HPLC result. In a one-pot synthesis, amidines, *N*-arylation yielded quinazoline-4(3*H*)-one when combined with methyl 2-iodo or 2-bromo benzoate esters.

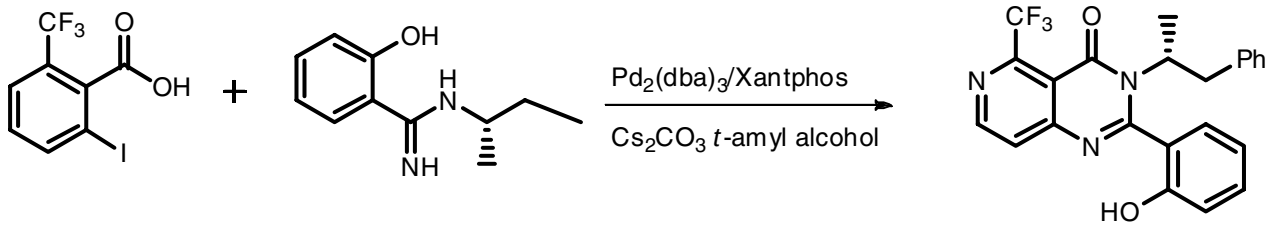
Pd-catalyzed carbonylations have come a long way since 4-(3*H*)-quinazolinones palladium-catalyzed carbonylative synthesis in 1974 [96]. Carbonylative transformation catalyzed by Pd has evolved into a unique, potent and flexible method for generating carbonyl-containing heterocyclic molecules



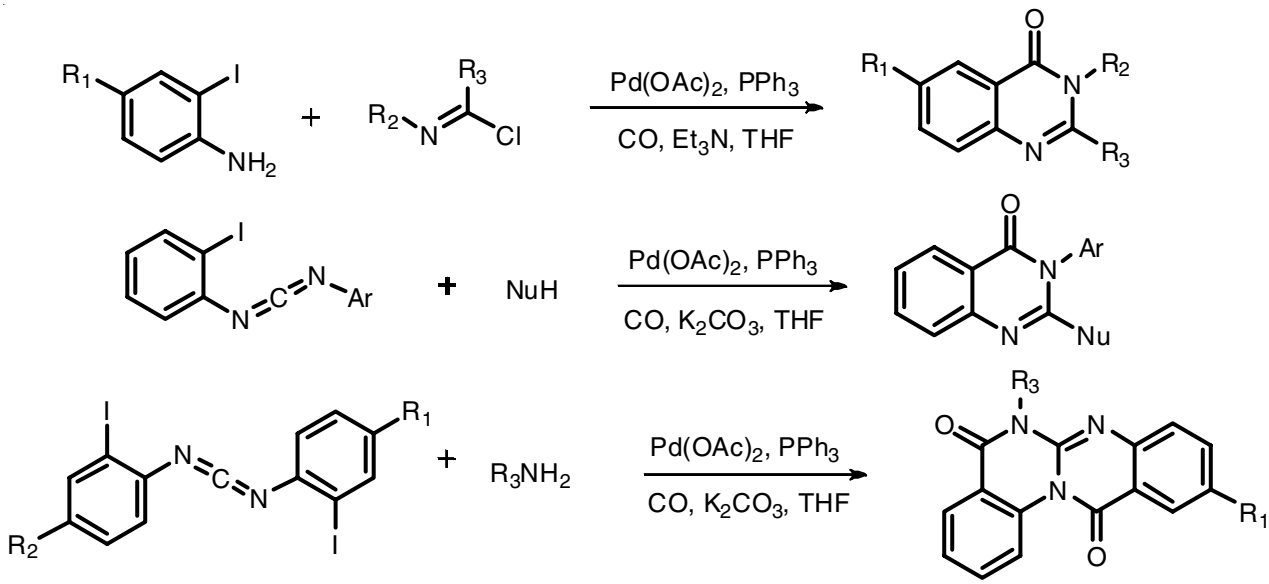
Scheme-XXXIV: Synthesis of quinazolinone moiety using Cu-catalyzed *N*-alkyl 2-halobenzoic acid in DMF



Scheme-XXXV: Synthesis of 2,3-disubstituted quinazolines using Cu-catalyzed aryl amidation

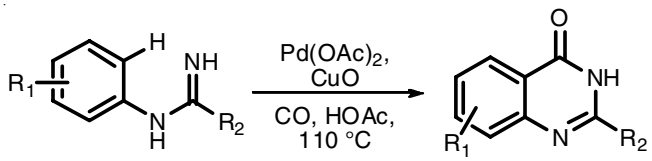


Scheme-XXXVI: Synthesis of 3*H*-pyrido[4,3-*d*]pyrimidin-4-one analogs using xantphos/$Pd_2(dba)_3$ system



Scheme-XXXVII: Synthetic routes of Pd-catalyzed carbonylation of 4(3*H*)-quinazolinone analogs

today. In 2008, Zheng & Alper [97] reported a practical palladium catalyzed three-component synthesis of imidoyl chlorides, *o*-iodoanilines and carbon monoxide (**Scheme-XXXVII**). Using palladium catalyzed intermolecular addition and intramolecular cyclocarbonylation cascade reaction technique, the same group also accomplished a one-step synthesis of a potentially essential 2-heteroquina-zolin-4-(3*H*)-one derivative [98]. The same elegant domino method has been used to synthesize quinazolino[3,2-*a*]quina-zolinones [99]. Zhu *et al.* [100] reported an intriguing Pd-catalyzed intramolecular C(sp^2)-H carboxamidation (**Scheme-XXXVIII**). The reactions were placed in CH_3COOH as a solvent, using one equivalent of cuprous oxide and one bar of carbon monoxide with *N*-arylamidines produced high yields of various quinazolinones. Because no

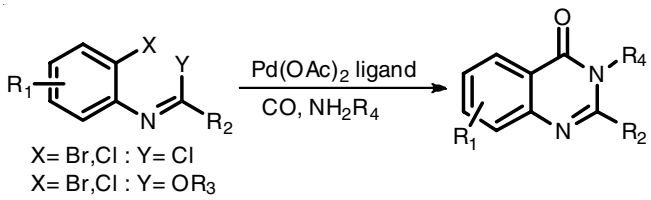


Scheme-XXXVIII: Pd(II)-catalyzed 4(3*H*)-quinazolinone synthesis through C-H carboxamidation of *N*-arylamidine

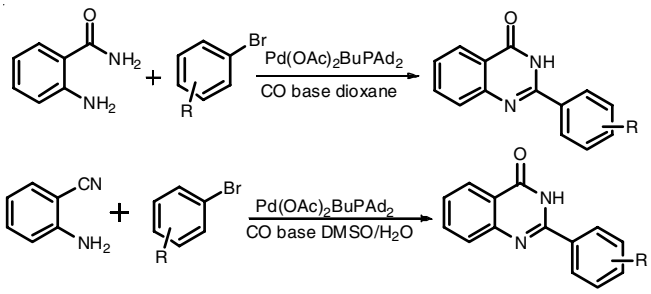
atoms in substrates were lost throughout the process, this technique, unlike other approaches to quinazoline-4(3*H*)-one, has atom economy and step-efficiency.

Willis *et al.* [101] showed that imitates or *N*-(*o*-halophenyl)-imidoyl chlorides may be used as complementary materials for the synthesis of quinazolinones moiety by including Pd-

catalyzed aminocarbonylation reaction workup (**Scheme-XXXIX**). Under CO ambient pressure, good to excellent yields of 2,3-disubstituted quinazolinones was obtained. Quinazolinones were synthesized in high yields with a variety of amine nucleophiles. Wu *et al.* [102] developed a simple carbonylative quinazolinone synthesis using aryl bromides and 2-aminobenzamide (**Scheme-XL**). The synthesis of structurally different quinazolinone products was made possible by a significant difference in the substrates. It is hypothesized that 2-aminobenzonitrile might be used as a substrate to quinazolinones moiety are made by hydration of the nitrile group through an amide group *in situ*. As an attractive alternative to 2-aminobenzamide. Using K_2CO_3 as a cheap base in an aqueous solution, aryl bromides and 2-aminobenzonitriles were used to make quinazolinones [40].



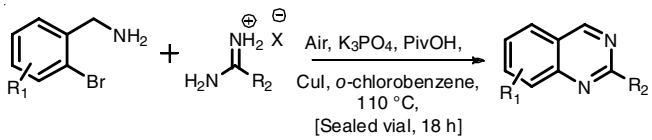
Scheme-XXXIX: Synthesis of 2,3-disubstituted quinazolinones from imidates or *N*-(*o*-halophenyl)imidoyl chlorides



Scheme-XL: Pd catalyst carbonylative synthesis of 4(3*H*)-quinazolinone using the three-component system

Neumann *et al*. [103] reported a simple and convergent Pd-catalyzed four-component carbonylative coupled system for the synthesis of 4(3*H*)-quinazolinone (**Scheme-XLI**), emphasizing the importance of quinazolinones and carbonylative transformations. Starting with economically available 2-bromoaniline, *o*-esters, amines and CO, the required products were separated in high yields in the presence of $BuPAd_2/Pd(OAc)_2$. The method tolerates a wide range of synthetically helpful functional groups, which opens up a new avenue for the efficient and long-term synthesis of highly functionalized amines.

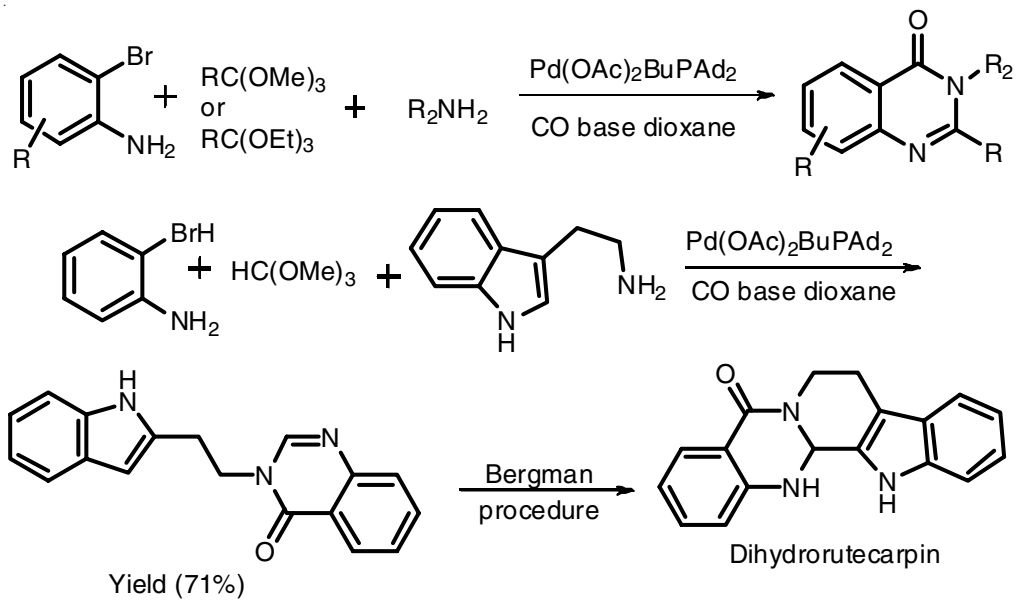
In one step, CuI-catalyzed cascade reactions of amidines and 1-(2-bromophenyl)methenamine with K_3PO_4 as base, pivalic acid as additive and aerial oxygen as the oxidant generate substituted quinazolines having yields ranging from 48 to 90% (**Scheme-XLII**). The stages in the mechanism include Cu(I)-catalyzed intermolecular *N*-arylation, followed by intramolecular nucleo-philic substitution and Cu(II)-catalyzed oxidation. 1-(2-iodo-phenyl)methenamine [104] can be used to replace the amidines and the reaction can be carried out using imitates.



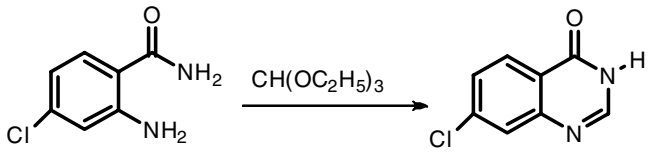
SchemeXLII: Synthesis of substituted quinazolines using CuI-catalyzed reactions of 1-(2-bromophenyl)methenamine and amidines

The synthetic route of 7-chloro-substituted quinazolinone analog *via* condensation reaction of 2-amino-4-chlorobenzamide using (diethoxymethoxy)ethane as a condensing reagent [105] (**Scheme-XLIII**). Quinazolin-4(3*H*)-one analog was then made by reacting 2-aminobenzoic acid with an excess amount of methanamide at 120 ºC (**Scheme-XLIV**). The Niementowski reaction [106] is another name for this reaction.

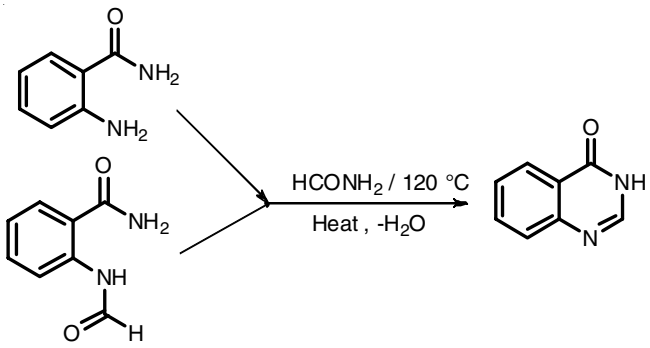
3-Phenyl cinnamoyl chloride with halo substituted 2-aminobenzonitrile, 2-styryl-4(3*H*)-quinazolinone moiety was synthe-



Scheme-XLI: Pd catalyst carbonylative synthesis of quinazolin-4(3*H*)-one analog using a four-component system



Scheme-XLIII: Synthesis of substituted quinazolines using condensation reaction of 2-amino-4-chlorobenzamide with triethyl ortho-formate

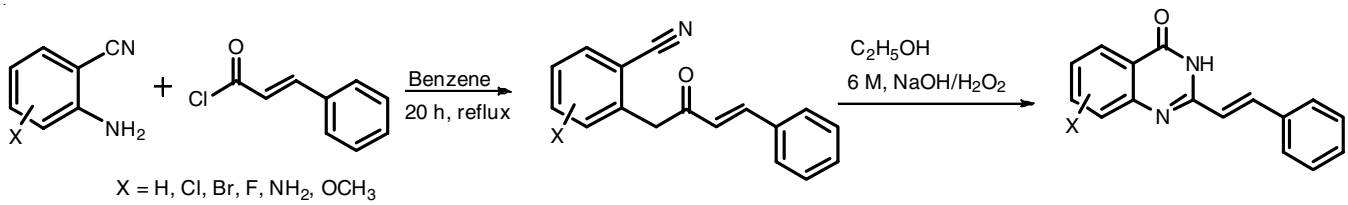


SchemeXLIV: Synthesis of quinazolin-4(3*H*)-one from anthranilic acid and formamides

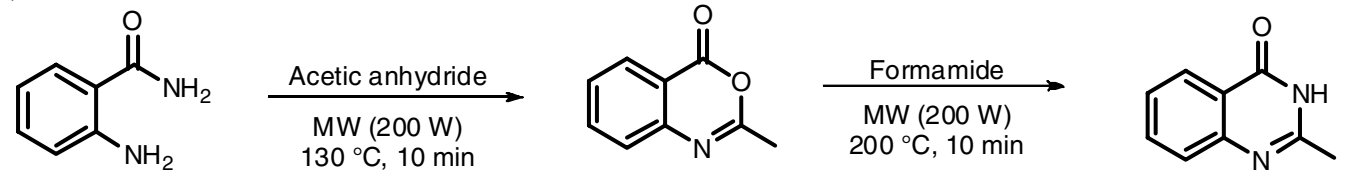
sized using the starting material. Under alkaline circumstances, 2-styryl-4(3*H*)-quinazolinone was obtained *via* intramolecular cyclization of cinnamate derivatives (**Scheme-XLV**). This method has been demonstrated to work with a wide range of substituted aromatic rings [107]. The response of 2-aminobenzoic acid with ammonium acetate was observed utilizing methanamide beneath microwave condition at 200 W to synthesize the preferred 2-substituted-4(3*H*)-quinazolinones products [108] (**Scheme-XLVI**). Under reflux circumstances, anthranilamide was reacted with substituted aldehydes or ketone in the presence of TEE to produced 2,2-disubstituted-2,3-dihydro-4(1*H*)-quinazolinone analogs in moderate yields [109] (**Scheme-XLVII**).

In the synthesis of 2-amino-quinazolin-4(3*H*)-one analog used the response of methyl anthranilate and an extra quantity of guanidine in the presence of ethyl alcohol with NaOH to produce sodium ethoxide at 130 ºC and 5 h to received an average yield [110] (**Scheme-XLVIII**). 4-Arylaminoquinazolines offer a lot of potential as anticancer medicines. By treating 2-aminobenzonitrile and other substituted amino benzene with anhydrous $AlCl_3$, substituted amidines were quickly synthesized (**Scheme-XLIX**) [111].

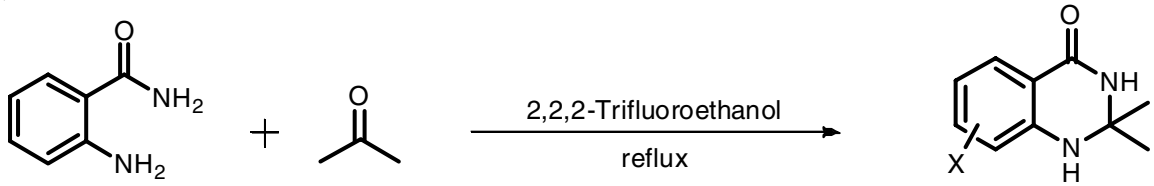
2,3-Alkyl/aryl-disubstituted-4(3*H*)-quinazolinone moiety were synthesized by reacting 2-acetamidobenzoic acid with a suitable arylamine presence phosphoryl chloride to give the desired product having excellent yields [112] (**Scheme-L**). The most often used synthesis intermediates of 2,3-alkyl/aryl-



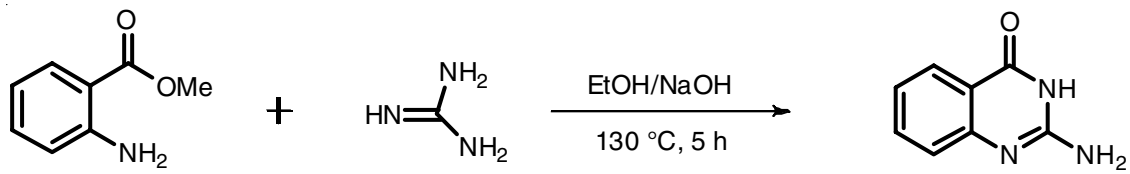
SchemeXLV: Synthesis of 2-[(*E*)-2-phenylethenyl]-3*H*-quinazolin-4-one derivatives using 2-aminobenzonitrile as starting material



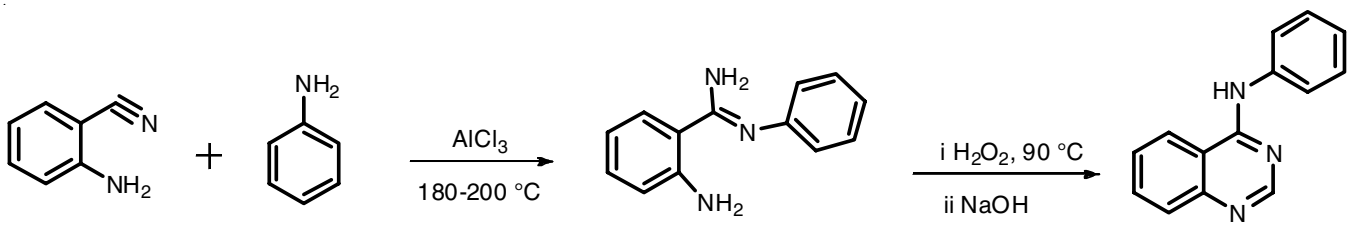
Scheme-XLVI: Synthesis of 2-substituted-4(3*H*)-quinazolinones from 2-aminobenzoic acid with ammonium acetate followed by Methanamidation



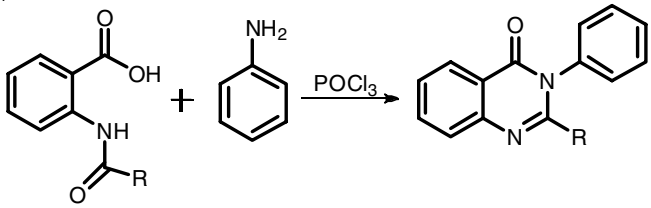
Scheme-XLVII: Synthesis of 2,2-disubstituted-2,3-dihydro-4(1*H*)-quinazo-linone analog from anthranilamide and aldehydes/ketone in the presence of TEE under reflux conditions



SchemeXLVIII: Synthesis of 2-aminoquinazolin-4(3*H*)-one using methyl anthranilate and guanidine



Scheme-XLIX: Synthesis of 4-arylaminoquinazolines as anticancer drugs

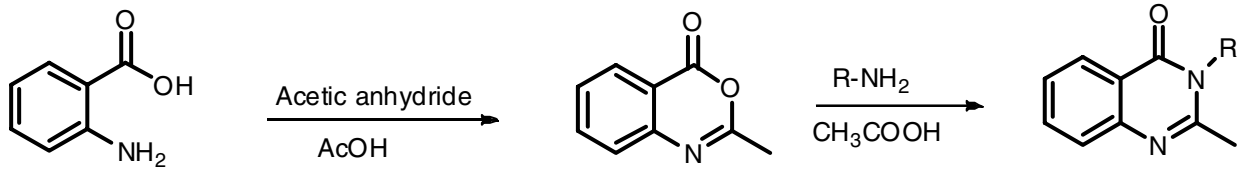


Scheme-L: Synthesis of 2,3-disubstituted-4(3*H*)-quinazolinone moiety using phosphorous oxychloride as catalyst

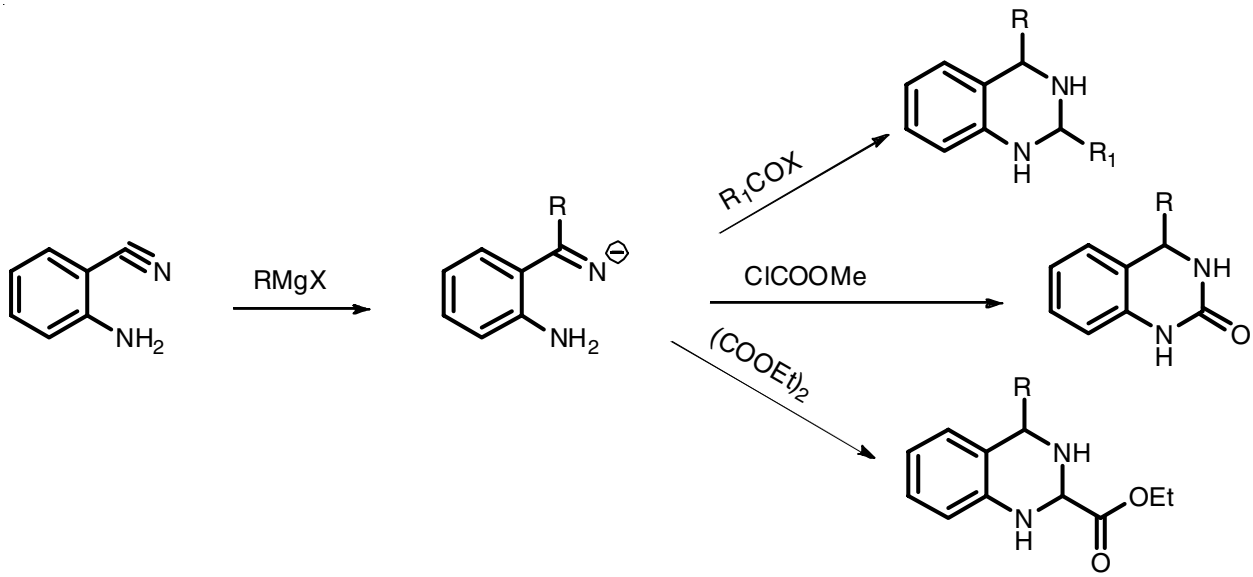
disubstituted quinazolinone moiety are benzoxazinone derivatives. A refluxing combination of 2-aminobenzoic acid and ethanoic anhydride in ethanoic acid yielded 2-methyl-3,1-benzoxaza-4-one with moderate to high yields (**Scheme-LI**) [113]. The intermediates were synthesized by reacting 2-aminobenzonitrile with alkyl magnesium halide (Grignard reagents) (**Scheme-LII**). The resulting intermediate derivatives were crucial in the production of various quinazolinone moieties. Furthermore, the corresponding quinazoline derivatives were obtained in yields that range from good to exceptional when cyclized with acid chlorides, anhydrides and forms. As a result, this generic technique for making different 2,4-alkyl/aryl-disubstituted quinazoline moieties is extraordinarily versatile and valuable [114].

2-(Chloromethyl)-4-methylquinazoline moiety were synthesized by reacting 1-(2-aminophenyl)ethanone with HCl gas in the anhydrous state in the presence of chloroacetonitriles, as illustrated in **Scheme-LIII**. The molecule was treated with various amines derivatives in a basic condition using potassium carbonate in DMF solvent, yielding 2-chloromethyl-4-methyl-quinazoline moiety with good yields [107]. A three-component reaction using isotonic anhydride, aliphatic/aromatic amine and oxaldehydic acid; hydrate as reactants in PEG-400 using freshly prepared lemon juice at room temperature (25-30 ºC) under ultrasound irradiation condition moderate yields obtained [115] (**Scheme-LIV**).

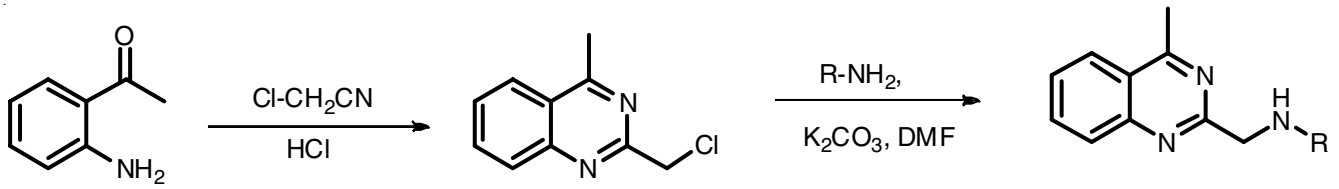
A four-component method based on aniline, aromatic aldehydes and ammonium iodide was developed for synthesizing substituted quinazolines derivatives. In anilines, the C-H bond was immediately functionalized in a metal-free environment in the direction of the amino group. Two moles of aromatic aldehydes were used in this synthesis and ammonium iodide



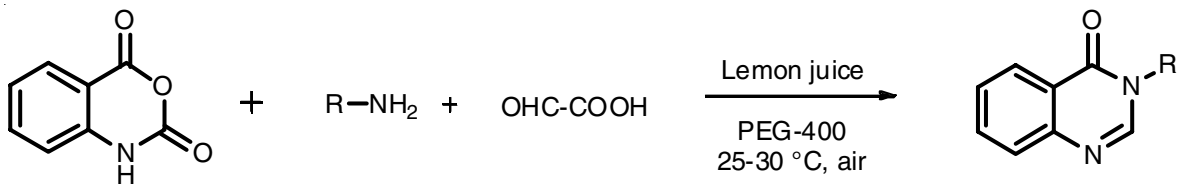
Scheme-LI: Synthesis of 2,3-alkyl/aryl-disubstituted quinazolinone derivatives using anthranilic acid, acidic anhydride and primary amine



Scheme-LII: Synthesis of several 2,4-disubstituted quinazoline derivatives using 2-aminobenzonitrile



Scheme-LIII: Synthesis of 2-chloromethyl-4-methyl-quinazoline moiety using 1-(2-aminophenyl)-ethanone and HCl gas



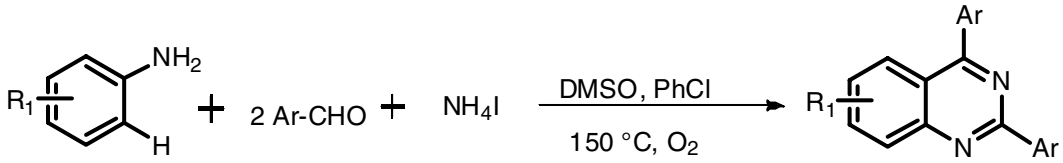
Scheme-LIV: Synthesis of substituted quinazolines using isotonic anhydride, amine and oxaldehydic acid; hydrate in three-component reaction

as a nitrogen source. The reaction allows substituted quinazolines to be made from simple anilines and other widely accessible compounds. The most often described procedure for the preparation of substituted quinazolines moiety from *ortho* functionalized anilines derivatives such as 2-carbonyl anilines, 2-aminobenzylamine and 2-aminobenzonitriles, have been described as starting materials for the formation of benzo-heterocyclic compounds by condensation with aldehydes, benzylamine, benzylic acid or benzonitrile (**Scheme-LV**). Others discovered that the most stable *o*-nitroacetophenone might be utilized as a raw material to make substituted quinazolines using a hydrogen transfer method in addition to *ortho*-functionalized anilines. *N*-Arylamides were being used as starting materials for the intramolecular cyclization observed in quinazoline synthesis. The aniline ring does not need to be preactivated in the ortho configuration. In recent years, other activated nitrogen containing rea gents, such as aryl diazonium salts, 2-ethynylanilines, 2-alkylaminobenzonitriles, *N*-sulfinyl imines, imines and amidines are various alternative substrates for the synthesis of substituted quinazolinone analogs [116].

The efficient metal-free synthesis of 2,4-dialkyl/diaryl/alkyl, aryl-substituted quinazolines have been established using a hydrogen peroxide-mediated one-pot containing three component reaction involving 2-aminoaryl ketone, aromatic or aliphatic aldehydes and ammonium ethanoate (**Scheme-LVI**). The transition occurred fast under favourable conditions in the corporation of commercially available hydrogen peroxide. The lack of a transition metal catalyst, the moderate reaction conditions and the broad substrate scope are all key advantages of this technique. Additionally, this method is compatible with the last 2,4-substituted quinazoline manufacturing techniques [117].

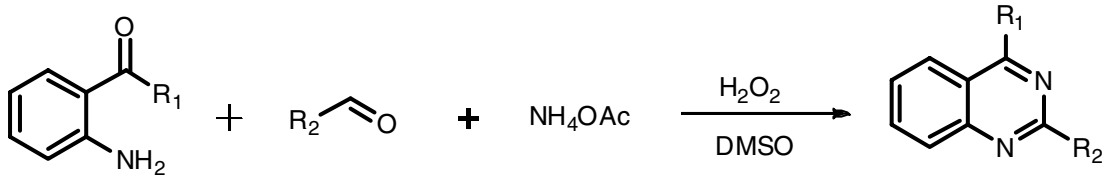
Synthesis assisted by microwaves: Sarma & Prajapati [118] used microwave heating to synthesize quinazoline moiety from aromatic aldehydes, 2-aminobenzophenone and ammonium ethanoate without the need of a catalyst or solvent (**Scheme-LVII**). The technique was tested on a variety of electron-rich and electron-deficient groups and it produced the required quinazoline analog in satisfied isolated yields (70-91%) in under a minute. Furthermore, the reaction is clean and straightforward and it provides an environmentally acceptable method for removing organic solvents in medicinal chemistry through organic synthesis [118].

Synthesis in water driven by bases: Cho *et al.* [119] reported a transition/catalytic metal-free synthesis of quinazoline moiety from readily available trihalotoluene and *o*-amino-



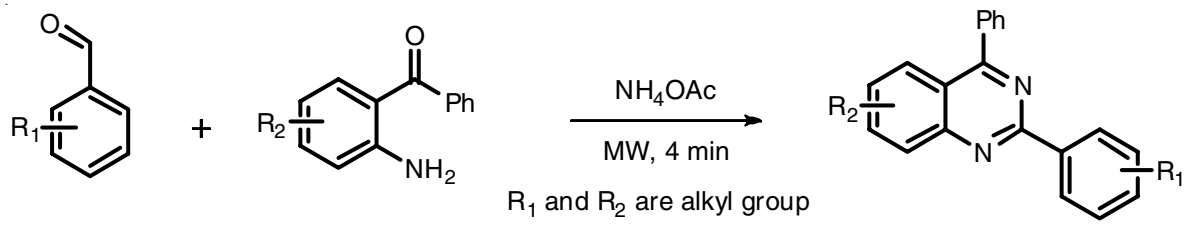
Four-component, Aniline C-H Functionalization, NH_4I as a nitrogen source, metal- Free.

Scheme-LV: Synthesis of substituted quinazolines from aniline using NH_4I as a nitrogen source



R_1 = Aryl, Me. R_2 = Aryl, Heteroaryl, Alkyl

Scheme-LVI: Synthesis of quinazoline under three-component one-pot process using green oxidant without metals



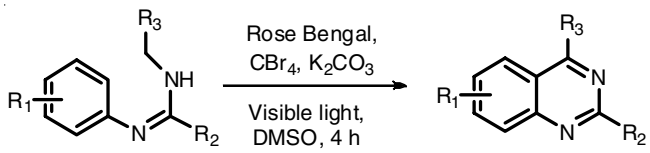
Scheme-LVII: Synthesis of aldehydes and 2-amino benzophenone under microwave heating conditions

benzylamines in H_2O, with isolated yields ranging from 43 to 78% (**Scheme-LVIII**). This method is the more cost-effective and sustainable due to the recrystallization of the crude reaction mixture for purification and the considerable solvent-consuming workup.

Imidazolate framework synthesis catalyzed by cobalt zeolite: Truong *et al.* [120] achieved excellent yields of quinazoline compounds by cyclizing benzylamines with 2-aminobenzoketones using a heterogeneous catalytic system (*via* ZIF-67) (**Scheme-LIX**). At 80 ºC, TBHP was demonstrated to have good reaction conditions as an oxidant in methylbenzene solvent. Furthermore, ZIF-67 functions as a catalyst in a system while regenerating or recycling much of its catalytic activity.

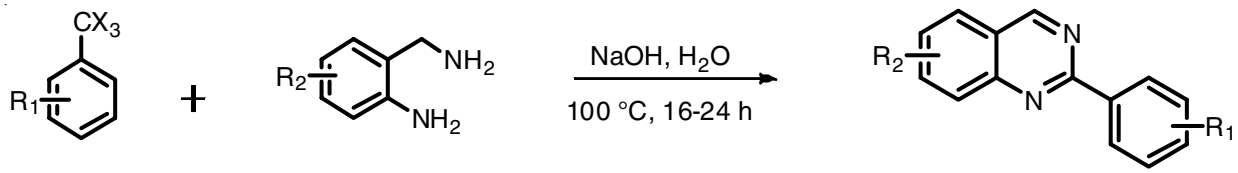
Synthesis using Lewis acid as catalyst: Deng *et al.* [121] proposed a method to synthesize quinazoline scaffolds under transition/catalytic-metal-free conditions using polyoxymethylene and *N*-phenyl-benzimidamides as carbon sources. The enhanced reaction state was well sustained with electron-rich and electron-deficient substituents on the aromatic ring, giving moderate to suitable yield of 45-92% (**Scheme-LX**). Transition/catalytic-metal-free reaction and medium settings are two of this approach's most appealing features. This novel method also provides a straightforward, ecologically benign and complementary method for producing 2-arylquinazoline scaffolds.

Photo-redox oxidative annulation assisted by visible light: The oxidative C(sp^2)-C(sp^3) bond formation in the synthesis of substituted quinazoline moiety from amidine derivatives using visible light (**Scheme-LXI**). This is a metal-free oxidative coupling with the help of a photo-redox catalytic device. Having a broad range of functional groups was found to be tolerated by the technique [122].

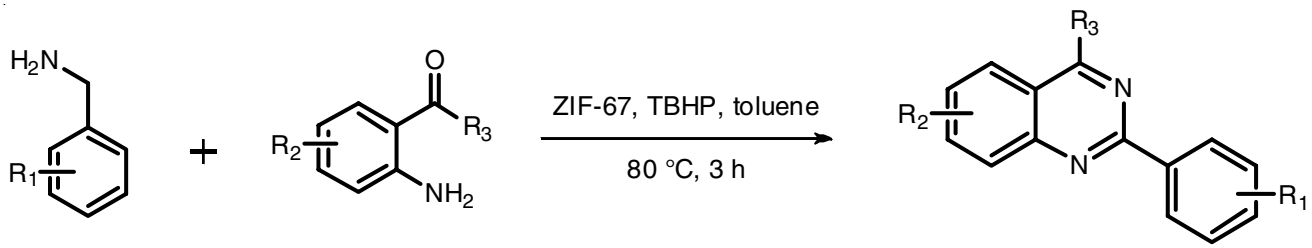


Scheme-LXI: Arylamide cyclization catalyzed by a photo-redox organocatalyst

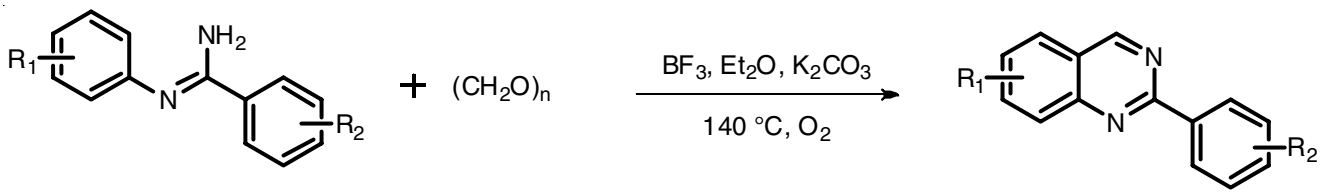
Carbonitrile or cyanamide-based metal-free oxidative annulation: North *et al.* [123] established a viable technique for synthesizing substituted 2-aminoquinazoline analogs in moderate to excellent yields from 2-amino benzophenone and 4-morpholine carbonitrile or cyanamide. This method is



Scheme-LVIII: Reaction of *o*-aminobenzylamines with α,α,α-trihalotoluenes in water to produce quinazoline derivatives



Scheme-LIX: ZIF-67 catalyzes the reaction of substituted benzylamines with 2-aminoacetophenones



Scheme-LX: Lewis acid-catalyzed reaction of polyoxymethylene with *N*-phenyl benzimidamide moiety

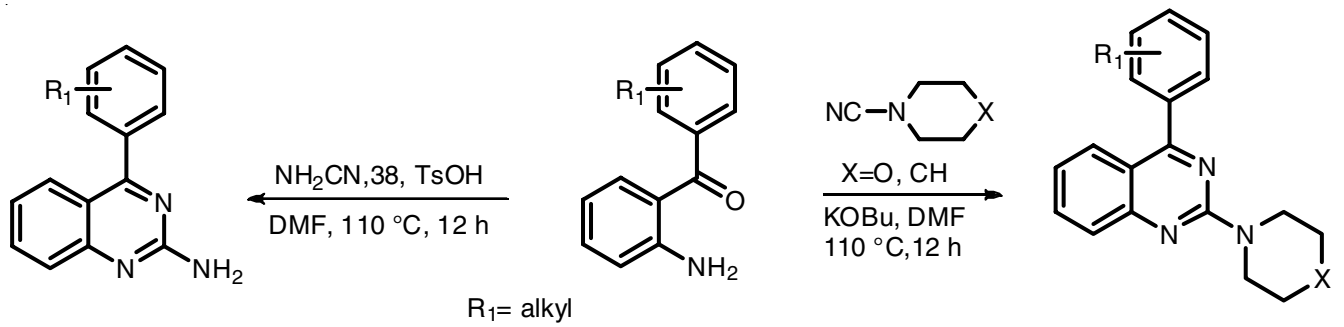
transition/catalytic metal-free and mild (**Scheme-LXII**), which enables the synthesis of bioactive substituted 2-aminoquinazoline analogs using a cyclic substituted amine or a free amine in DMF, ensuring atomic economics and biological properties.

Catalytic systems based on iron: Chen *et al.* [124] used 2-hydroperoxy-2-methylpropane (TBHP) as a terminal oxidant to demonstrate iron dichloride-catalyzed carbon-hydrogen oxidation and intramolecular carbon-nitrogen bond formation synthesize substituted quinazolines. Grignard reagent treatment of 2-alkylaminobenzonitrile produced 2-alkylamino N-H ketamines. The method had a wide range of 2,4-dialkyl/diaryl/alkyl-aryl disubstituted quinazoline analogs, ranging from 43 to 86% (**Scheme-LXIII**).

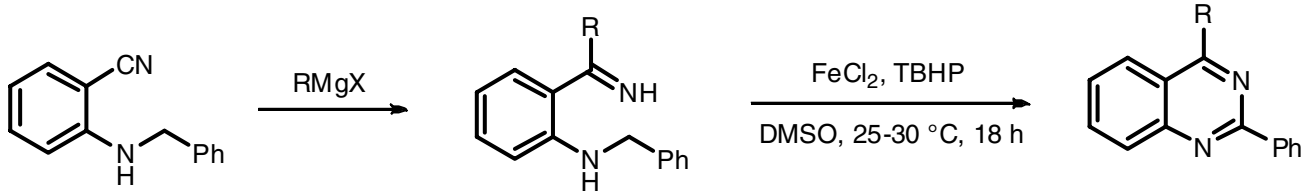
Gopalaiah *et al.* [125] used an iron(III)bromide-catalyzed one-pot cascade to make quinazoline analogs from 2-hydroxymethylanilines and aromatic amines in benzene chloride at 110 ºC for 12-14 h under aerobic oxidative conditions. The process starts with *N*-benzylidene benzylamine intermediate contraction, followed by ammonia intramolecular cyclization through oxidative trapping (**Scheme-LXIV**). In this method, both heteroaromatic and aromatic amines worked well, giving matching substituted quinazoline moiety in good to outstanding isolated yields of 61-94%. Since, the O_2 molecule was employed as an oxidant and inexpensive and plentiful iron salts were used as a catalyst, this conversion is exceptionally sustainable and practicable.

Using ultrasonication and ferric fluoride as a catalyst, Jeong & Shinde [126] reported a green and efficient method for synthesizing substituted quinazoline moiety from indazol-3-amine analog and aliphatic aldehydes (**Scheme-LXV**). Furthermore, without compromising the quinazoline, the catalytic system can regenerate and recycle for at least four cycles. Through a one-pot three-component reaction combining *o*-amino aryl ketone, ammonium acetate and aldehydes, a unique and effective method for manufacturing 2,4-disubstituted quinolines has been developed (**Scheme-LXVI**). Compatibility with a broad spectrum of functional groups, neutral conditions, atom economy and simple workup processes is advantageous [127].

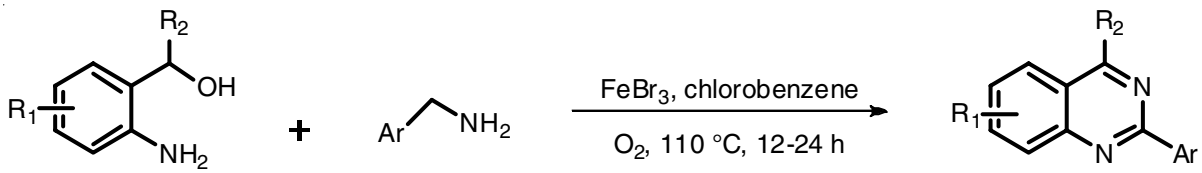
The benzylic Csp^3-H bond amination of 2-amino benzaldehyde, 2-aminobenzophenone or 2-aminobenzyl alcohol with phenylmethanamine was catalyzed by molecular iodine, resulting in moderate to high yields of the quinazoline moiety



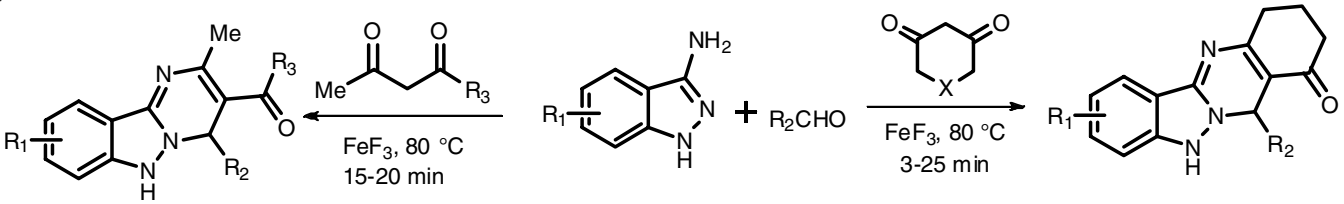
Scheme-LXII: Reaction of 2-Amino benzophenone with 4-morpholinecarbonitrile or cyanamide to form 4-morpholinecarbonitrile or cyanamide



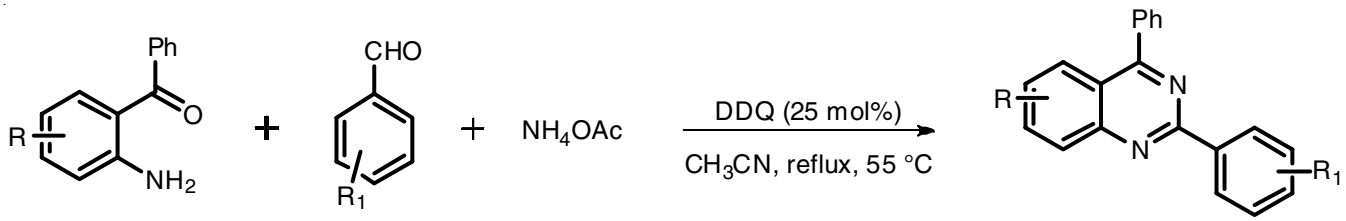
Scheme-LXIII: $FeCl_2$/TBHP mediates oxidative amination of 2-alkylamino N-H ketamines in DMSO



Scheme-LXIV: Reaction of 2-hydroxymethylanilines with benzylamines catalyzed by ferric bromide

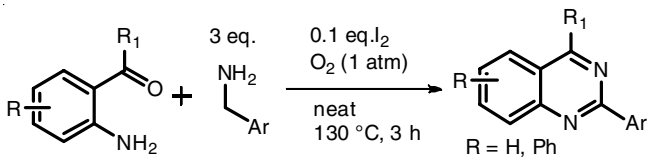


Scheme-LXV: Synthesis of high functionalized quinazolines using sonochemical ferric fluoride in a solvent-free environment

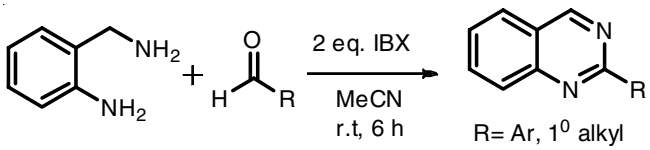


Scheme-LXVI: Synthesis of 2,4-disubstituted quinolones using one-pot three-component process

(**Scheme-LXVII**). Because of the oxidant O_2 molecules and the transition/catalytic metal, reagent and solvent-free conditions [128]. A mild *o*-iodoxybenzoic acid (IBX) mediated tandem reaction of widely accessible *o*-aminobenzylamine and aromatic/aliphatic aldehydes allows the synthesis of variously modified quinazolines, 2-alkyl quinazolines analog in good yields in the presence of acetonitrile at room temperature [129] (**Scheme-LXVIII**).



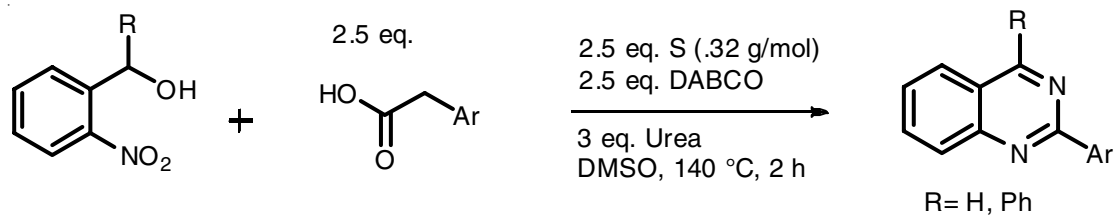
Scheme-LXVII: Amination of 2-amino benzaldehyde and 2-amino benzophenone with benzylamines catalyzed by molecular iodine



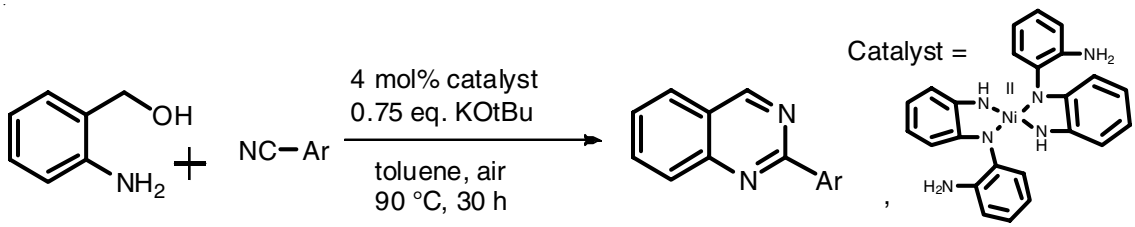
Scheme-LXVIII: Synthesis of quinazoline using *o*-aminobenzylamine and aldehydes

Substituted quinazolines are produced by condensation of substituted 2-nitrophenyl methanol with aryl acetic acid in urea as a nitrogen source, elemental sulphur as an activator, DABCO as base and DMSO as solvent (**Scheme-LXIX**). Fluoro, chloro thienyl, trifluoromethyl and indolyl groups are tolerated by the reaction [130]. Singlet diradical Ni(II) with two antiferromagnetically paired singlet diradical diamine type ligands catalyzes the direct atom-efficient synthesis of alkyl/aryl substituted quinolines 2-aminoquinolines and substituted quinazolines in moderate to good yields using toluene as solvent at 90 ºC *via* biomimetic dehydrogenative coupling/condensation reactions (**Scheme-LXX**) [131].

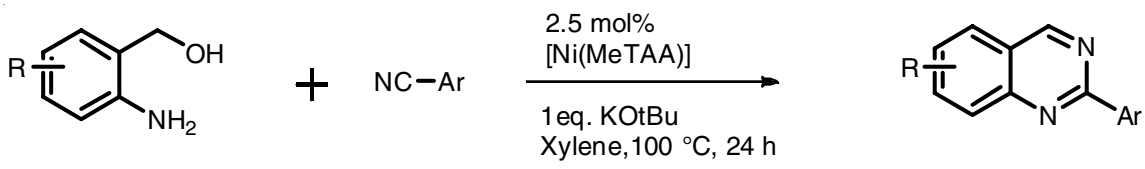
The modified synthesis of quinazolines was accomplished by combining benzyl alcohol with 2-aminobenzylamine and 2-aminobenzyl alcohol with benzonitrile in an accepting or less dehydrogenative manner. Nickel catalysts use low-cost, easy-to-make tetraaza macrocyclic ligands to catalyze the reactions (**Scheme-LXXI**). As a result, a broad range of modified quinazolines analogs with good yields was synthesized [132]. A highly selective reaction of dehydrogenation coupling in amines with a 2-aminophenyl ketone employing an *in situ* generated ruthenium catalyst allows the synthesis of quinazoline compounds. Quinazolinones were synthesized by combining 2-amino-



Scheme-LXIX: Synthesis of substituted quinazolines via condensation of 2-nitrophenyl methanol with aryl acetic acid



Scheme-LXX: Synthesis of quinazoline derivatives using Ni(II) complex as catalyst



MeTAA = Tetramethyltetraaza[14]annulene

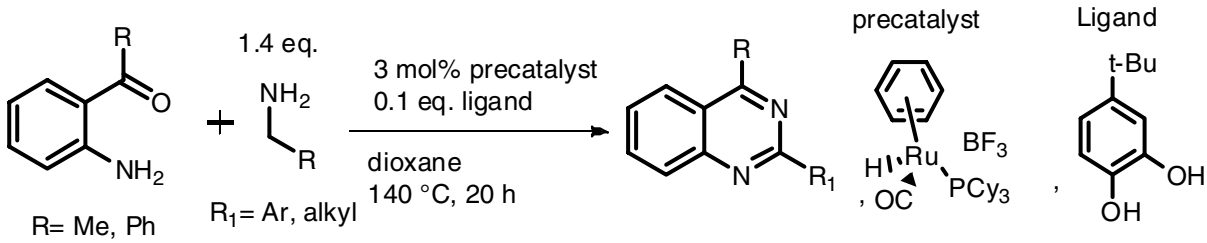
Scheme-LXXI: Synthesis of quinazoline compounds using [Ni(MeTAA)] as catalyst

benzamide with amines in a deaminative reaction (**Scheme-LXXII**) [133].

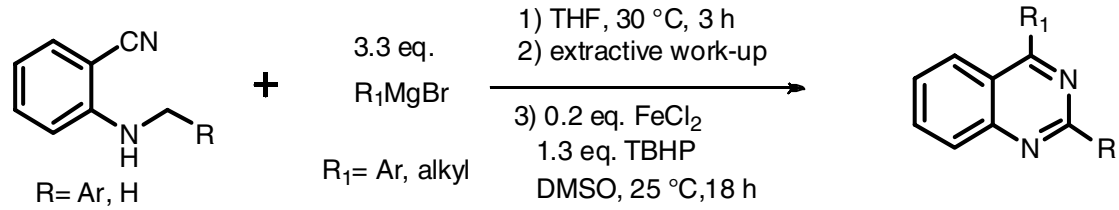
The efficient synthesis of quinazolines moiety using 2-alkylamino N-H ketamine analogs was produced by various organometallic reagents and DMSO as a solvent used in 2-alkylaminobenzonitriles is enabled Fe-catalyzed sp^3 hybridized carbon-hydrogen corrosion, intramolecular C-N bond formation, followed by aromatization (**Scheme-LXXIII**) [124]. A copper catalyzed formulation of benzonitriles with 2-ethynylanilines produced substituted quinazolines by cleaving the C-C triple bond link in two aromatic rings and generating new C=N and C-C bonds throughout the availability of oxygen molecules (O_2) act as the oxidant in reaction (**Scheme-LXXIV**) [134]. Anthranils catalyzed by Cu/Ag annulate 3-aryl-2*H*-azirines, yielding (quinazolin-2-yl)methanone moiety (**Scheme-LXXV**). The copper-catalyzed breakdown of both the N-C azirins link and the N-O bond in anthranil results in a 1,3-hydroxyl group migration followed by *N*-elimination [135]. A highly effective one-pot in DMF as a solvent synthesis of 4-aminoquinazoline derivatives from conveniently accessible 2-bromo or 2-iodobenzimidamides, sodium azide and aldehydes was accomplished using Cu-catalyzed ArSN substitution, followed by reduction with cyclization and oxidation followed by tautomerization (**Scheme-LXXVI**) [136].

Conclusion

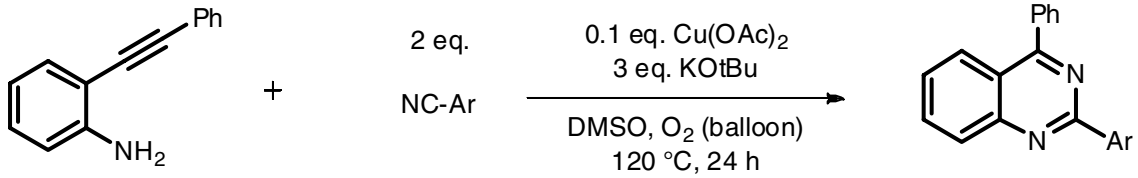
In recent decades, more emphasis has been placed on producing better medicines with fewer adverse effects. This



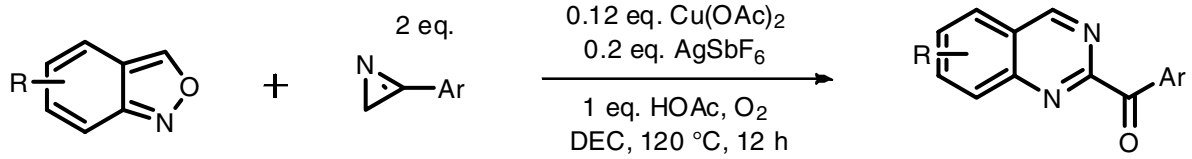
Scheme-LXXII: Synthesis of quinazoline derivatives using precatalyst and ligand



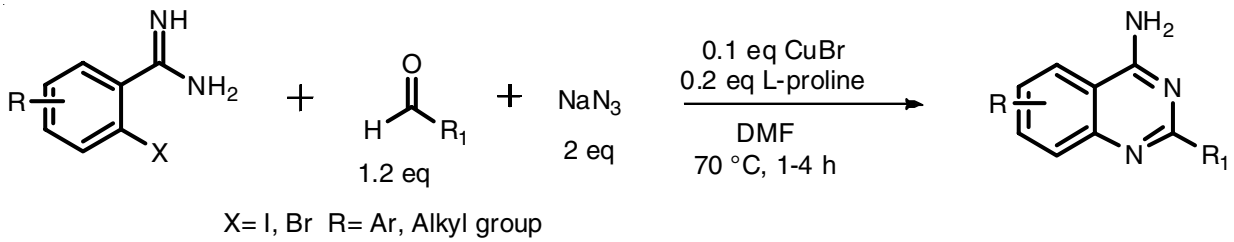
Scheme-LXXIII: Synthesis of quinazolines from 2-alkylamino N-H ketamine derivatives



Scheme-LXXIV: Synthesis of quinazoline derivatives using copper-catalyzed reaction of benzonitriles and 2-ethynylanilines



Scheme-LXXV: Annulation reaction of 3-aryl-2*H*-azirines



Scheme-LXXVI: Copper-catalyzed SNAr substitution for the synthesis of 4-aminoquinazoline

review article covers a wide range of synthetic techniques for 4(3*H*)-quinazolinone and quinazolinones analogs. The quinazoline moiety results in the formation of wide variety of products. The activity of quinazoline was determined by the substituent present at the favourable location. To emphasize the current advancement as in 4(3*H*)-quinazolinone analogs synthesis, a favoured analog mainly in the pharmaceutical chemistry for its medicinal potential managing various diseases. The complementarity of simple techniques aids the ability to build libraries of synthesized 4(3*H*)-quinazolinone variants. There is the possibility for future advancement when novel research in a related sector of medicinal chemistry is performed.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. Ambedkar College, Nagpur and RTM Nagpur University, Nagpur, for providing financial support under the Smruti Sanshodhan Fellowship.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

REFERENCES

1. M. Chand, A. Gupta and S.C. Jain, *Heterocycl. Lett.*, **1**, 201 (2017).
2. D. He, M. Wang, S. Zhao, Y. Shu, H. Zeng, C. Xiao, C. Lu and Y. Liu, *Fitoterapia*, **119**, 136 (2017); https://doi.org/10.1016/j.fitote.2017.05.001
3. P.M. Dewick, Medical Natural Products, John Wiley & Sons Ltd.: U.K., Ed.: 3, pp. 395-397 (2006).
4. P. Wiklund and J. Bergman, *J. Curr. Org. Syn.*, **3**, 379 (2006); https://doi.org/10.2174/157017906777934926
5. J.A. Patel, B.D. Mistry and K.R. Desai, *E.J. Chem.*, **3**, 97 (2006); https://doi.org/10.1155/2006/586512
6. F. Hassanzadeh, E. Jafari, G.H. Hakimelahi and M.R. Khajouei, *Res. Pharm. Sci.*, **7**, 87 (2012).
7. E. Manivannan and S.C. Chaturvedi, *Bioorg. Med. Chem.*, **19**, 4520 (2011); https://doi.org/10.1016/j.bmc.2011.06.019
8. F. Liu and Y. Huang, *Pestic. Biochem. Physiol.*, **101**, 248 (2011); https://doi.org/10.1016/j.pestbp.2011.10.002
9. S. Gabriel, *Ber.*, **36**, 800 (1903).
10. S.E. Abbas, F.M. Awadallah, N.A. Ibrahin, E.G. Said and G.M. Kamel, *Eur. J. Med. Chem.*, **53**, 141 (2012); https://doi.org/10.1016/j.ejmech.2012.03.050
11. G. Saravanan, V. Alagarsamy and C.R. Prakash, *Bioorg. Med. Chem. Lett.*, **22**, 3072 (2012); https://doi.org/10.1016/j.bmcl.2012.03.068
12. L. Zhu, J. Jin, C. Liu, C. Zhang, Y. Sun, Y. Guo, D. Fu, X. Chen and B. Xu, *Bioorg. Med. Chem.*, **19**, 2797 (2011); https://doi.org/10.1016/j.bmc.2011.03.058
13. K. Singh, P.P. Sharma, A. Kumar, A. Chaudhary and R.K. Roy, *Mini Rev. Med. Chem.*, **13**, 1177 (2013); https://doi.org/10.2174/1389557511313080006
14. J.P. Michael, *Nat. Prod. Rep*., **24**, 223 (2007); https://doi.org/10.1039/b612168n
15. J. Zhang, D. Zhu, C. Yu, C. Wan and Z. Wang, *Org. Lett.*, **12**, 2841 (2010); https://doi.org/10.1021/ol100954x
16. T.P. Selvam and P.V. Kumar, *Res. Pharm.*, **1**, 1 (2011).
17. A. Arora, A. Kapoor, N.S. Gill and A.C. Rana, *Int. Res. J. Pharm.*, **2**, 22 (2011).
18. S. Eguchi, Quinazoline Alkaloids and Related Chemistry, In: Bioactive Heterocycles I. Topics in Heterocyclic Chemistry, Springer, vol. 6, 113-156 (2006).
19. M. Kita and D. Uemura, Eds.: S. Eguchi, Bioactive Heterocyclic Alkaloids of Marine Origin, In: Bioactive Heterocycles I, Topics in Heterocyclic Chemistry, Springer, vol. 6, pp 157-179 (2006).
20. D. Wang and F. Gao, *Chem. Centr. J.*, **7**, 95 (2013); https://doi.org/10.1186/1752-153X-7-95
21. D. Gupta, R. Kumar, R.K. Roy, A. Sharma, I. Ali and M. Shamsuzzaman, *Med. Chem. Res.*, **22**, 3282 (2013); https://doi.org/10.1007/s00044-012-0293-6
22. V. Alagarsamy and G. Saravanan, *Med. Chem. Res.*, **22**, 1711 (2013); https://doi.org/10.1007/s00044-012-0169-9
23. M.M. Heravi, S. Sadjadi, N. Mokhtari Haj, H.A. Oskooie, R.H. Shoar and F.F. Bamoharram, *Tetrahedron Lett.*, **50**, 943 (2009); https://doi.org/10.1016/j.tetlet.2008.12.044
24. M. Wang, Z.G. Song and T.T. Zhang, *Chin. Chem. Lett.*, **21**, 1167 (2010); https://doi.org/10.1016/j.cclet.2010.05.021
25. B. Wang, Z. Li, X. Wang, J. Tan, L. Gu and Z. Huang, *Chin. Chem. Lett.*, **22**, 951 (2011); https://doi.org/10.1016/j.cclet.2011.01.034
26. M.T. Richers, C. Zhao and D. Seidel, *Beilstein J. Org. Chem.*, **9**, 1194 (2013); https://doi.org/10.3762/bjoc.9.135
27. N. Mulakayala, B. Kandagatla, Ismail, R.K. Rapolu, P. Rao, C. Mulakayala, C.S. Kumar, J. Iqbal and S. Oruganti, *Bioorg. Med. Chem. Lett.*, **22**, 5063 (2012); https://doi.org/10.1016/j.bmcl.2012.06.003
28. M. Sharif, J. Opalach, P. Langer, M. Beller and X.F. Wu, *RSC Adv.*, **4**, 8 (2014); https://doi.org/10.1039/C3RA45765F
29. J. Zhou and J. Fang, *J. Org. Chem.*, **76**, 7730 (2011); https://doi.org/10.1021/jo201054k
30. J. Fang and J. Zhou, *Org. Biomol. Chem.*, **10**, 2389 (2012); https://doi.org/10.1039/c2ob07178a
31. H. Hikawa, Y. Ino, H. Suzuki and Y. Yokoyama, *J. Org. Chem.*, **77**, 7046 (2012); https://doi.org/10.1021/jo301282n
32. H. Wang, X. Cao, F. Xiao, S. Liu and G.J. Deng, *Org. Lett.*, **15**, 4900 (2013); https://doi.org/10.1021/ol402350x
33. Y.F. Wang, F.L. Zhang and S. Chiba, *Org. Lett.*, **15**, 2842 (2013); https://doi.org/10.1021/ol4011745
34. F.L. Zhang, Y.F. Wang and S. Chiba, *Org. Biomol. Chem.*, **11**, 6003 (2013); https://doi.org/10.1039/c3ob41393d
35. K. Karnakar, J. Shangkar, S.N. Murthy, K. Ramesc, Y.V.D. Nageshwar, *Synlett.*, 1089 (2011); https://doi.org/10.1055/s-0030-1259960
36. T. Liu, C. Zhu, H. Yang and H. Fu, *Adv. Synth. Catal.*, **354**, 1579 (2012); https://doi.org/10.1002/adsc.201100951
37. B. Li, L. Samp, J. Sagal, C.M. Hayward, C. Yang and Z. Zhang, *J. Org. Chem.*, **78**, 1273 (2013); https://doi.org/10.1021/jo302515c
38. B. Ma, Y. Wang, J. Peng and Q. Zhu, *J. Org. Chem.*, **76**, 6362 (2011); https://doi.org/10.1021/jo2007362
39. J.E.R. Sadig, R. Foster, F. Wakenhut and M.C. Willis, *J. Org. Chem.*, **77**, 9473 (2012); https://doi.org/10.1021/jo301805d
40. H. Li, L. He, H. Neumann, M. Beller and X.F. Wu, *Green Chem.*, **16**, 1336 (2014); https://doi.org/10.1039/C3GC42089B
41. J. Alam, O. Alam, J. Naim and P. Alam, *Int. J. Adv. Res.*, **12**, 1656 (2015).
42. https://en.wikipedia.org/wiki/Quinazoline (accessed on Oct 27, 2017).
43. T. Besson, J. Guillard, C.W. Rees, *Tetrahedron Lett*., **41**, 1027 (2000); https://doi.org/10.1016/S0040-4039(99)02221-2
44. P.M. Chandrika, A.R.R. Rao and B. Narsaiah, *Int. J. Chem. Sci.*, **6**, 1119 (2008).
45. S.M.D. Noorulla, N. Sreenivasulu, A. Khan and A. Sayeed, *Int. J. Adv. Pharm. Sci.*, **2**, 229 (2011).
46. A.R. Desai and K.R. Desai, *ARKIVOC*, 98 (2005); https://doi.org/10.3998/ark.5550190.0006.d09

47. Y. Kabri, A. Gellis and P. Vanelle, *Green Chem.*, **11**, 201 (2009); https://doi.org/10.1039/B816723K
48. M.K. Kathiravan, R.R. Jalnapurkar, A.S. Chothe, T.S. Chitre, R.S. Tamboli and K.V. Srinivasan, *Green Sustain. Chem.*, **1**, 12 (2011); https://doi.org/10.4236/gsc.2011.11003
49. T. Sugimori, T. Okawa, S. Eguchi, E. Yashima and Y. Okamoto, *Tetrahedron*, **54**, 7997 (1998); https://doi.org/10.1016/S0040-4020(98)00437-2
50. J.A. Bleda, P.M. Fresneda, R. Orenes and P. Molina, *Eur. J. Org. Chem.*, **2009**, 2490 (2009); https://doi.org/10.1002/ejoc.200900082
51. X.H. Yang, M.H. Wu, S.F. Sun, M.W. Ding, J.L. Xie and Q.H. Xia, *J. Heterocycl. Chem.*, **45**, 1365 (2008); https://doi.org/10.1002/jhet.5570450518
52. M.M. Vögtle and A.L. Marzinzik, *QSAR Comb. Sci.*, **23**, 440 (2004); https://doi.org/10.1002/qsar.200420018
53. C. Xie, H.X. Li, M.G. Liu and M.W. Ding, *Chin. Chem. Lett.*, **19**, 505 (2008); https://doi.org/10.1016/j.cclet.2008.03.013
54. W.M. Welch, F.E. Ewing, J. Huang, F.S. Menniti, M.J. Pagnozzi, K. Kelly, P.A. Seymour, V. Guanowsky, S. Guhan, M.R. Guinn, D. Critchett, J. Lazzaro, A.H. Ganong, K.M. DeVries, T.L. Staigers and B.L. Chenard, *Bioorg. Med. Chem. Lett.*, **11**, 177 (2001); https://doi.org/10.1016/s0960-894x(00)00622-3
55. A. Kamal, E.V. Bharathi, M.J. Ramaiah, D. Dastagiri, J.S. Reddy, A. Viswanath, F. Sultana, S.N.C.V.L. Pushpavalli, M. Pal-Bhadra, H.K. Srivastava, G.N. Sastry, A. Juvekar, S. Sen and S. Zingde, *Bioorg. Med. Chem.*, **18**, 526 (2010); https://doi.org/10.1016/j.bmc.2009.12.015
56. J.F. Liu, J. Lee, A.M. Dalton, G. Bi, L. Yu, C.M. Baldino, E. McElory and M. Brown, *Tetrahedron Lett.*, **46**, 1241 (2005); https://doi.org/10.1016/j.tetlet.2005.01.008
57. J.F. Liu, P. Ye, B. Zhang, G. Bi, K. Sargent, L. Yu, D. Yohannes and C.M. Baldino, *J. Org. Chem.*, **70**, 6339 (2005); https://doi.org/10.1021/jo0508043
58. T. Güngör, Y. Chen, R. Golla, Z. Ma, J.R. Corte, J.P. Northrop, B. Bin, J.K. Dickson, T. Stouch, R. Zhou, S.E. Johnson, R. Seethala and J.H.M. Feyen, *J. Med. Chem.*, **49**, 2440 (2006); https://doi.org/10.1021/jm0509389
59. M.R. Yadav, S.T. Shirude, A. Parmar, R. Balaraman and R. Giridhar, *Chem. Heterocycl. Compd.*, **42**, 1038 (2006); https://doi.org/10.1007/s10593-006-0201-4
60. S. Boyapati, U. Kulandaivelu, S. Sangu and M.R. Vanga, *Arch. Pharm.*, **343**, 570 (2010); https://doi.org/10.1002/ardp.201000065
61. H.I. El-Sabbagh, G.S. Hassan, S.M.El-Messery, S.T. Al-Rashood, F.A.M. Al-Omary, Y.S. Abulfadl and M.I. Shabayek, *Eur. J. Med. Chem.*, **74**, 234 (2014); https://doi.org/10.1016/j.ejmech.2014.01.004
62. D. Gupta, R. Kumar, R.K. Roy, A. Sharma, I. Ali and M. Shamsuzzaman, *Med. Chem. Res.*, **22**, 3282 (2013); https://doi.org/10.1007/s00044-012-0293-6
63. V. Alagarsamy and G. Saravanan, *Med. Chem. Res.*, **22**, 1711 (2013); https://doi.org/10.1007/s00044-012-0169-9
64. A.R. Khosropour, I. Mohammadpoor-Baltork and H. Ghorbankhani, *Tetrahedron Lett.*, **47**, 3561 (2006); https://doi.org/10.1016/j.tetlet.2006.03.079
65. K. Ighilahriz, B. Boutemeur, F. Chami, C. Rabia, M. Hamdi and S.M. Hamdi, *Molecules*, **13**, 779 (2008); https://doi.org/10.3390/molecules13040779
66. M.M. Heravi, S. Sadjadi, N.M. Haj, H.A. Oskooie, R.H. Shoar and F.F. Bamoharram, *Tetrahedron Lett.*, **50**, 943 (2009); https://doi.org/10.1016/j.tetlet.2008.12.044
67. M.M. Heravi, S. Sadjadi, S. Sadjadi, H.A. Oskooie and F.F. Bamoharram, *Ultrason. Sonochem.*, **16**, 708 (2009); https://doi.org/10.1016/j.ultsonch.2009.02.010
68. M. Wang, Z.G. Song and T.T. Zhang, *Chin. Chem. Lett.*, **21**, 1167 (2010); https://doi.org/10.1016/j.cclet.2010.05.021
69. B. Wang, Z. Li, X. Wang, J. Tan, L. Gu and Z. Huang, *Chin. Chem. Lett.*, **22**, 951 (2011); https://doi.org/10.1016/j.cclet.2011.01.034
70. N. Saemian, O.K. Arjomandi and G. Shirvani, *J. Labelled Compd. Radiopharm.*, **52**, 453 (2009); https://doi.org/10.1002/JLCR.1658
71. M. Bakavoli, O. Sabzevari and M. Rahimizadeh, *Chin. Chem. Lett.*, **18**, 1466 (2007); https://doi.org/10.1016/j.cclet.2007.10.023
72. M. Bakavoli, A. Shiri, Z. Ebrahimpour and M. Rahimizadeh, *Chin. Chem. Lett.*, **19**, 1403 (2008); https://doi.org/10.1016/j.cclet.2008.07.016
73. C. Zhang, C.K. De, R. Mal and D. Seidel, *J. Am. Chem. Soc.*, **130**, 416 (2008); https://doi.org/10.1021/ja077473r
74. M.T. Richers, C. Zhao and D. Seidel, *Beilstein J. Org. Chem.*, **9**, 1194 (2013); https://doi.org/10.3762/bjoc.9.135
75. H. Hioki, K. Matsushita, S. Nakamura, H. Horiuchi, M. Kubo, K. Harada and Y. Fukuyama, *J. Comb. Chem.*, **10**, 620 (2008); https://doi.org/10.1021/cc800056c
76. N. Mulakayala, B. Kandagatla, Ismail, R.K. Rapolu, C. Mulakayala, P. Rao, C.S. Kumar, J. Iqbal and S. Oruganti, *Bioorg. Med. Chem. Lett.*, **22**, 5063 (2012); https://doi.org/10.1016/j.bmcl.2012.06.003
77. M. Sharif, J. Opalach, P. Langer, M. Beller and X.F. Wu, *RSC Adv.*, **4**, 8 (2014); https://doi.org/10.1039/C3RA45765F
78. J. Zhou and J. Fang, *J. Org. Chem.*, **76**, 7730 (2011); https://doi.org/10.1021/jo201054k
79. J. Fang and J. Zhou, *Org. Biomol. Chem.*, **10**, 2389 (2012); https://doi.org/10.1039/C2OB07178A
80. H. Hikawa, Y. Ino, H. Suzuki and Y. Yokoyama, *J. Org. Chem.*, **77**, 7046 (2012); https://doi.org/10.1021/jo301282n
81. H. Wang, X. Cao, F. Xiao, S. Liu and G.J. Deng, *Org. Lett.*, **15**, 4900 (2013); https://doi.org/10.1021/ol402350x
82. A. Servais, M. Azzouz, D. Lopes, C. Courillon and M. Malacria, *Angew. Chem., Int. Ed.*, **46**, 576 (2007); https://doi.org/10.1002/anie.200602940
83. M.H. Larrau, C. Courillon, C. Ollivier, E. Lacote, M. Malacria and L. Fensterbank, *J. Am. Chem. Soc.*, **132**, 4381 (2010); https://doi.org/10.1021/ja910653k
84. A. Beaume, C. Courillon, E. Derat and M. Malacria, *Chem. Eur. J.*, **14**, 1238 (2008); https://doi.org/10.1002/chem.200700884
85. Y.F. Wang, F.L. Zhang and S. Chiba, *Org. Lett.*, **15**, 2842 (2013); https://doi.org/10.1021/ol4011745
86. F.L. Zhang, Y.F. Wang and S. Chiba, *Org. Biomol. Chem.*, **11**, 6003 (2013); https://doi.org/10.1039/C3OB41393D
87. X. Liu, H. Fu, Y. Jiang and Y. Zhao, *Angew. Chem., Int. Ed.*, **48**, 348 (2009); https://doi.org/10.1002/anie.200804675
88. D. Yang, H. Fu, L. Hu, Y. Jiang and Y. Zhao, *J. Comb. Chem.*, **11**, 653 (2009); https://doi.org/10.1021/cc9000339
89. W. Xu, Y. Jin, H. Liu, Y. Jiang and H. Fu, *Org. Lett.*, **13**, 1274 (2011); https://doi.org/10.1021/ol1030266
90. T. Liu, C. Zhu, H. Yang and H. Fu, *Adv. Synth. Catal.*, **354**, 1579 (2012); https://doi.org/10.1002/adsc.201100951
91. X.D. Zhang, D.J. Ye, H.F. Sun, D.L. Guo, J. Wang, H. Huang, X. Zhang, H.L. Jiang and H. Liu, *Green Chem.*, **11**, 1881 (2009); https://doi.org/10.1039/B916124B
92. D. Guo, H. Huang, Y. Zhou, J. Xu, H. Jiang, K. Chen and H. Liu, *Green Chem.*, **12**, 276 (2010); https://doi.org/10.1039/B917010C
93. L. Yu, M. Wang, P. Li and L. Wang, *Appl. Organomet. Chem.*, **26**, 576 (2012); https://doi.org/10.1002/aoc.2902
94. L. Xu, Y. Jiang and D. Ma, *Org. Lett.*, **14**, 1150 (2012); https://doi.org/10.1021/ol300084v
95. B. Li, L. Samp, J. Sagal, C.M. Hayward, C. Yang and Z. Zhang, *J. Org. Chem.*, **78**, 1273 (2013); https://doi.org/10.1021/jo302515c

96. A. Schoenberg and R.F. Heck, *J. Am. Chem. Soc*., **96**, 7761 (1974); https://doi.org/10.1021/ja00832a024
97. Z. Zheng and H. Alper, *Org. Lett*., **10**, 829 (2008); https://doi.org/10.1021/ol7029454
98. F. Zeng and H. Alper, *Org. Lett*., **12**, 1188 (2010); https://doi.org/10.1021/ol902924x
99. F. Zeng and H. Alper, *Org. Lett*., **12**, 3642 (2010); https://doi.org/10.1021/ol101428v
100. B. Ma, Y. Wang, J. Peng and Q. Zhu, *J. Org. Chem*., **76**, 6362 (2011); https://doi.org/10.1021/jo2007362
101. J.E.R. Sadig, R. Foster, F. Wakenhut and M.C. Willis, *J. Org.Chem*., **77**, 9473 (2012); https://doi.org/10.1021/jo301805d
102. X.F. Wu, L. He, H. Neumann and M. Beller, *Chem. Eur. J*., **19**, 12635 (2013); https://doi.org/10.1002/chem.201302182
103. L. He, H. Li, H. Neumann, M. Beller and X.F. Wu, *Angew. Chem*., *Int. Ed*., **53**, 1420 (2014); https://doi.org/10.1002/anie.201308756
104. M.A. Omar, J. Conrad and U. Beifuss, *Tetrahedron*, **70**, 3061 (2014); https://doi.org/10.1016/j.tet.2014.02.066
105. M.K. Mckee, R.L. Mckee and R.W. Bost, *J. Am. Chem. Soc*., **69**, 184 (1947); https://doi.org/10.1021/ja01193a502
106. F.-R. Alexandre, A. Berecibar, R. Wrigglesworth and T. Besson, *Tetrahedron*, **59**, 1413 (2003); https://doi.org/10.1016/S0040-4020(03)00053-X
107. R.Z. Qiao, B.L. Xu and Y.H. Wang, *Chin. Chem. Lett*., **18**, 656 (2007); https://doi.org/10.1016/j.cclet.2007.04.036
108. I. Nouira, I.K. Kostakis, C. Dubouilh, E. Chosson, M. Iannelli and T. Besson, *Tetrahedron*., **49**, 7033 (2008); https://doi.org/10.1016/j.tetlet.2008.09.135
109. H.J. Hess, T.H. Cronin and S. Scriabine, *J. Med. Chem*., **11**, 130 (1968); https://doi.org/10.1021/jm00307a028
110. W. Szczepankiewicz, J. Suwinski and R. Bujok, *Tetrahedron*., **56**, 9343 (2000); https://doi.org/10.1016/S0040-4020(00)00899-1
111. I.R. Ager, D.R. Harrison, P.D. Kennewell and J.B. Taylor, *J. Med. Chem*., **20**, 379 (1968); https://doi.org/10.1021/jm00213a013
112. W.M. Welch, F.E. Ewing, J. Huang, F.S. Menniti, M.J. Pagnozzi, K. Kelly, P.A. Seymour, V. Guanowsky, S. Guhan, M.R.Guinn, D. Critchett, J. Lazzaro, A.H. Ganong, K.M. DeVries, T.L. Staigers and B.L. Chenard, *Bioorg. Med. Chem Lett*., **11**, 177 (2001); https://doi.org/10.1016/S0960-894X(00)00622-3
113. J. Bergman, A. Brynolf, B. Elman and E. Vuorinen, *Tetrahedron*, **42**, 3697 (1986); https://doi.org/10.1016/S0040-4020(01)87338-5
114. J. Dempcy, M.S. Searle, A.J. Maynard, H.E. Williams, *Bioorg. Mol. Chem*., **7**, 60 (1992).
115. M.G. Prasad, C.V. Lakshmi, N.K. Katari, R. Karpoormath and M. Pal, *Anticancer Agent Med Chem*., **19**, 2001 (2019); https://doi.org/10.2174/1871520619666190723151909
116. J. Chen, D. Chang, F. Xiao and G.J. Deng, *Green Chem*., **20**, 5459 (2018); https://doi.org/10.1039/C8GC02654H
117. K.H. Trinh, K.X. Nguyen, P.T.T. Nguyen, A.N.Q. Phan and N.T.S. Phan, *RSC Adv*., **10**, 29900 (2020); https://doi.org/10.1039/D0RA05040G
118. R. Sarma and D. Prajapati, *Green Chem*., **13**, 718 (2011); https://doi.org/10.1039/c0gc00838a
119. T. Chatterjee, D.I. Kim and E.J. Cho, *J. Org. Chem*., **83**, 7423 (2018); https://doi.org/10.1021/acs.joc.8b00327
120. T. Truong, T.M. Hoang, C.K. Nguyen, Q.T.N. Huynh and N.T.S. Phan, *RSC Adv*., **5**, 24769 (2015); https://doi.org/10.1039/C4RA16168H
121. X. Cheng, H. Wang, F. Xiao and G.J. Deng, *Green Chem.*, **18**, 5773 (2016); https://doi.org/10.1039/C6GC02319C
122. Z.C. Shen, P. Yang and Y. Tang, *J. Org. Chem.*, **81**, 309 (2016); https://doi.org/10.1021/acs.joc.5b02366
123. A.N. Pandya, E.M. Villa and E.J. North, *Tetrahedron Lett*., **58**, 1276 (2017); https://doi.org/10.1016/j.tetlet.2017.02.033
124. C. Chen, F. He, G. Tang, H. Yuan, N. Li, J. Wang and and R. Faessler, *J. Org. Chem.*, **83**, 2395 (2018); https://doi.org/10.1021/acs.joc.7b02943
125. K. Gopalaiah, A. Saini and A. Devi, *Org. Biomol. Chem*., **15**, 5781 (2017); https://doi.org/10.1039/c7ob01159h
126. V.V. Shinde and Y.T. Jeong, *Tetrahedron Lett.*, **57**, 3795 (2016); https://doi.org/10.1016/j.tetlet.2016.07.031
127. D.S. Bose and N. Ramesh, *Synth. Commun*., **50**, 1532 (2020); https://doi.org/10.1080/00397911.2020.1744014
128. D.S. Deshmukh and B.M. Bhanage, *Synlett*., **29**, 979 (2018); https://doi.org/10.1055/s-0037-1609200
129. S. Hati and S. Sen, *Synthesis*, **48**, 1389 (2016); https://doi.org/10.1055/s-0035-1560416
130. K.X. Nguyen, D.K. Nguyen, P.H. Phem, H.V. Le, T.T. Nguyen and N.T.S. Phan, *Synlett.*, **31**, 1112 (2020); https://doi.org/10.1055/s-0040-1707113
131. G. Chakraborty, R. Sikari, S. Das, R. Mondal, S. Sinha, S. Banerjee and N.D. Paul, *J. Org. Chem*., **84**, 2626 (2019); https://doi.org/10.1021/acs.joc.8b03070
132. S. Parua, R. Sikari, S. Singa, G. Chakraborty, R. Mondal and N.D. Paul, *J. Org. Chem.*, **83**, 11154 (2018); https://doi.org/10.1021/acs.joc.8b01479
133. P.T.K. Arachchige and C.S. Yi, *Org. Lett.*, **21**, 3337 (2019); https://doi.org/10.1021/acs.orglett.9b01082
134. X. Wang, D. He, Y. Huang, W. Wu, Q. Fan and H. Jiang, *J. Org. Chem.*, **83**, 5458 (2018); https://doi.org/10.1021/acs.joc.8b00378
135. Y. Sun, H. Sun, Y. Wang and F. Xie, *Org. Lett*., **22**, 6756 (2020); https://doi.org/10.1021/acs.orglett.0c02222
136. L. Yang, H. Luo, Z. Shi, Y. Sun, K. Ni, F. Li and D. Chen, *Synthesis*, **49**, 2535 (2017); https://doi.org/10.1055/s-0036-1588727