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3.3.1

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Criterion 3

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

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1	Implementation of Hybrid Cryptosystem Using Blowfish and RSA Algorithms	**Harshala B. Pethe**, Varsha C. Pande Dr. Subhash R. Pande	International Journal of Researches in Biosciences, Agriculture and Technology	BCA	No	1-4
2	Comparative Analysis of Various Classification Algorithms using Text Mining	V.C. Pande, **Harshala B. Pethe,** Dr. (Mrs.) Abha Khandelwal	International Journal of Researches in Biosciences, Agriculture and Technology (IJRBAT)	BCA	No	5-9
3	Novel aromatic polyketides from soil Streptomyces spp.: purification, characterization and bioactivity studies.	Bundale, S., **D. Begde**, D. Pillai, K. Gangwani, N. Nashikkar, T. Kadam, and A. Upadhyay	World Journal of Microbiology and Biotechnology	Biochemistry	Yes	**10-25**
4	Culturable rare actinomycetes from Indian forest soils: Molecular and physicochemical screening for biosynthetic genes.	Bundale, S., J. Singh, **D. Begde**, N. Nashikkar, and A. Upadhyay	Iranian Journal of Microbiology	Biochemistry	Yes	**26-36**
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8	Analysis of Groundwater Quality Parameters in Selected Villages of Arvi Region of Wardha District, Maharashtra, Research	**Dr. N. G. Telkapalliwar**	Research J. Engineering and Tech.	Chemistry	No	**48-50**
9	Adsorption of Phosphoric Acid on Pulses Husk Bio-Adsorbent and Verification of Freundlich And Langmuir Adsorption Isotherms	**V. M. Shivankar**	Bionano Frontier	Chemistry	Yes	**51-54**
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Implementation of Hybrid Cryptosystem Using BLOWFISH and RSA Algorithms

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ABSTRACT

An important data can be transferred through email, banking transaction and online purchase. Network security is an essential part to do such secured transactions and cryptography is the science that widely used for network security

This paper gives the implementation and analysis of hybrid cryptosystem using BLOWFISH and Rivest-Shamir-Adleman (RSA) algorithm. Blowfish is a symmetric block cipher and can be effectively used for encryption and safeguarding of data. It is suitable for applications where the key does not change often, like a communication link or an automatic file encryptor. RSA is an asymmetric key algorithm. In this algorithm two separate keys are used for encryption and decryption. The efficiency of the algorithm is measured by execution time. The program simulation result provides the better performance as well as security.

Keywords: Symmetric key cryptography, asymmetric key cryptography, encryption, decryption, BLOWFISH, RSA, Cryptographic algorithms.

1. INTRODUCTION

Cryptography is the science of keeping messages secret and widely used for network security. Cryptography means to transfer sensitive information across insecure networks such as internet. The goals of cryptography are confidentiality, integrity, authentication, and non repudiation [1] [2]. An original message is known as the plaintext, while the coded message is called the ciphertext. The process of converting from plaintext to ciphertext is called encryption; restoring the plaintext from the ciphertext is decryption.

Cryptography algorithms are either symmetric algorithms, which use symmetric keys (also called secret keys), or asymmetric algorithms, which use asymmetric keys (also called public and private keys) .

Symmetric Algorithms

Symmetric algorithms, sometimes called conventional algorithms, are algorithms where the encryption key can
be calculated from the decryption key and vice versa. These algorithms, also called secret-key algorithms, single key algorithms, or one-key algorithms, require that the sender and receiver agree on a key before they can communicate securely. The security of a symmetric algorithm rests in the key

Encryption and decryption with a symmetric algorithm are denoted by:

$E_K(M) = C$

$D_K(C) = M$

Symmetric algorithms can be divided into two categories. Some operate on the plaintext a single bit (or sometimes byte) at a time; these are called stream algorithms or stream ciphers. Others operate on the plaintext in groups of bits. The groups of bits are called blocks, and the algorithms are called block algorithms or block ciphers.

Public-Key Algorithms

Public-key algorithms are also called asymmetric algorithms and are designed so that the key used for encryption is different from the key used for decryption. The decryption key cannot be calculated from the encryption key. The algorithms are called "public-key" because the encryption key can be made public. Any person can use the encryption key to encrypt a message, but only a specific person with the corresponding decryption key can decrypt the message. In these systems, the encryption key is often called the public key, and the decryption key is often called the private key.

Encryption using public key K is denoted by:

$E_K(M) = C$

Even though the public key and private key are different, decryption with the corresponding private key is denoted by:

$D_K(C) = M$

In this paper we have done the comparative analysis of AES which is symmetric key algorithm and RSA, which is asymmetric key algorithm.

Blowfish is a symmetric block cipher designed by Brute Schneier in December 1993. Blowfish is a replacement of DES or IDEA. Blowfish algorithm is a symmetric block cipher with a 64-bit block size and variable key length from 32 bits to 448 bits [3].

RSA is asymmetric key algorithm developed in 1978. The simulation speed is fast different keys are used for encryption and decryption process. The power consumption of RSA algorithm is high[4].

2. GOALS OF CRYPTOGRAPHY

2.1 Confidentiality

Confidentiality means protection against unauthorized disclosure of information. It may be applied to whole messages, parts of messages, and even existence of messages. Confidentiality provides the protection of transmitted data from passive attacks.

2.2 Authentication

The process of proving one's identity. This includes verifying the message's source. Authentication is of two types: (i) Peer entity authentication, and (ii) Data origin authentication.

2.3 Data integrity

The integrity is an assurance that the message has not been modified. This can be applied to a stream of messages, a single message, or selected fields within a message. It assures that messages are received as sent, with no duplication, insertion, modification, reordering, or replays.

2.4 Access control

It is the ability to limit and control the access to host systems and applications via communications links. To achieve this, each entity trying to gain access must first be identified, or authenticated, so that access rights can be tailored to the individual.

2.5 Non repudiation

Sender or receiver cannot deny for a transmitted message. When a message is sent, the receiver can prove that the sender in fact sent the message [5][6].

3. OVERVIEW OF BLOWFISH

The expansion of the key: break the original key into a set of subkeys. Specifically, a key of no more than 448 bits is separated into 4168 bytes. There is a P-array and four 32-bit S-boxes. The P-array contains 18 32-bit subkeys, while each S-box contains 256 entries.

The encryption of the data: 64-bit input is denoted with an x, while the P-array is denoted with a Pi (where i is the iteration).

- The input is a 64-bit data element, x.
- Divide x into two 32-bit halves: XL, XR.
- Then, for i = 1 to 16.
- XL = XL XOR Pi
- XR = F(XL) XOR XR
- Swap XL and XR
- After the sixteenth round, swap XL and XR again to undo the last swap.
- Then, XR = XR XOR P17 and XL = XL XOR P18.
- Finally, recombine XL and XR to get the cipher text [7].

Blowfish is unpatented and license-free, and is available free for all uses. Blowfish Algorithm is a Feistel network, iterating a simple encryption function 16 times. The block size is 64 bits, and the key can be any length up to 448 bits. Although there is complex initialization phase required before any encryption can take place, the actual encryption of data is very efficient on large microprocessors [8].

4. OVERVIEW OF RSA

RSA is widely used in encrypted connection, digital certificates core algorithms. Public key algorithm invented in 1977 by Ron Rivest, Adi Shamir and Leonard Adleman (RSA).It is the main operation of RSA to compute modular exponentiation [9]. Especially, when RSA decrypts the cipher text and generates the signatures, more computation capacity and time will be required. Reducing modules in modular exponentiation is a technique to speed up the RSA decryption. The security of RSA comes from integer to find. Generation of random prime numbers gives the algorithm extra strength and efficiency.

Following steps are followed in RSA to generate the public and private keys [10]:

Step 1: Choose large prime numbers p and q such that

p not equal to q.

Step 2: Compute n=p*q

Step 3: Compute φ (pq) = (p-1)*(q-1)

Step 4: Choose the public key e such that

gcd (φ (n), e) =1; 1<e< φ (n)

Step 5: Select the private key d such that

d*e mod φ (n) =1

In RSA algorithm encryption and decryption are performed as-

Encryption:

Calculate cipher text C from plaintext message M such that

C=M ^e mod n

Decryption:

M=C^d mod n=M^ed mod n

HYBRID ALGORITHM

The hybrid algorithm using BLOWFISH-RSA is as follows:

Step 1: Input image

Step2: Encrypt original image using Blowfish algorithm.

Step 3: Encrypt encrypted image using RSA algorithm.

Step 4: Decrypt encrypted image using RSA algorithm

Step 5: Decrypt using Blowfish algorithm

Step 6: Stop.

5. EXPERIMENTAL RESULTS

The BLOWFISH and RSA algorithm is implemented using MATLAB 2013a. The time required for encryption and decryption is shown in the following table. The image files are taken from SVT dataset.

Table1: Encryption and decryption time using hybrid algorithm

Image File	Encryption Time for BLOWFISH	Encryption Time for RSA	Encryption Time for Hybrid algorithm
simg_1	6.7298	2.604	5.6928
simg_2	3.522	1.4834	2.79687
simg_3	4.4263	1.3884	3.5156
simg_4	4.3395	1.7571	3.5681
simg_5	2.4764	1.1496	3.4883
simg_6	4.7778	2.0446	3.9234
simg_7	4.4189	1.1389	6.8565
simg_8	4.7858	1.3789	6.2526
simg_9	3.9494	1.6731	3.5707
simg_10	4.7381	1.8306	3.4811

RSA algorithm is implemented using MATLAB2013a. The time required for encryption and decryption is shown in the following table with p=19 and q=23. The image files are taken from SVT dataset.

Table 2: Encryption and decryption time using RSA algorithm

Image File	Decryption Time for BLOWFISH	Decryption Time for RSA	Decryption Time for Hybrid algorithm
simg_1	4.1683	41.9616	3.9883
simg_2	3.984	19.1139	1.757
simg_3	4.4798	25.2828	2.3772
simg_4	4.5421	25.0157	2.3959
simg_5	2.56084	22.5839	2.32
simg_6	4.5084	27.6251	2.50723
simg_7	4.6812	26.5331	2.5698
simg_8	5.2663	31.3381	3.0367
simg_9	4.3673	24.3389	2.4913
simg_10	4.6239	25.5949	2.4673

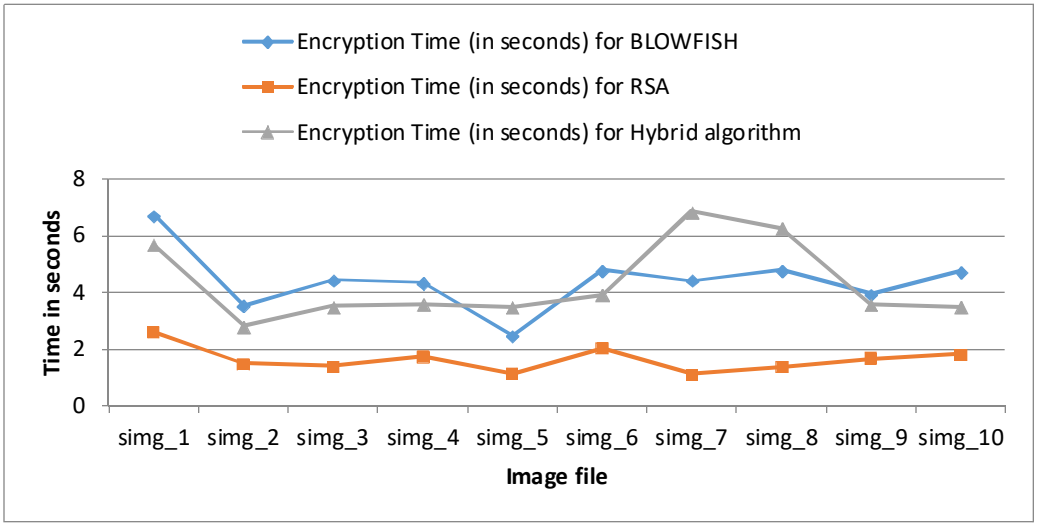

Figure 2: Encryption time for BLOWFISH, RSA and Hybrid algorithm

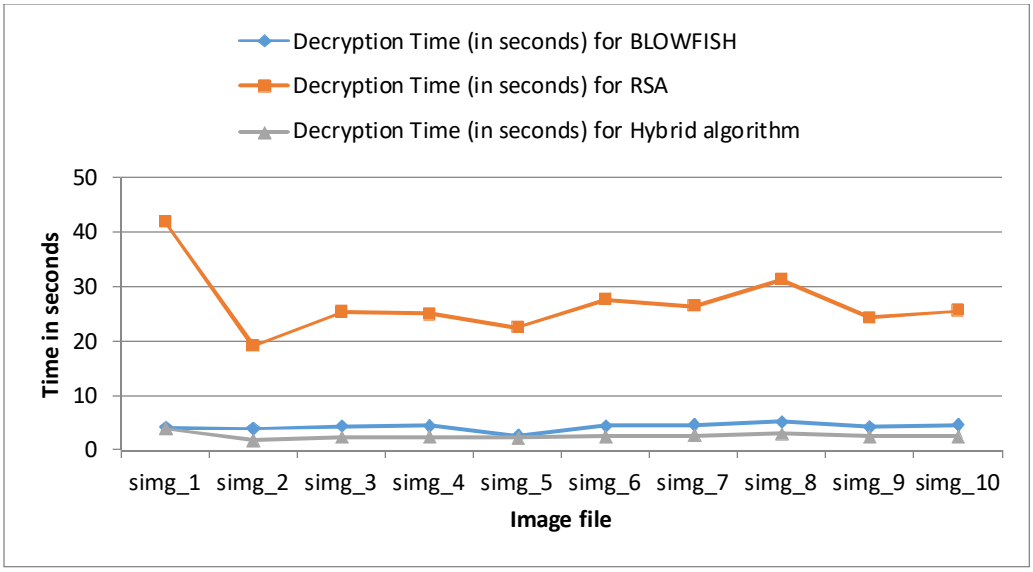

Figure 3: Decryption time for BLOWFISH, RSA and Hybrid algorithm

6. CONCLUSION

In this paper we have implemented the BLOWFISH and RSA algorithms and a hybrid algorithm (BLOWFISH-RSA) using MATLAB R2013a for different image files of increasing sizes, keeping key constant and it is observed that the time required for encryption for hybrid algorithm is less than BLOWFISH and greater than RSA but the time required for decryption for hybrid algorithm is less than both the algorithms. Therefore the hybrid algorithm is efficient in terms of time.

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Comparative Analysis of Various Classification Algorithms Using Text Mining

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Abstract
Classification of data has become an important research area. The process of classifying documents into predefined categories based on their content is Text classification. It is the automated assignment of natural language texts to predefined categories. The primary requirement of text retrieval systems is text classification, which retrieve texts in response to a user query, and text understanding systems, which transform text in some way such as answering questions, producing summaries or extracting data. In this paper we are studying the various classification algorithms. Classification is the process of dividing the data to some groups that can act either dependently or independently. Our main aim is to show the comparison of the various classification algorithms like K-nn, Naïve Bayes, Decision Tree, Random Forest and Support Vector Machine (SVM) with rapid miner and find out which algorithm will be most suitable for the users.

Keywords: Text Mining, K-nn, Naïve Bayes, Decision Tree, Random Forest and Support Vector Machine, Rapidminer.

INTRODUCTION

Text mining or knowledge discovery is that sub process of data mining, which is widely being used to discover hidden patterns and significant information from the huge amount of unstructured written material. Text mining is largely growing field of computer science simultaneously to big data and artificial intelligence. Text mining and data mining are similar, except data mining works on structured data while text mining works on semi-structured and unstructured data. Data mining is responsible for extraction of implicit, unknown and potential data and text mining is responsible for explicitly stated data in the given text [1]. Today's world can be described as the digital world as we are being dependent on the digital / electronic form of data. This is environment friendly because we are using very less amount of paper. But again this dependency results in very large amount of data. Even any small activity of human produces electronic data. For example, when any person buys a ticket online, his details are stored in the database. Today approx 80% of electronic data is in the form of text. This huge data is not only unclassified and unstructured (or semi-structured) but also contain useful data, useless data, scientific data and business specific data, etc. According to a survey, 33% of companies are working with very high volume of data i.e. approx. 500TB or more. In this scenario, to extract interesting and previously hidden data pattern process of text mining is used. Commonly, data are stored in the form of text. Broadly there are five steps involved in Text Data Mining. They are:

1. Text Gathering
2. Text Pre-processing
3. Data Analysis (Attribute generation & selection)
4. Visualization (Applying Text Mining algorithms)
5. Evaluation

For this text mining uses techniques of different fields like machine learning, visualization, case-based reasoning, text analysis, database technology statistics, knowledge management, natural language processing and information retrieval [2].

TEXT PRE-PROCESSING

The pre-processing itself is made up of a sequence of steps. The first step in text-pre-processing is the morphological analyses. It is divided into three subcategories: tokenization, filtering and stemming [3].

- TOKENIZATION: Text Mining requires the words and the endings of a document. Finding words and separating them is known as tokenization.
- FILTERING: The next step is filtering of important and relevant words from our list of words which were the output of tokenization. This is also called stop words removal.
- STEMMING: The third step is stemming. Stemming reduces words variants to its root form. Stemming of words increases the recall and precision of the information retrieval in Text Mining. The main idea is to improve recall by automatic handling of word endings by reducing the words to their word roots, at the time of indexing and searching. Stemming is usually done by removing any attached suffixes and prefixes (affixes) from index terms before the actual assignment of the term to the index.

CLASSIFICATION

Classification is a supervised learning technique which places the document according to content. Text classification is largely used in libraries. Text classification or Document categorization has several application such as call center routing, automatic metadata extraction, word sense disambiguation, e-mail forwarding and spam detection, organizing and maintaining large catalogues of Web resources, news articles categorization etc. For text classification many machine learning techniques has been used to evolve rules (which helps to assign particular document to particular category) automatically [1].

Text classification (or text categorization) is the assignment of natural language documents to predefined categories according to their content. Text classification is the act of dividing a set of input documents into two or more classes where each document can be said to belong to one or multiple classes. Huge growth of information flows and especially the explosive growth of Internet promoted growth of automated text classification [4].

CLASSIFICATION METHODS

1. Decision Trees

Decision tree methods rebuild the manual categorization of the training documents by constructing well-defined true/false queries in the form of a tree structure where the nodes represent questions and the leaves represent the corresponding category of documents. After having created the tree, a new document can easily be categorized by putting it in the root node of the tree and let it run through the query structure until it reaches a certain leaf. The main advantage of decision trees is the fact that the output tree is easy to interpret even for persons who are not familiar with the details of the model [5].

2. k-Nearest Neighbor

The categorization itself is usually performed by comparing the category frequencies of the k nearest documents (neighbors). The evaluation of the closeness of documents is done by measuring the angle between the two feature vectors or calculating the Euclidean distance between the vectors. In the latter case the feature vectors have to be normalized to length 1 to take into account that the size of the documents (and, thus, the length of the feature vectors) may differ. A doubtless advantage of the k-nearest neighbor method is its simplicity.

3. Bayesian Approaches

There are two groups of Bayesian approaches in document categorization: Naïve [6] and non-naive Bayesian approaches. The naïve part of the former is the assumption of word independence, meaning that the word order is irrelevant and consequently that the presence of one word does not affect the presence or absence of another one. A disadvantage of Bayesian approaches [7] in general is that they can only process binary feature vectors.

4. Neural Networks

Neural networks consist of many individual processing units called as neurons connected by links which have weights that allow neurons to activate other neurons. Different neural network approaches have been applied to document categorization problems. While some of them use the simplest form of neural networks, known as perceptions, which consist only of an input and an output layer, others build more sophisticated neural networks with a hidden layer between the two others.

The advantage of neural networks is that they can handle noisy or contradictory data very well. The advantage of the high flexibility of neural networks entails the disadvantage of very high computing costs. Another disadvantage is that neural networks are extremely difficult to understand for an average user [4].

5. Vector-based Methods

There are two types of vector-based methods. The centroid algorithm and support vector machines. One of the simplest categorization methods is the centroid algorithm. During the learning stage only the average feature vector for each category is calculated and set as centroid-vector for the category. A new document is easily categorized by finding the centroid-vector closest to its feature vector. The method is also inappropriate if the number of categories is very large. Support vector machines (SVM) need in addition to positive training documents also a certain number of negative training documents which are untypical for the category considered.

An advantage of SVM [8] is its superior runtime-behavior during the categorization of new documents because only one dot product per new document has to be computed. A disadvantage is the fact that a document could be assigned to several categories because the similarity is typically calculated individually for each category.

PERFORMANCE EVALUATION

- **Precision**: exactness – what % of tuples that the classifier labeled as positive are actually positive

Precision = TP/(TP+FP)

- **Recall:** completeness – what % of positive tuples did the classifier label as positive?

recall=TP/(TP+FN)

- Perfect score is 1.0.
- Inverse relationship between precision & recall.
- *F* **measure (***F1* or *F***-score)**: harmonic mean of precision and recall,

F=2×(*precision* × *recall)/ (precision* + *recall)*

IMPLEMENTATION

In this study, many classification algorithms have been implemented on two data sets i.e. Tokens dataset and Mini News Group dataset both are publically available datasets, And the performance of this algorithm has been analyzed by the Text Mining tool RAPIDMINER.

We are applying five algorithms i.e. K-NN, Naïve Bayes, Decision Tree, Random Forest and Support Vector Machine (SVM) in Mini NewsGroup dataset and the following results are shows in figure1, figure2, figure3, figure4 and figure5 respectively.

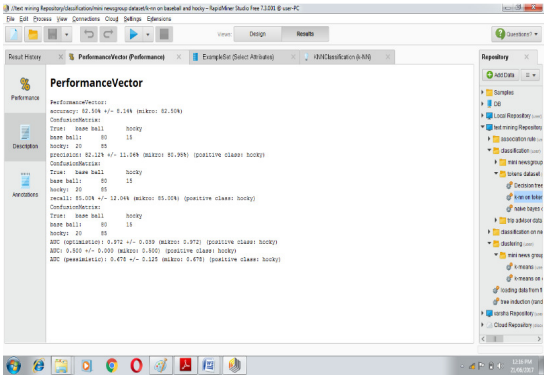

Figure 1: K-NN algorithm on Mini Newsgroup dataset.

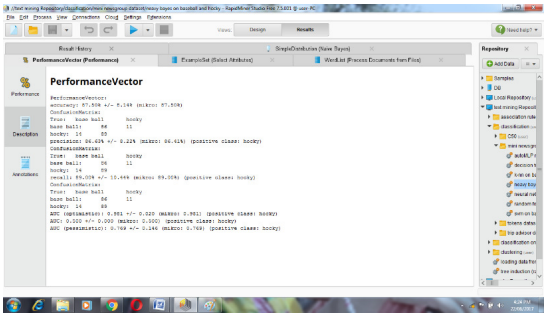

Figure 2: : Naïve Bayes algorithm on Mini Newsgroup dataset

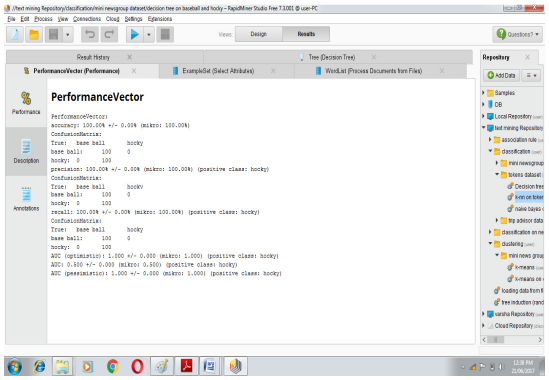

Figure 3: Decision tree algorithm on Mini Newsgroup dataset.

Similarly, We are applying five algorithms i.e. K-NN, Naïve Bayes, Decision Tree, Random Forest and Support Vector Machine (SVM) in Tokens dataset and the following results are shows in figure6, figure7, figure8, figure9 and figure10 respectively.

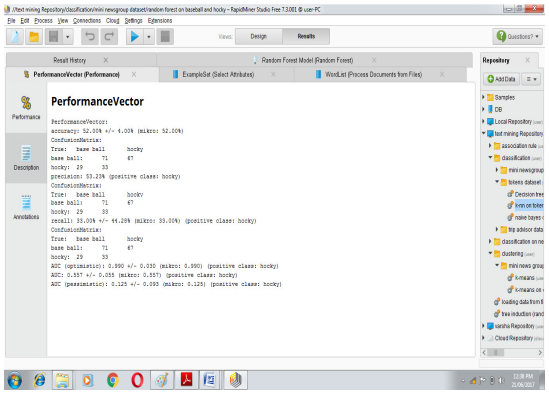

Figure 4: Random Forest algorithm on Mini Newsgroup dataset

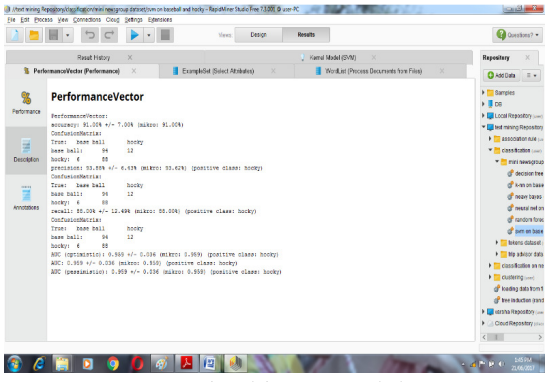

Figure 5: SVM algorithm on Mini Newsgroup dataset

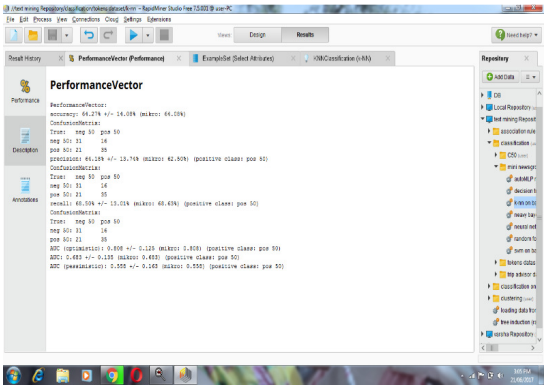

Figure 6: K-NN algorithm on Tokens dataset

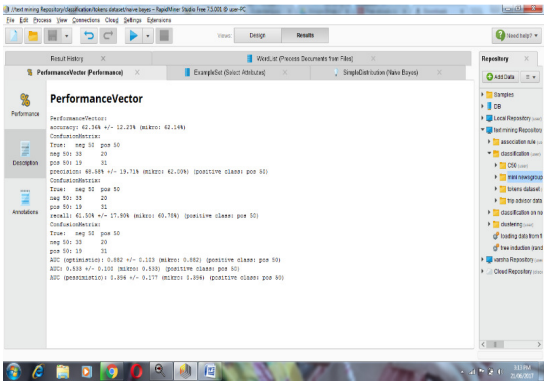

Figure 7: Naïve Bayes algorithm on Tokens dataset

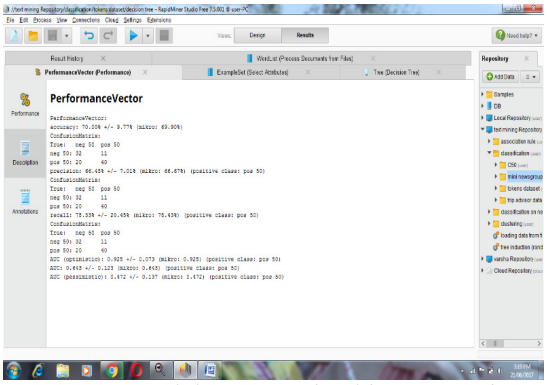

Figure 8: Decision tree algorithm on Tokens dataset

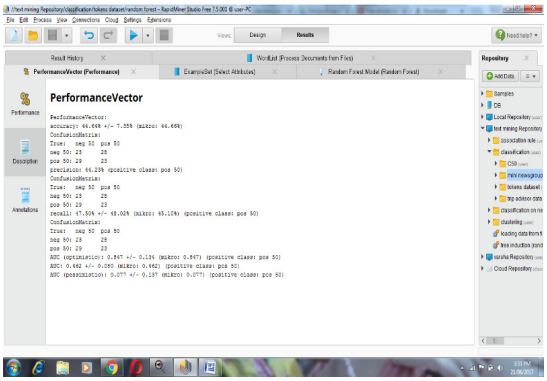

Figure 9: K-NN algorithm on Tokens dataset

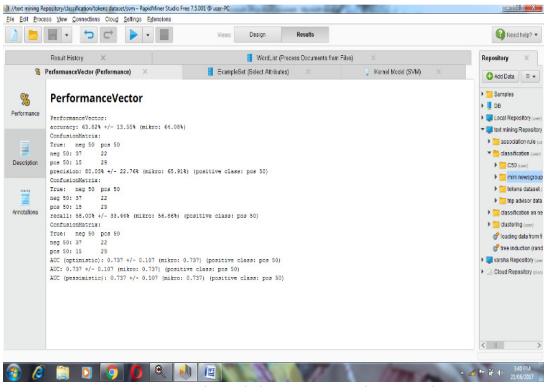

Figure 10: SVM algorithm on Tokens dataset

The following table shows the results for Mini NewsGroup Dataset and Tokens Dataset.

Results For Mini NewsGroup Dataset

Algorithms	**Accuracy**	**Precision**	**Recall**	**Execution Time(sec)**
K-NN	82.50%	82.12%	85.00%	42
Naïve Bayes	87.50%	86.63%	89.90%	26
Decision Tree	100.00%	100.00%	100%	36
Random Forest	52.00%	53.23%	33.00%	4:32
SVM	91.00%	93.86%	88.00%	1:22

Results For Tokens Dataset

Algorithms	Accuracy	Precision	Recall	Execution Time (sec)
K-NN	64.27%	64.18%	68.50%	40
Naïve Bayes	62.36%	68.58%	61.50%	51
Decision Tree	70.00%	66.45%	78.33%	1:10
Random Forest	44.64%	44.23%	47.50	10:27
SVM	63.82%	80.03%	58.00%	52

CONCLUSION

Text mining techniques are mainly used in medicals, banking, insurances, education etc. The classification algorithms K-NN, Naïve Bayes, Decision Tree, Random Forest and SVM have their own importance and we use them on the behavior of the two datasets that are Mini NewsGroup and Tokens, but on the basis of this research we found that Decision tree classification algorithm is simplest algorithm as compared to other algorithms.

The different classification algorithms are studied and implemented using **RAPIDMINER**. The implementation results show the values for Accuracy, Precision and Recall. The overall results for the entire algorithms are shown in tables based on datasets i.e. Table1 and Table 2. The Decision Tree algorithm is better than other algorithms on both the datasets. The Overall Performance of all the algorithms is better for **Mini NewsGroup Dataset** rather than **Tokens dataset.**

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ORIGINAL PAPER

Novel aromatic polyketides from soil *Streptomyces* spp.: purification, characterization and bioactivity studies

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Abstract
Aromatic polyketides are important therapeutic compounds which include front line antibiotics and anticancer drugs. Since most of the aromatic polyketides are known to be produced by soil dwelling *Streptomyces*, 54 *Streptomyces* strains were isolated from the soil samples. Five isolates, R1, B1, R3, R5 and Y8 were found to be potent aromatic polyketide producers and were identified by 16S rRNA gene sequencing as *Streptomyces spectabilis, Streptomyces olivaceus, Streptomyces purpurascens, Streptomyces coeruleorubidus* and *Streptomyces lavendofoliae* respectively. Their sequences have been deposited in the GenBank under the accession numbers KF468818, KF681280, KF395224, KF527511 and KF681281 respectively. The *Streptomyces* strains were cultivated in the media following critically optimised culture conditions. The resulting broth extracts were fractionated on a silica gel column and preparative TLC to obtain pure compounds. The pure compounds were tested for bioactivity and the most potent compound from each isolate was identified by UV–Vis, IR and NMR spectroscopic methods. Isolated *S. spectabilis* (R1), yielded one potent compound identified as dihydrodaunomycin with an MIC of 4 µg/ml against *Bacillus cereus* and an IC_{50} value of 24 µM against HeLa. *S. olivaceus* (B1), yielded a comparatively less potent compound, elloramycin. *S. purpurascens* (R3) yielded three compounds, rhodomycin, epelmycin and obelmycin. The most potent compound was rhodomycin with an MIC of 2 µg/ml against *B. cereus* and IC_{50} of 15 µM against HeLa. *S. coeruleorubidus* (R5), yielded daunomycin showing an IC_{50} of 10 µM and also exhibiting antimetastatic properties against HeLa. *S. lavendofoliae* (Y8), yielded a novel aclacinomycin analogue with IC_{50} value of 2.9 µM and potent antimetastatic properties at 1 µM concentration against HeLa. The study focuses on the characterization of aromatic polyketides from soil *Streptomyces* spp., which can serve as potential candidates for development of chemotherapeutic drugs in future.

Keywords *Streptomyces* · Anthracyclines · Anticancer · Aromatic polyketides

Introduction

Streptomyces are aerobic, Gram-positive, filamentous, soil dwelling bacteria which belong to the order *Actinomycetales* within the class *Actinobacteria* (Anderson and Wellington 2001).These bacteria with exceptional metabolic diversity are a rich source of several useful bioactive natural products, such as polyketides (Arifuzzaman et al. 2010; Holkar et al. 2013b). Polyketides are pharmacologically very important and are considered second to penicillins in terms of their importance as naturally derived medicines. Aromatic polyketides consist of a large group of structurally diverse natural products which include tetracyclines, anthracyclines (e.g., daunorubicin), aureolic acids (e.g., mithramycin), tetracenomycins, angucyclines (e.g., jadomycin, pradimicin), and benzisochromanequinones (e.g., actinorhodin and frenolicin). They exhibit a broad range of biological activities such as antibacterial, antifungal, antitumor and antiviral activities and afford some of the most common antibiotics and anticancer drugs currently in clinical use.

The commonly used anticancer drugs are: daunomycin and doxorubicin as preferred antineoplastic agents; adriamycin for treatment of breast cancer, Hodgkin's

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lymphoma, lung cancer, multiple myeloma, and recurring ovarian cancer; mithramycin for treating Paget's disease, chronic myelogenous leukemia and advanced testicular carcinoma; epirubicin, a less cardiotoxic doxorubicin analogue for treating sarcomas, breast and gastric cancer; idarubicin, for acute myeloid leukemia; and valrubicin, for the intravesical treatment of bladder cancer (Kummar et al. 2006; Kizek et al. 2012). However, a major problem with their clinical use, in addition to adverse common side effects like myelosuppression, nausea and vomiting, mouth ulcers, local aggressivity and alopecia, is their cardiotoxicity, gastrointestinal, hepatic, and bone marrow toxicity (Rahman et al. 2007). Similarly, the biggest problem hampering the use of the current antimicrobial drugs in use like tetracyclines, macrolides and aminoglycosides is the development of resistance to them leading to the emergence of MDR strains. Nevertheless, despite an extensive list of available anticancer and antimicrobial compounds, new compounds that are more effective, less toxic and possessing broader activity are still required.

Most known aromatic polyketides are produced by *Streptomyces* (Hertweck et al. 2007). A systematic screening program was undertaken with the aim of isolating *Streptomyces* species producing novel aromatic polyketides. Fifty-four *Streptomyces* strains were isolated from the soil samples collected from in and around Nagpur, India. Five isolates, R1, B1, R3, R5 and Y8 were found to be potent aromatic polyketide producers and were selected for further studies (Bundale et al. 2014). The microscopic, morphological, biochemical and physiological characterization strongly suggested that the isolates belong to the genus *Streptomyces*. Furthermore, these strains were identified by 16S rRNA gene sequencing as *Streptomyces spectabilis, Streptomyces olivaceus, Streptomyces purpurascens, Streptomyces coeruleorubidus* and *Streptomyces lavendofoliae* and their sequences were deposited in the GenBank under the accession numbers KF468818, KF681280, KF395224, KF527511 and KF681281 respectively.

The current study involves the purification and characterization of the bioactive aromatic polyketides from the crude antibiotic complexes of the five selected isolates and the evaluation of their antimicrobial and anticancer properties.

Materials and methods

Chemicals and media

All chemicals and solvents were of analytical grade and purchased from Merck, Germany and culture media from Himedia, Mumbai, India. Standard doxorubicin was obtained from Sigma-Aldrich (St. Louis, MO, USA).

Test organisms

The target strains used for screening antimicrobial activity were procured from microbial type culture collection and gene bank (IMTECH, Chandigarh, India) and were: *Bacillus cereus* MTCC 430, *Escherichia coli* MTCC 443, *Candida albicans* MTCC 227, and *Aspergillus niger* MTCC 282. The cell lines were purchased from NCCS, Pune, India.

Cultivation and organic extraction

For each of the selected isolates, sterile media optimized in an earlier study (Bundale et al. 2015) were used for growth in a rotary shaker incubator (REMI CIS-24 BL) at 130 rpm at 28 °C for 10 days. Crude antimicrobial compound was recovered from the mycelium as well as culture filtrate of each bioactive isolate by solvent extraction with ethyl acetate (1:1 v/v). The solvent was evaporated to dryness in a vacuum concentrator to obtain the crude cell and broth extracts which were stored at − 20 °C until further use.

Purification of the bioactive components

The dried crude extract was dissolved in ethyl acetate and 100–500 µl was loaded over the silica gel column. A stepwise gradient of chloroform /methanol was applied and the fractions thus separated were collected.

Preparative thin layer chromatography with Silica gel plate 60 F_{254} was used for the partial purification of antimicrobial products. The crude extracts were spotted and developed in different solvent systems. The solvent systems used were SS1: chloroform:petroleum ether:methanol (10:10:3), SS2: benzene:acetone:methanol (100:10:1), SS3: methanol:chloroform:acetic acid:water (80:20:2:0.2), SS4: chloroform:methanol:aq ammonia (25%) (85:14:1), SS5: chloroform:methanol (8:2) and SS6: chloroform:benzene:ethyl acetate:acetic acid (40:40:15:5), SS7: chloroform:methanol (9:1), SS8: chloroform:methanol:acetic acid:water (80:20:16:6), SS9: chloroform:methanol (15:1), SS10: chloroform:methanol (10:1) (Yoshimoto et al. 1980; Batel et al. 1990; Johdo et al. 1991; Saito et al. 1995; Dickens et al. 1997). The developed plates were air dried and the separated bands were detected by observations of the color of the bands. The TLC was repeated several times and the mean R*f* of the bands was calculated. The fractions were physically separated from each other by scraping the bands from the plates, extracting with methanol, concentrating the extracts

and again subjecting each concentrate to TLC using the same solvent system, thereby confirming the purity of each fraction (Johdo et al. 1991; Kim et al. 1996).

Identification and structural elucidation

Qualitative determination of aglycone and sugar residues by TLC

To an aliquot of the purified fraction, 0.5 ml of 0.1 N HCl was added and was heated at 85 °C for 30 min in a water bath. The pigment aglycone thus obtained was extracted with chloroform. The chloroform layer was evaporated to dryness and the residue was chromatographed on a Silica gel plate 60 F_{254} in SS9 solvent system. The identity of aglycones was determined by comparing their R*f* values and colors on the TLC plate with that of the standards (Holkar et al. 2013b; Johdo et al. 1991).

The aqueous layer containing sugar components was neutralized by adding silver carbonate with a small amount of charcoal and centrifuged. The supernatant fluid was concentrated in vacuo and chromatographed on TLC Silica gel plate 60 F_{254} in butanol:acetic acid:H_2O (4:1:1). The sugar spots were detected with *p*-anisaldehyde—H_2SO_4 (each 5%) in 90% ethanol spray reagent followed by heating at 90° (Yoshimoto et al. 1980; Saito et al. 1995; Johdo et al. 1991).

Spectral studies

The UV–visible absorption spectra (190–1100 nm) of the purified fractions were determined to identify the chromophores present in the metabolites by using a double beam Bio-spectrophotometer (BL-198, Elico Ltd.) (Silverstein et al. 2014). Furthermore, FT-IR spectrum of each active extract was obtained (as KBr discs) between 400 and 4000 cm^{-1} on Perkin Elmer 2000 FT-IR spectrophotometer and plotted as intensity versus wave number (Augustine et al. 2005). ^1H NMR spectra of the purified bioactive compounds was measured using a Bruker AMX 300 Coupling constants (*J*) in Hz. The software, ChemDraw was used for predicting the ^1H NMR spectra of the suspected compounds and the predicted spectra were compared with that of the physically determined ^1H NMR spectra (Workman 2000).

Antimicrobial activity

The antimicrobial activity of the pure compounds was assessed by the agar well diffusion method using Mueller–Hinton agar for antibacterial (Roe et al. 2003) and Potato Dextrose Agar for anti-fungal assays.

15 µl of 1 mg/ml stock extracts were used for the tests. The diameter of the inhibition zones was determined after 24 h of incubation at 37 °C for bacteria and 28 °C for fungi. The minimum inhibitory concentrations (MICs) of the bioactive compounds were determined via a microdilution method using sterile 24-well plates with tetracycline as a standard (Arthington-Skaggs et al. 2002).

MTT-based cytotoxicity assay

The cytotoxicity of bioactive fractions on established cell lines like HeLa cervical cell line and mouse fibroblast cell line L929 was determined in vitro (Mosmann 1983; Begde et al. 2011; Wang et al. 2015). Freshly passaged subconfluent HeLa cells were centrifuged and washed with HBSS. The cell count was adjusted to 2.5×10^5 cells/ml by suspending the cells in fresh DMEM with 10% FBS. This cell suspension (200 µl) was then transferred to a 96-well TC plate for the assay and a monolayer was developed at 37 °C for 24 h. Thereafter, the spent medium was discarded and the adherent cells were exposed to a concentration gradient of each purified fraction supplemented in the medium to obtain a final concentration of 2.5, 5, 10, 15, 20, 25, 30 and 35 µM respectively. The plate was incubated at 37 °C in a humidified environment with 5% CO_2 in air for 48 h. After incubation the cells were washed and resuspended in fresh medium containing MTT and were further incubated for 3 h. The MTT formazan produced by the viable cells was extracted in DMSO and quantified at 570 nm in the Bio-Rad ELISA plate reader.

Anti-metastatic efficacy by scratch/in vitro wound healing assay

Anti-metastatic activity of the purified compounds, was analyzed by wound healing assay (Liang et al. 2007). HeLa cells were seeded in 24-well tissue culture plates and cultured in DMEM containing 10% FBS to confluent cell monolayers, which were then carefully wounded using sterile 200 µl micropipette tips and any cell debris was removed with PBS. The cells were then exposed to sub inhibitory concentration of the purified compounds dissolved in the growth medium containing 5% FBS for 24 h at 37 °C (Gebäck et al. 2009). The extent of cell migration and wound healing was determined by using T-scratch analysis software (http://www.cselab.ethz.ch/software.html).

Statistical analysis

For MIC, values were expressed as average of four independent replicates ± SD and for MTT based cytotoxicity assay as an average of eight replicates ± SD. Student's *t* test was performed using SYSTAT Software (Systat Software Inc., Chicago, IL, USA). *P* value ≤ 0.05 was considered significant unless otherwise mentioned. For in vitro wound

healing assay, values were expressed as mean of four replicates ± SD.

Results

Five aromatic polyketide producing *Streptomyces* strains, R1, B1, R3, R5 and Y8 were selected on the basis of prescreening results. The following sections describe the characterization of the most potent bioactive compounds produced by the respective organisms followed by bioactivity studies.

Characterization of the aromatic polyketides produced by isolated *Streptomyces* spp.

The antibiotic complexes from all five producer organisms were purified using silica gel adsorption column chromatography followed by preparative TLC. The purified fractions were named R1A, R1B, R1C, R1D, R1E and R1F for isolate R1. A similar numbering scheme was used for all bioactive fractions obtained from their respective organisms. The solvent system used, and the color, R*f*'s and λmax of the fractions obtained from each organism are given in the Table 1. On acid hydrolysis, followed by TLC analysis, the purified fractions separated into aglycones and corresponding sugar components, the details of which are summarized in Table 2.

Identification of compound R1D

Compound R1D, obtained as a red colored compound, on acid hydrolysis yielded the corresponding aglycone whose R*f* was found to be 0.25 in the solvent system chloroform:methanol (20:1). The sugar on direct comparison of R*f* on TLC with the standard was found to be daunosamine. Compound R1D resolved as one single sharp red band with an R*f* of 0.63 in the solvent system SS8. The UV visible spectra showed prominent peaks at 292, 334, 472 and 537 nm (Fig. 1a). The IR (KBr) spectra showed prominent peaks at 3351, 2945, 2832, 1449, 1116 and 1028 (cm^{-1}) (Fig. 1c). The chemical shifts shown by the proton NMR of R1D were δ 4.4 (CH tetrahydronaphthlene), δ 1.99–2.4 (CH_2), δ 3.12–3.37 (CH_2), δ 5.0 (aromatic OH), δ 4.8 (CH_2), δ 3.6–3.8 (tetrahydropyran), δ 4.8 (CH), δ 1.21 (CH_3), δ 2.0 (NH2), δ 3.73 (methyl) (Fig. 1d).

Identification of compound B1B

Compound B1B was obtained as a dark yellow compound which was insoluble in water and soluble in chloroform and acetone. B1B showed a sharp orange-yellow band with an R*f* of 0.69 in SS7. On acid hydrolysis, compound B1B dissociated into an aglycone with an R*f* of 0.45, which is the reported R*f* of elloramycinone. The sugar residue was found to be rhamnose on comparison with standard rhamnose. The IR (KBr) spectra showed prominent peaks at 3619, 3045, 1561, 1361, 1286 and 1182 cm^{-1} (Fig. 2c). The ^1H NMR of B1B is shown in Fig. 2d. The shifts seen in the aglycone part were δ 5.0 (H), δ 3.80 (–OCH_3), δ 3.14 (–OH), δ 8.01 (H), δ 7.15 (H), δ 2.90 (–CH_3) and in the sugar residue attached to the chromophore were at δ 3.77, δ 3.24, δ 3.59, δ 1.21 and δ 4.11.

Identification of compound R3E

Compound R3E was found to contain β-rhodomycinone (β-RMN) as the aglycone and L-rhodosamine as the sugar on the basis of R*f* and UV–Vis spectra. Also the UV–Vis spectrum of R3E was found to have λmax at 297, 492 and 561 nm (Fig. 3a). The IR (KBr) spectra showed characteristic peaks at 3394, 2292, 1736, 1577, 1490, 1458 and 1190 cm^{-1} (Fig. 3c). The chemical shifts shown by the proton NMR of R3E were δ 7.02–δ 7.38 (Benzene), δ 4.2(CH tetrahydronaphthlene), δ 1.72–1.97 (CH_2), δ 5.0(aromatic OH), δ 1.44(CH_2), δ 1.66–1.95 (tetrahydropyran), δ 2.81–3.55 (tetrahydropyran), δ 4.8(CH), δ 1.21 (CH_3), δ 2.27(CH_3) and δ 3.73 (CH_3) (Fig. 3d).

Identification of the compound R5F

18.8 mg of the compound R5F was obtained, which was orange red in color and on treatment with 0.5% magnesium acetate changed color from orange-red to violet. Acid hydrolysis of this compound liberated the aglycone, daunomycinone and the sugar daunosamine.

The UV–Vis spectra of the standard daunomycin and R5F showed the same peaks at 292, 421, 472 and 517. A comparison of their spectra is shown in Fig. 4a. The IR (KBr) spectra of R5F showed prominent peaks at 3431, 2949, 2837, 1645, 1474, 1288, 1118, 1068 and 1018 (cm^{-1}) and that of the standard daunomycin showed peaks at 3351, 2982, 2945, 2863, 2832, 1655, 1452, 1208, 1116 and 1032 (cm^{-1}). From the similarity in the two IR spectra, it can be concluded that R5F is very similar to daunomycin (Fig. 4b).

Using the software ChemDraw, the NMR spectra of daunomycin was predicted. The spectra showed shifts at δ 7.06–7.44 (3 aromatic protons), δ 1.99 and δ 2.24 (CH_2,1,2,3,4 tetrahydronaphthalene), δ 3.12 and 3.37 (CH_2,1,2,3,4 tetrahydronaphthalene), 5 δ (aromatic OH), δ 2.09 (CH_3), δ 3.13–3.86 (tetrahydropyran), δ 2 (NH_3), 1.21 and δ 3.73 (CH_3). These shifts could also be seen in the NMR spectra of compound R5F (Fig. 4d).

Table 1 R*f* values and UV–Vis λmax of fractions of the isolates

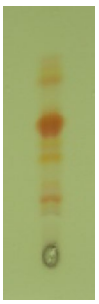
Isolates	Solvent system	Fractions	R*f* of the fractions	Color		λmax
Isolate R1	SS6	A	0.90	Light pink		277, 487, 532
		B	0.66	Yellow		222, 272
		C	0.57	Orange		272, 540
		D	0.34	Red		417, 535
		E	0.30	Pink		273, 532
		F	0.24	Violet		267, 532
Isolate B2	SS7	A	0.77	Yellow		292, 416, 452
		B	0.69	Orange		292, 422, 503
		C	0.55	Blue		245, 262
		D	0.22	Brown		288, 419, 458
Isolate R3	SS4	A	0.88	Red		284, 492, 522
		B	0.80	Orange		297, 492
		C	0.79	Reddish orange		237, 495, 522
		D	0.68	Yellowish orange		287, 437
		E	0.62	Orange		297, 492
		F	0.48	Pink		297, 497
		G	0.17	violet		

Table 1 (continued)

Isolates	Solvent system	Fractions	R*f* of the fractions	Color	λmax
Isolate R5	SS6	A	0.92	Purple 	292, 492
		B	0.85	Yellow	270, 293, 490
		C	0.71	Pink	257, 292, 492
		D	0.53	Yellowish brown	257, 387
		E	0.38	Yellowish orange	242, 492, 525
		F	0.23	Orange	256, 419, 472, 517
Isolate Y8	SS10	A	0.47	Dark yellow 	247,379,422,445
		B	0.23	Pale yellow	242, 377, 417, 437

SS4—chloroform:methanol:aq ammonia (25%) (85:14:1), SS6—chloroform:benzene:ethyl acetate:acetic acid (40:40:15:5), SS7—chloroform:methanol (9:1), SS10—chloroform:methanol (10:1)

Identification of the compound Y8A

The dark yellow band with an R*f* of 0.11 in chloroform:methanol (20:1) afforded 54 mg of the pure compound Y8A. Y8A on acid hydrolysis, yielded a yellow aglycone and two sugar moieties. The yellow aglycone on the basis of R*f* and UV–Vis spectra was found to be aklavinone. The sugars on the basis of R*f* and color reactions on TLC were found to be daunosamine and deoxyfucose. Thus this compound is a daunosaminyl deoxyfucosyl aklavinone, which may be a new aclacinomycin analogue. The UV–Vis spectra showed prominent peaks at 311, 423 and 444 nm (Fig. 5a). The IR (KBr) spectra exhibited prominent peaks at 3048, 2949, 2849, 2775, 1737, 1654, 1585 and 1004 cm^{-1} (Fig. 5c). The ^{1}H NMR showed chemical shifts at δ 4.8, δ 3.3, δ 2.2, δ 1.8–2.0 (CH_2), δ 1.3 (CH_3), δ 2.0 (NH_2) as seen in aclacinomycins.

Table 3 summarizes the physicochemical properties of the most potent purified compounds obtained from all the five isolates.

Antimicrobial and antitumor activity

Antimicrobial activity

Compounds R1A and R1B did not exhibit any activity against *B. cereus*, whereas R1C–R1F showed good activity with zones of inhibition in the range of 4–8 mm. Though isolate R1 was found to possess antifungal activity in preliminary screening by cross streak method, subsequent secondary screening results with *C. albicans* and *A. niger* were negative. The MIC of R1C and R1D against *B. cereus* were found to be 10 and 4 µg/ml, respectively, while those for R1E and R1F were both 8 µg/ml. The pure compounds of isolate B1 failed to show any appreciable antifungal activity against *C. albicans* and *A. niger*. Also no antibacterial activity was observed against *B. cereus*. All the pure compounds obtained from isolate R3 were found to exhibit antibacterial activity against *B. cereus*, the most potent being R3A and R3E with zones of inhibition of 7 and 9 mm respectively.

Table 2 Preliminary identification of the components obtained from each isolate

Isolate	Fractions	Aglycones		Sugars			Compound predicted
		Rf[a]	Aglycone detected	Rf[b]	Color	Sugar detected	
Isolate R1	A	0.33	7-Deoxydihydrodaunomycinone	ND			ND
	B	0.70	7-Deoxyaklavinone	0.34	Sky blue	Daunosamine	Daunosaminyl 7-deoxyaklavinone
	C	0.79	ε RMN	0.34	Sky blue	Daunosamine	Rhodomycin D
				0.71		Rhodinose	
				0.56	Grayish blue	2-Deoxy-L-fucose	
	D	0.25	Dihydrodaunomycinone	0.34	Sky blue	Daunosamine	Di hydrodaunomycin
	E	0.58	13-Deoxydaunomycinone	0.34	Sky blue	Daunosamine	13-Deoxydaunomycin
				0.71		Rhodinose	
				0.56	Grayish blue	2-Deoxy-L-fucose	
	F	0.43	β Iso RMN	0.34	Sky blue	Daunosamine	Antibiotic DCP-2
Isolate B2	A	0.45	Elloramycinone	0.36	Brown	Rhamnose	ETME
	B	0.45	Elloramycinone	0.36	Brown	Rhamnose	Elloramycin
	C	0.43	Tetracenomycinone	–			Tetracenomycin C
	D	ND					ND
Isolate R3	A	0.27	α_2-RMN	0.56	Grayish blue	2-Deoxy-L-fucose	α_2-Rhodomycin II
	B	0.45	β RMN	0.56	Grayish blue	L-Rhodosamine 2-Deoxy-L-fucose	Rhodomycin
	C	0.79	ε RMN	0.56	Grayish blue	2-Deoxy-L-fucose	Epelmycin B
	D	0.67	Aklavinone	0.12	Sky blue	L-Rhodosamine	Aclacinomycin A
				0.56	Grayish blue	2-Deoxy-L-fucose	
	E	0.45	β-RMN	0.12	Sky blue	L-Rhodosamine	Rhodomycin A or B
				0.56	Grayish blue	2-Deoxy-L-fucose	
	F	0.59	γ-Iso RMN	0.12	Sky blue	L-Rhodosamine	Obelmycin
				0.56	Grayish blue	2-Deoxy-L-fucose	
	G	0.27	α_2-RMN	0.12	Sky blue	L-Rhodosamine	Alldimycin B
				0.56	Grayish blue	2-Deoxy-L-fucose	
Isolate R5	A	0.45	ε-RMN	0.34	Sky blue	Daunosamine	Rhodomycin D
	B	0.90	ND	0.34	Sky blue	Daunosamine	ND
	C	0.73	7-Deoxyaklavinone	0.34	Sky blue	Daunosamine	7-Deoxyaklavin
	D	0.61	4-*o*-Methyl aklavinone	0.56	Grayish blue	2-Deoxy-L-fucose	ND
	E	0.57	10-Decarbomethoxy aklavinone	0.34	Sky blue	Daunosamine	10-Decarbomethoxyaklavin
	F	0.59	Daunomycinone	0.34	Sky blue	Daunosamine	Daunomycin
Isolate Y8	A	0.48	Aklavinone	0.34	Sky blue	Daunosamine	Aclacinomycin
				0.56	Grayish blue	2-Deoxy-L-fucose	
	B	0.32	Deoxyaklavinone	0.34	Sky blue	Daunosamine	Deoxyaklavin

Except R3E, which showed a very weak antibacterial activity against *E. coli*, no other compound showed any activity against *E. coli*. The MIC of R3A and R3F against *B. cereus* was observed to be > 20 µg/ml, whereas that of R3E was found to be an impressive 2 µg/ml. Of all the compounds obtained from isolate R5, R5F proved to be the most potent with a zone of inhibition of 8 mm against *B. cereus* and an MIC of 8 µg/ml. R5A and R5B were observed to have an MIC > 40 µg/ml. None of the compounds showed any activity against *E. coli*.

Y8A proved to be highly potent with a zone of inhibition of 18 mm against *B. cereus* whereas Y8B was much less potent with a zone of a meagre 7 mm. However the MIC of both Y8A and Y8B was observed to be > 40 µg/ml. Neither of them showed any activity against *E. coli*. Y8A showed a huge zone of 20 mm against *C. albicans*.

In vitro antitumor activity

In vitro antitumor activity of the bioactive compounds was judged by MTT based cytotoxicity assay against an established human cervical cancer cell line, HeLa and compared with that of a normal established mouse fibroblast cell line L929.

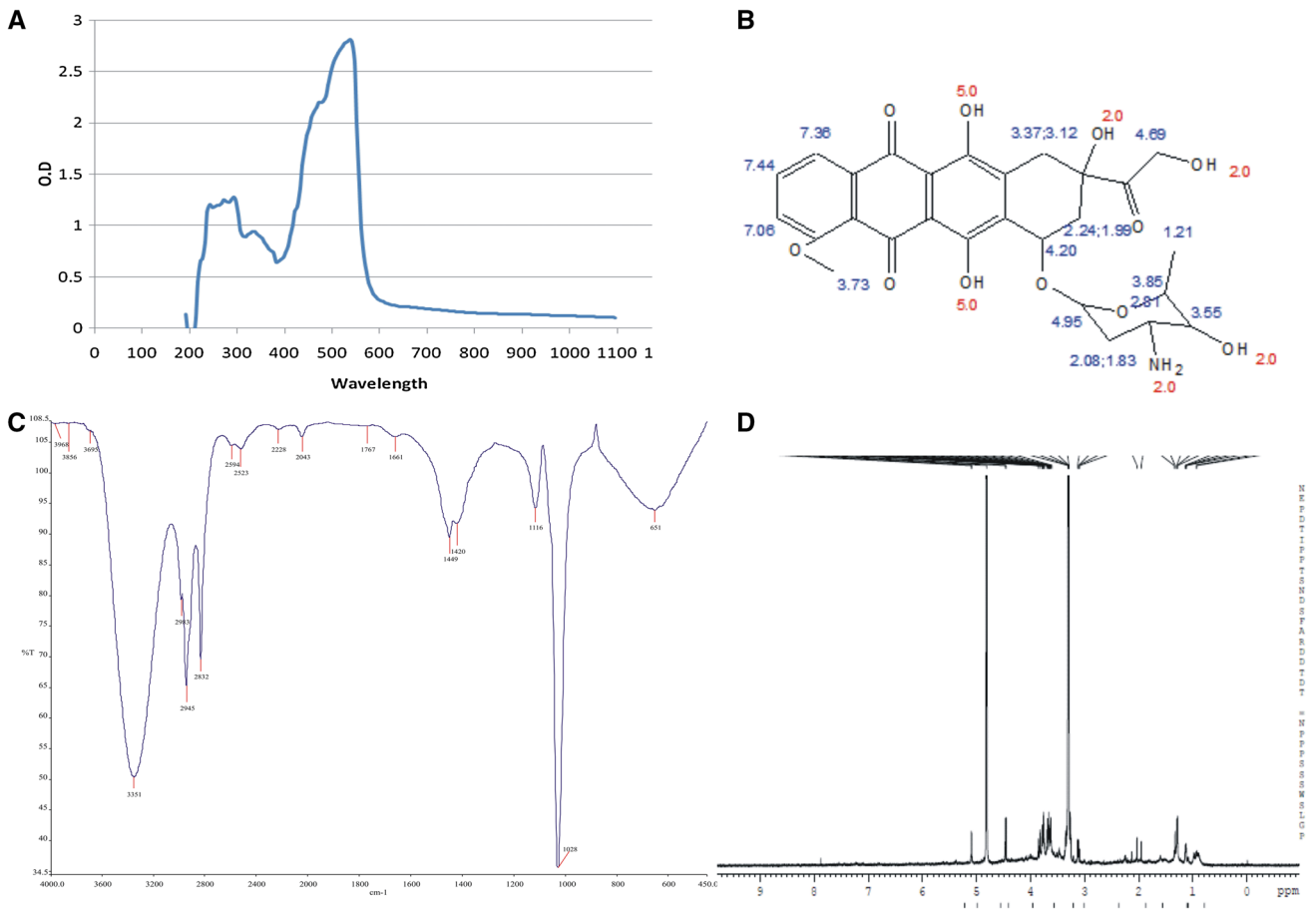


Fig. 1 Characterization of compound R1D obtained from isolate R1. **a** UV–Visible spectra of compound R1D. **b** Structure of dihydrodaunomycin. **c** IR spectra of compound R1D. **d** Proton NMR of compound R1D

The IC_{50} of R1C, R1D, R1E and R1F as determined from the graph (Fig. 6a) was ~5, 8, 14 and 9.5 µM for L929. The IC_{50} of R1E and R1F was found to be 20 and 23 µM for the tumor cell line, HeLa (Fig. 6b). Similarly, the IC_{50} of R3A, R3E and R3F on HeLa cell line was determined from the graph to be 20, 12 and 25 µM (Fig. 6c).

Figure 6d shows the comparative effect of R5F and Y8B on HeLa. The IC_{50} of R5F and Y8B as determined from the graph was 10 and 25 µM respectively. Figure 6e shows the IC_{50} of the standard doxorubicin and Y8A. It was found to be ~3 and ~2.9 µM respectively for doxorubicin and Y8A.

In vitro wound scratch assay

Anti-metastatic activity of the isolated aromatic polyketides was tested in vitro by performing scratch assay on the tumor cell line HeLa. As shown in Fig. 7, the migration of HeLa cells as indicated by the ability to close the artificial wound, was significantly inhibited by the compounds Y8A, identified as an aclacinomycin analogue and R5F, identified as daunomycin, even at nontoxic concentrations. The open area in the case of Y8A treated cells was 36.2% as compared to that of 16.1% of the untreated control. In the case of compound R5F, the inhibition was less with 49.8% open area as compared to that of 36.0% in untreated cells. Compound R3E, identified as rhodomycin, did not show any significant inhibition.

Discussion

Polyketides form the major class of medicinally used secondary metabolites of *Streptomyces* and related species. These compounds, which represent 20% of pharmaceutical drugs in the market, contain repeating (–CH_2–CO–) groups and possess antimicrobial, antifungal, antiparasitic, antitumor and antiviral activities (Donadio et al. 2010). *Streptomyces* are considered to be prolific producers of polyketides (Liu et al. 2012). The current study was undertaken with the aim of isolating novel aromatic polyketides from soil *Streptomyces* spp. These were purified and their antimicrobial and antitumor activities were assessed. The study also

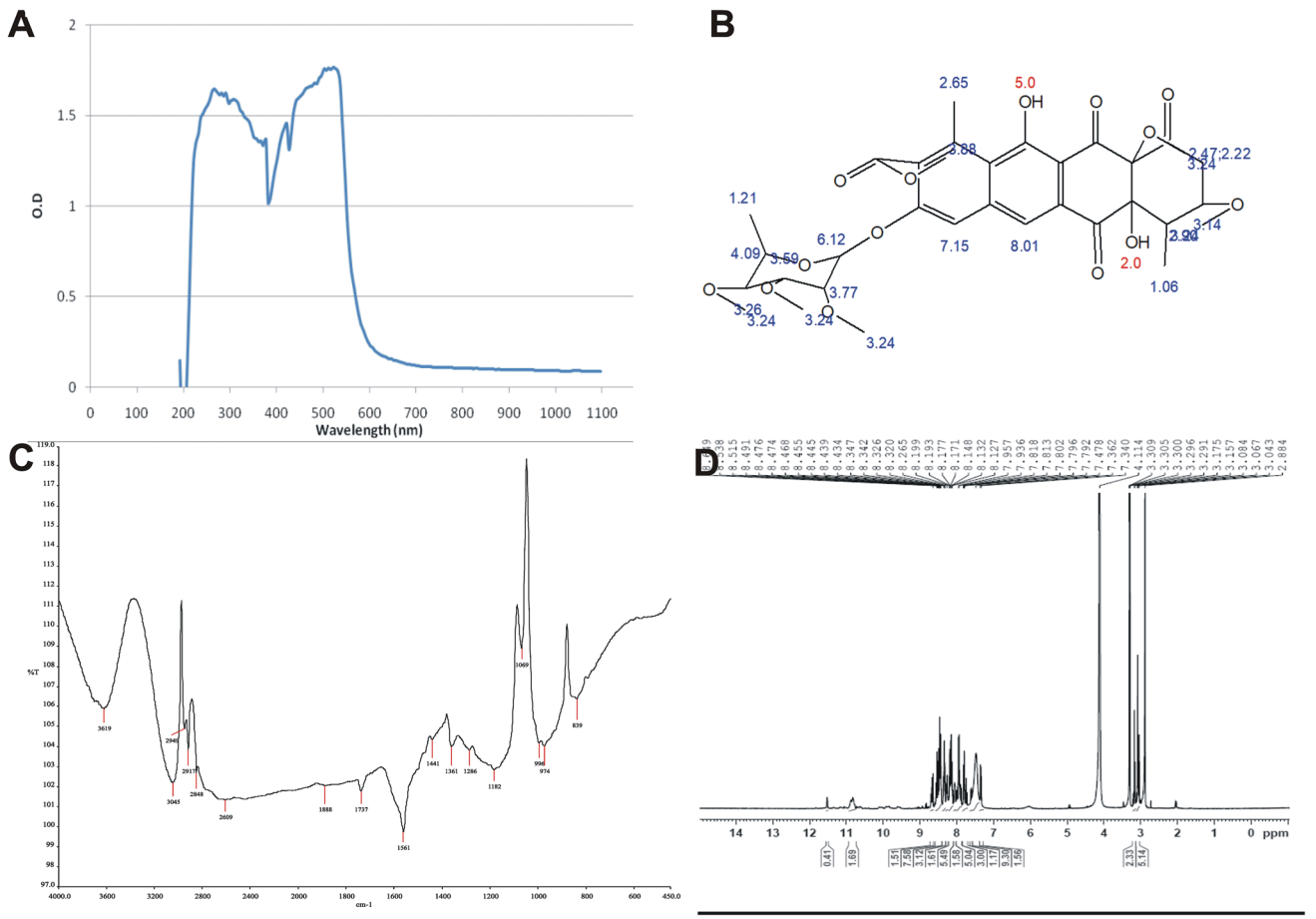


Fig. 2 Characterization of compound B1B obtained from isolate B1. **a** UV–Visible spectra of compound B1B. **b** Structure of elloramycin. **c** IR spectra of compound B1B. **d** Proton NMR of compound B1B

involved the structure elucidation of these aromatic polyketides. *Streptomyces* species usually produce the bioactive compounds as a complex, which can be separated on TLC to yield distinct bands. In this study, TLC with different solvent systems yielded 2–7 bands from the ethyl acetate extracts of each *Streptomyces* isolate. A bioactivity guided approach was used to select the most potent compound from each isolate. Although the structure of only the most potent bioactive compound from each isolate was elucidated, all the other fractions were also subjected to partial characterization to predict the compound identity (Table 2).

Isolate R1, identified as *S. spectabilis*, was grown for antibiotic production using the medium and culture conditions optimized in a previous study (Holkar et al. 2013a). The UV visible and IR spectra of the most potent compound, R1D, indicate that it is an aromatic polyketide, belonging to daunomycin group of anthracyclines (Dornberger et al. 1985; Bervanakis 2008). Acid hydrolysis of compound R1D yielded dihydrodaunomycinone and daunosamine indicating that the compound is perhaps dihydrodaunomycin. The chemical shift values shown by the proton NMR of R1D were very similar to that of dihydrodaunomycin as previously reported (Arcamone et al. 1969; Yoshimoto et al. 1980). Thus UV–Vis, IR and NMR spectroscopy identified this compound as dihydrodaunomycin, which belongs to the anthracycline class of aromatic polyketides. This is the first report of dihydrodaunomycin, an anthracycline being produced by *S. spectabilis*. Earlier, other researchers have reported the production of aureolic acids and macrolides such as spectomycins and streptovaricins but not anthracyclines from this organism (Staley and Rinehart 1994). MIC of R1D was found to be much lower than the reported value of 12.5 µg/ml against *B. cereus*. However, IC_{50} values obtained for R1D in the present study were much higher than those reported for dihydrodaunomycin for HeLa by other researchers (Arcamone et al. 1972). These results indicate that some substituent groups on R1D might be slightly different from conventional dihydrodaunomycin.

Isolate B1, identified as *Streptomyces olivaceus* was grown in Potato Dextrose Broth (PDB) and yielded an orange-yellow compound B1B as the major product. This compound did not show any colour change on treatment

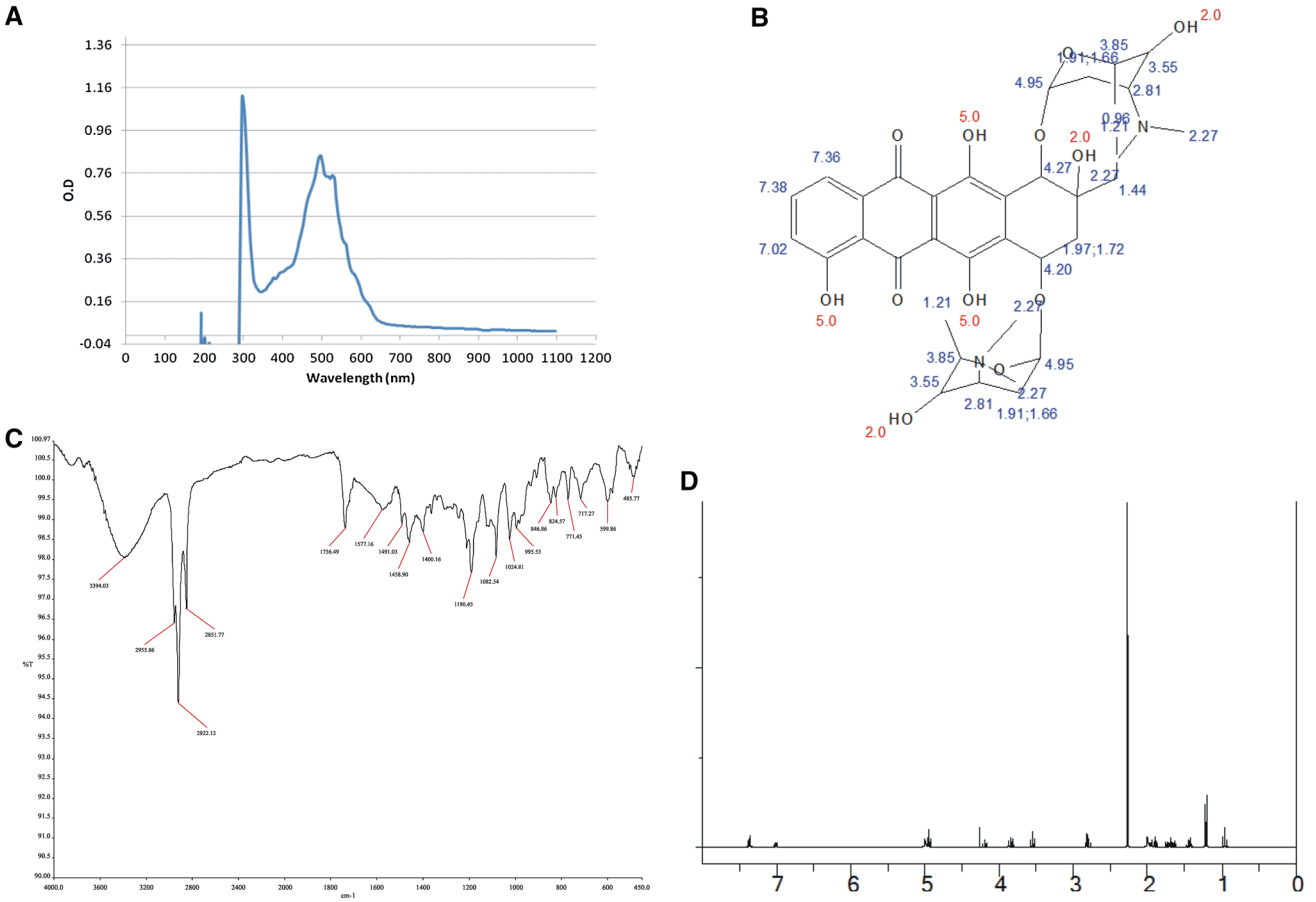
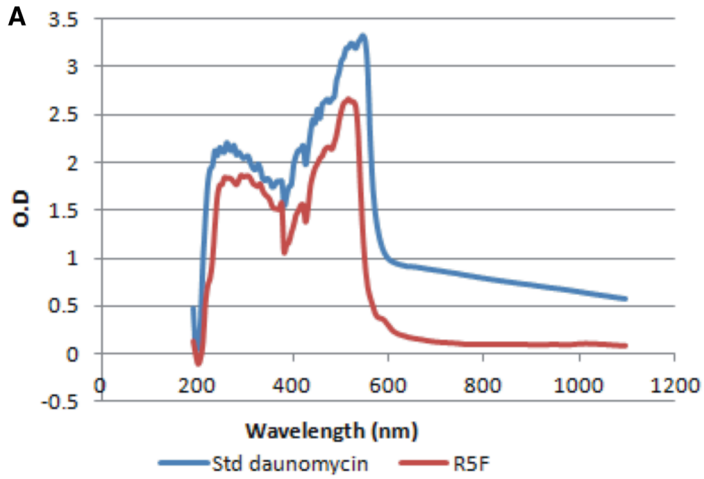


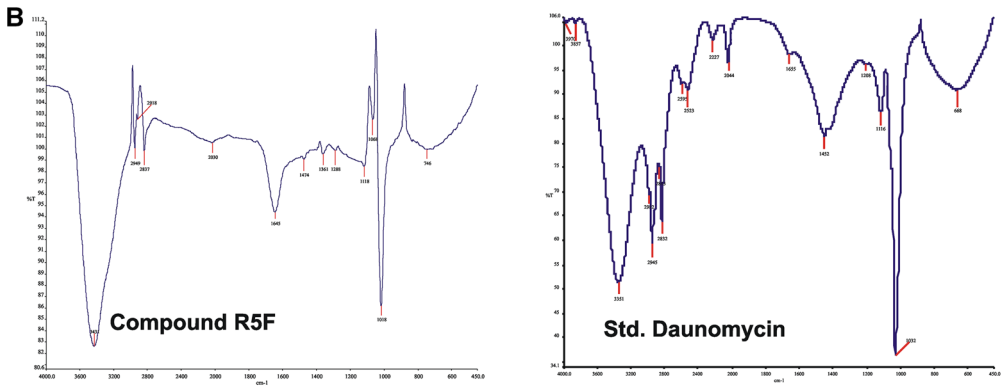
Fig. 3 Characterization of compound R3E obtained from isolate R3. **a** UV–Vis spectra of compound R3E. **b** Structure of rhodomycin. **c** IR spectra of compound R3E. **d** Proton NMR of compound R3E

with 0.5% magnesium acetate indicating that it is not a peri-hydroxy quinone (Laatsch and Fotso 2008; Holkar et al. 2013b). Acid hydrolysis followed by TLC analysis indicated the presence of the aglycone, elloramycinone and the sugar rhamnose in its structure. Further, the IR (KBr) spectra were similar to that reported for elloramycin (Drautz et al. 1985). The shifts in ^{1}H NMR of B1B in the aglycone, elloramycinone and the shifts shown by the sugar residue attached to the chromophore, rhamnose correspond to that reported by Drautz. Hence the conclusion that compound B1B is rhamnosyl–elloramycinone, that is elloramycin is inescapable. Elloramycin is an aromatic polyketide belonging to the class of tetracenomycins. It is a phenolic glycoside, a glycoside type rare among the secondary metabolites of *Streptomyces*. Elloramycin is the first secondary metabolite of microbes with its sugar permethylated (Drautz et al. 1985). Isolate B1, in preliminary screening was found to be only antifungal, hence only its antifungal activities were pursued. But, when purified compounds were tested against *C. albicans* and *A. niger* by agar well diffusion method, hardly any activity was observed. IC_{50} of compound B1B against HeLa cells was observed to be 30 µM but was not found to be cytotoxic to L929 in the tested range. B1B thus showed promise of being an effective anticancer agent. Notably however, Elloramycin has been reported by Drautz to be weakly active against Gram-positive bacteria, especially Streptomycetes but not against *Bacillus subtilis, Micrococcus luteus* and *Mucor michei*. He also reported that the in vitro test against L-1210 leukemia cells showed 100 times weaker activity than doxorubicin which was attributed to the high grade of sugar methylation and the lipophilic character of the molecule. Therefore more careful investigations need to be planned to predict conclusions about the chemotherapeutic potential of B1B.

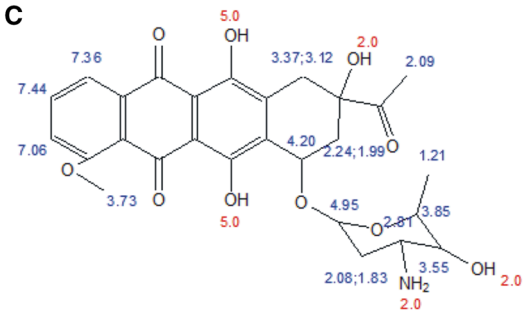
Isolate R3, identified as *S. purpurascens*, was grown for antibiotic production using the medium and culture conditions optimized in a previous study (Holkar et al. 2013b). The UV visible light absorption spectra of all the purified fractions of isolate R3, exhibited characteristic peaks of anthracyclines in the range of 297, 492–497, 522–526 and 557–562 nm (except R3D). The FT-IR spectra of all purified fractions indicated the presence of



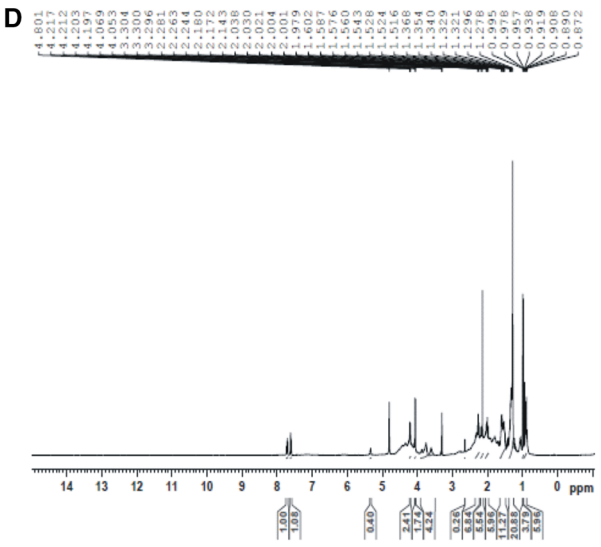
Comparison of UV –Vis spectra of Std. daunomycin & compound R5F



IR spectra of Compound R5F and Standard daunomycin



Structure of daunomycin



Proton NMR of compound R5F

Fig. 4 Characterization of compound R5F obtained from isolate R5. **a** Comparison of UV–Vis spectra of standard daunomycin and compound R5F. **b** IR spectra of compound R5F and standard daunomycin. **c** Structure of daunomycin. **d** Proton NMR of compound R5F

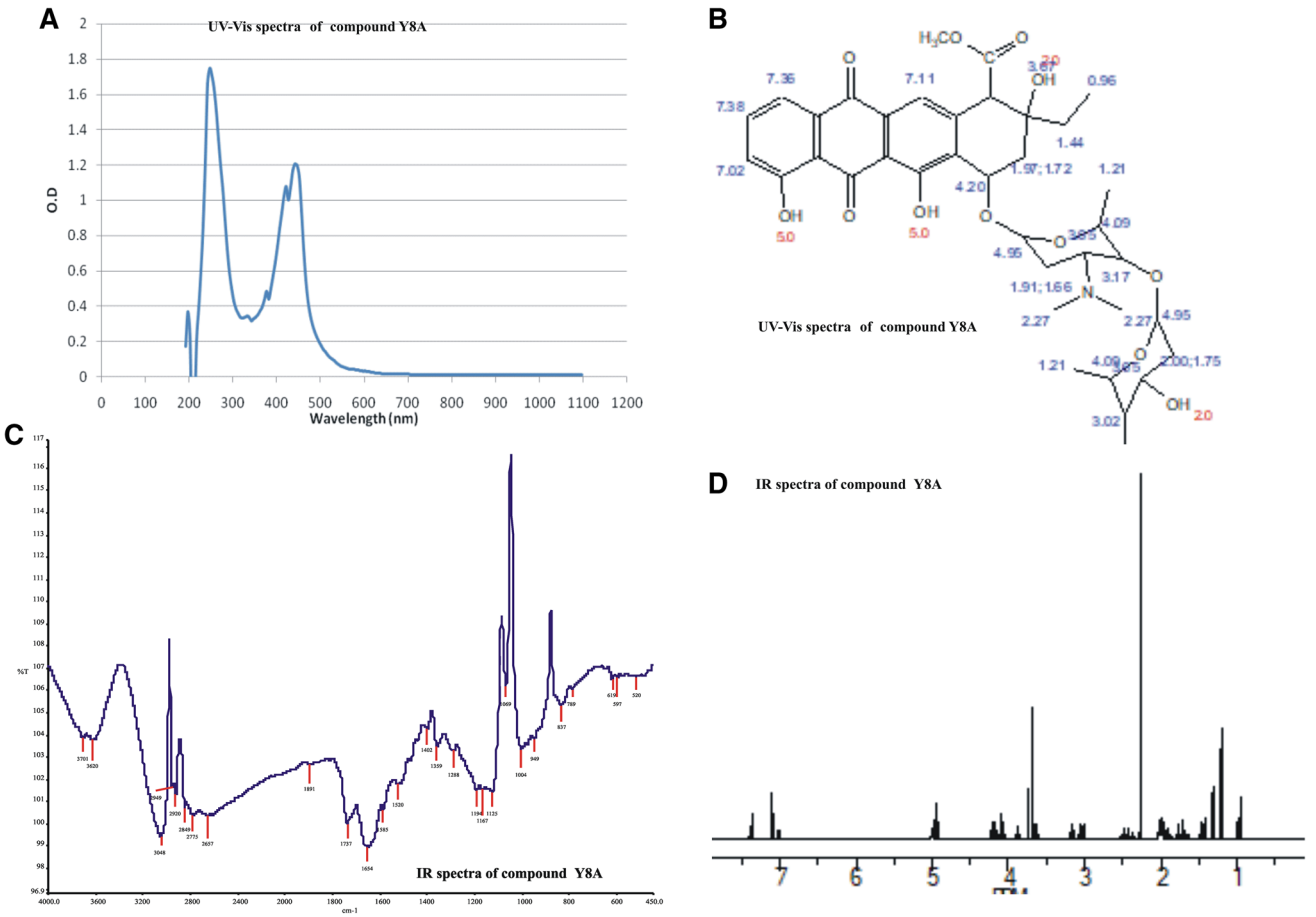


Fig. 5 Characterization of compound Y8A obtained from isolate Y8. **a** UV–Visible spectra of compound Y8A. **b** Structure of aclacinomycin. **c** IR spectra of compound Y8A. **d** Proton NMR of compound Y8A

Table 3 Physicochemical properties of the potent compounds

Properties	Compound				
	R1D	B1B	R3E	R5F	Y8A
R*f*	0.34(SS6)	0.69 (SS7)	0.62 (SS4)	0.00 (SS6)	0.47 (SS10)
UV–Vis λmax (nm)	417, 535	292, 422, 503	297, 492	256, 419, 472, 517	247, 379, 417, 437
IR max	3351, 2945, 2832, 1149, 1116, 1028	3619, 3045, 1561, 1361, 1286, 1182	3394, 2292, 1736, 1577, 1458, 1190	3431, 2949, 2837, 1645, 1474, 1118	3048, 2949, 2775, 1737, 1654, 1585
NMR	δ 4.4, δ 1.99–2.4, δ 3.12–3.37, δ 5, δ 4.8, δ 3.6–3.8, δ 4.8, δ 1.21, δ 3.73	δ 5, δ 3.8, δ 3.14, δ 8.01, δ 7.15, δ 2.9, δ 3.77, δ 1.21, δ 4.11, δ 3.59	δ 7.02–7.38, δ 4.2, δ 1.72–δ 1.97, δ 5, δ 1.44, δ 1.66–δ 1.95, δ 2.81–δ 3.55, δ 4.8	δ 7.06–δ 7.44, δ 1.99, δ 2.24, δ 3.12, δ 3.37, δ 5, δ 2.09, δ 1.21	δ 4.8, δ 3.3, δ 2.2, δ 1.8–2, δ 1.3, δ 2
Compound identified as	Dihydrodaunomycin	Elloramycin	Rhodomycin A	Daunomycin	Aclacinomycin

hydroxyl group (3400–3300 cm^{-1}) a ketonic group or ester carbonyl (1740 cm^{-1}) and a hydrogen bonded carbonyl (1600 cm^{-1}) which is characteristic of anthracyclines. However, an orange coloured compound R3E was found to be the most potent compound with an MIC of 2 µg/ml against *B. cereus*.

The R*f* and UV–Vis spectra of the aglycone of R3E was found to be similar to that of β-RMN. Also the UV–Vis spectra of compound R3E matched that of S-583AII, which is reported to be a rhodomycin (Shoji et al. 1968). The IR and ^{1}H NMR spectra confirmed the identity of compound R3E as rhodomycin in the present work.

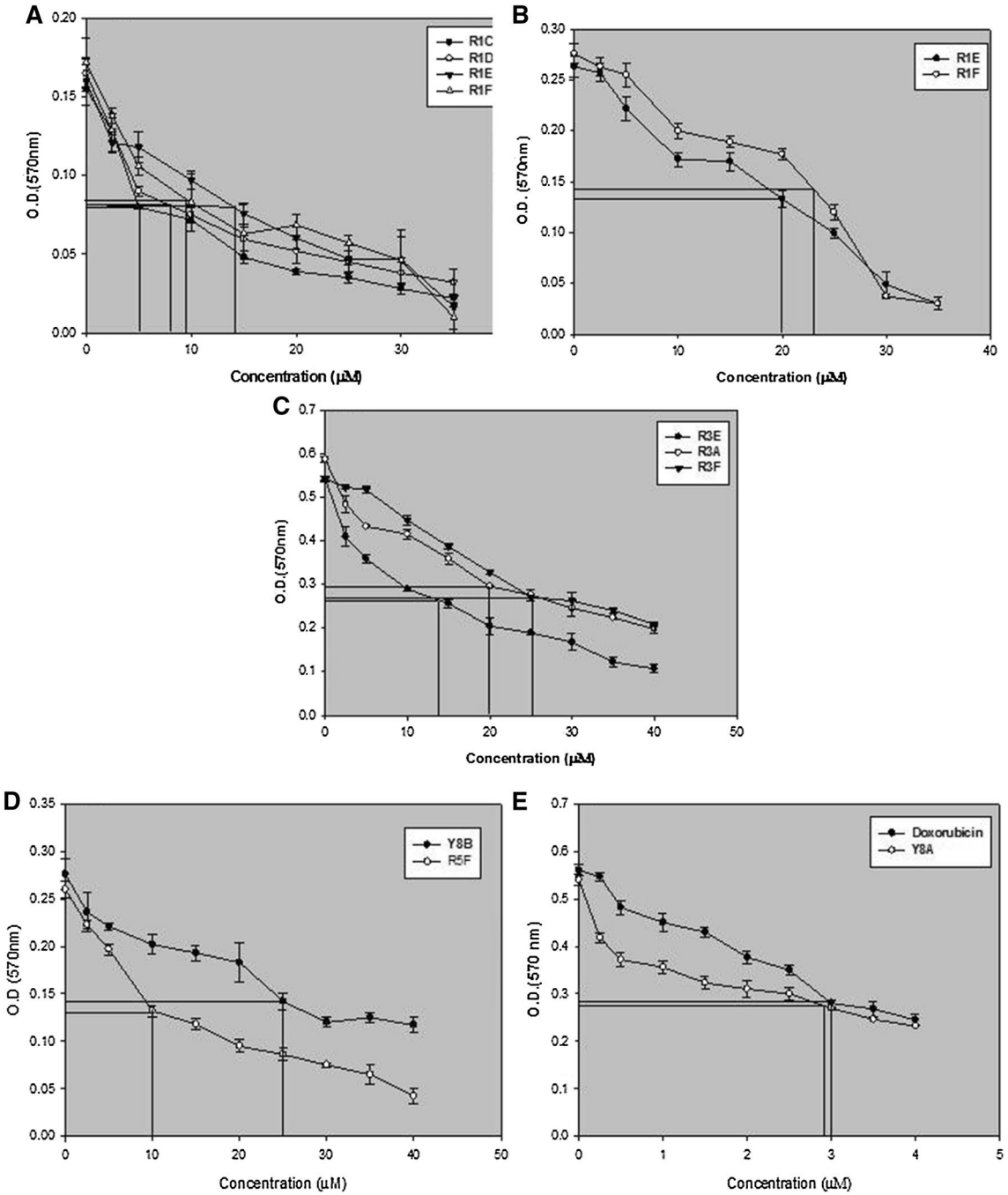


Fig. 6 **a** MTT based cytotoxicity assay of R1C, R1D, R1E and R1F on L929, IC_{50} was found to be 5, 8, 14 and 9.5 µM. **b** MTT based cytotoxicity assay of R1E and R1F on HeLa, IC_{50} was found to be 20 and 23 µM. **c** MTT based cytotoxicity assay of R3A, R3E and R3F against HeLa, IC_{50} was found to be 20, 12 and 25 µM. **d** MTT based cytotoxicity assay of Y8B and R5F against HeLa, IC_{50} was found to be 25 and 10 µM. **e** MTT based cytotoxicity assay of standard doxorubicin and Y8A against HeLa, IC_{50} was found to be 3 and 2.9 µM. Each point represents mean of three independent observations ± SD

Rhodomycin group of anthracyclines are characterized by having β-RMN as the aglycone and was the first anthracycline to be identified. The sugar moiety attached to C-7 or C-10 or both of the aglycone always contains one or more rhodosamines (Fujiwara et al. 1985). Rhodomycin B containing one rhodosamine and rhodomycin A containing two rhodosamines has been isolated previously from *S. purpurascens* (Saito et al. 1995).

In the present work, the MIC of R3E was found to be comparable to the reported value of 0.5–1 µg/ml (Shoji et al.

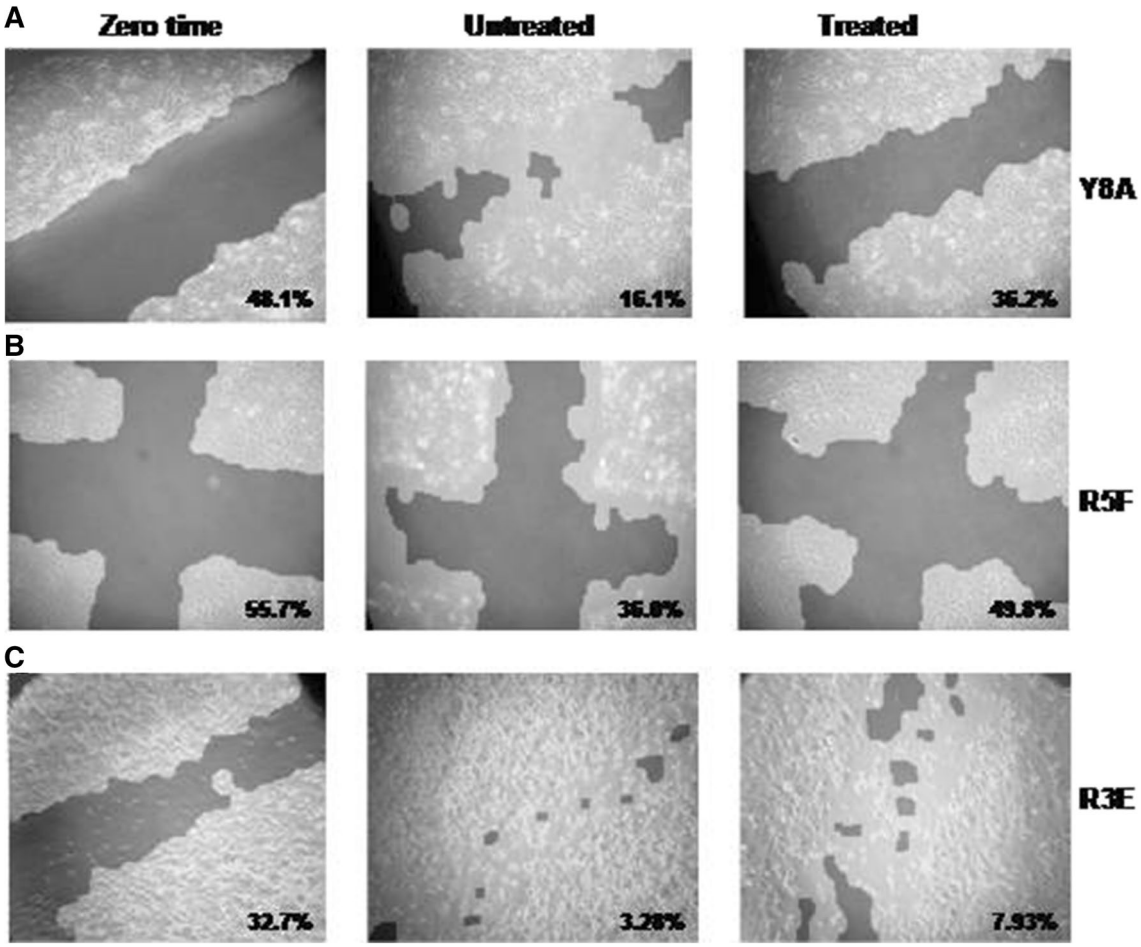


Fig. 7 Anti-metastatic activity by in vitro wound scratch assay. Cell migration of tumor cells (HeLa) in presence and absence of aromatic polyketides was compared. Analysis of cell migration was done by using T Scratch analysis software. Confluent cell cultures were scratched and immediately imaged at ×5 magnification (0 h). HeLa cells were incubated in medium alone (24 h untreated control) or aromatic polyketides, Y8A-1, R5F-3 and R3E-4 µM (24 h treated) for 24 h before re-imaging. The automated analysis was performed using a disk size of 7, default threshold 0.25 and erosion size 2. Percentage of open image area represented as mean ± standard deviation of 4 replicates (**$P \leq 0.05$)

1968). However, the IC_{50} value was higher than the reported value of 1 µg/ml (Saito et al. 1995).

Since the UV–Vis spectra and metabolic profile of both cell and broth extracts of isolate R5 (identified as *S. coeruleorubidus*) were similar, the two were mixed resulting in 185 mg of crude antibiotic complex. This crude complex when subjected to TLC using various solvent systems gave separation in SS6. Five well separated bands were obtained and were named R5A, R5B, R5C, R5D and R5E. A polar compound which did not migrate remained as a circular spot. This spot was scraped and run in SS3. It resolved as a single band indicating that it was a pure compound. This compound was named R5F, which on treatment with 0.5% magnesium acetate, changed color from orange-red to violet indicating the presence of perihydroxy quinone in the structure as seen in anthracyclines. The UV–Vis spectra of compound R5F showed peaks in the UV region (233, 252, 292 nm) and in the visible region (421, 472, 517 nm) which are characteristic of a dihydroxyanthraquinone as seen in daunomycin (Bouma et al. 1986). The UV–Vis spectra of standard daunomycin also showed similar peaks. Also R5F showed an R*f* of 0.75 in the same solvent system as has been reported for daunomycin (Dickens et al. 1997). Further the IR spectra of standard daunomycin and R5F were superimposable with similar peaks. The ^{1}H NMR spectra of R5F conclusively confirmed its identity as daunomycin. Daunomycin has been isolated previously from *Streptomyces peucetius, Streptomyces griseus, Streptomyces insignis* and other *Streptomyces* species and variously named by different researchers as rubomycin C, mitocromin D and leukaemomycin C. It has also been obtained from cultures of *S. coeruleorubidus* as rubidomycin (Arcamone et al. 1969). The antitumor activity of daunomycins, first established

using tumor bearing mice, was confirmed in clinical trials showing its powerful activity against acute leukemia. Daunomycin thus became the first anthracycline endowed with clinical usefulness. In the present work, Compound R5F was found to inhibit the proliferation of HeLa cells with an IC_{50} value of 10 µM which was slightly higher than that shown by standard daunomycin (3 µM) under similar experimental conditions. In vitro wound healing assay revealed the antimetastatic properties of compound R5F.

Isolate Y8, identified as *S. lavendofoliae* yielded an aklavinone glycoside which could be an aclacinomycin (Kitamura et al. 1981). Also an R*f* of 0.12 in SS9 and 0.47 in SS10 was observed. These R*f*'s when compared with literature suggested that the compound belongs to the aclacinomycin class of anthracyclines. The UV–Vis spectra and IR spectra also validated the fact that it could be an aclacinomycin. The chemical shifts in the ^{1}H NMR at δ 4.8 and δ 3.3 could be due to the proton at C-1 and equatorial proton at C-4 of the 2-deoxyfucose. The characteristic chemical shift around δ 2.2 in the NMR spectra of the compound Y8A suggests the presence of an amino sugar moiety in its structure (Oki et al. 1979). This amino sugar may be daunosamine as indicated on the basis of the shifts at δ 1.8–2.0 (CH2), δ 1.3 (CH3), δ 2.0 (NH_2) as reported by Yoshimoto (Yoshimoto et al. 1980). Thus compound Y8A may be an aclacinomycin analogue. Aclacinomycins, which are a type of anthracyclines, are aklavinone glycosides with antitumor activity and are known to be produced by *Streptomyces galilaeus*. This group of yellow anthracyclines has the widest variety of sugar substituents, mainly rhodosamine, deoxyfucose and cinerulose, and to a lesser extent amicetose, aculose and rhodinose (Fujiwara et al. 1985). Daunosamine and monomethyl daunosamine along with deoxyfucose and cinerulose have also been reported as sugars of aclacinomycin analogues produced by a mutant strain of *S. galilaeus* (Oki et al. 1979). Compound Y8A isolated in this work, was found to contain daunosamine and deoxyfucose but not cinerulose. Thus compound Y8A is perhaps a new aclacinomycin analogue which we isolated from the culture broth of Y8. Aclacinomycins are mainly produced by *Streptomyces galilaeus* or its mutants. However, in this study, Y8A was found to be produced by our isolate identified as *S. lavendofoliae*. There are only two reports before this where aclacinomycins have been reported to be produced by *S. lavendofoliae* (Kim et al. 1995a, b).

Compound Y8A was found to have an IC_{50} value of 2.9 µM against HeLa cells. However, it was found to be cytotoxic to the normal cells, L929 at a much higher concentration as compared to that of aclacinomycin A and aclacinomycin B whose reported values are 0.12 and 0.24 µg/ml. Compound Y8A was also found to exhibit antimetastatic activity wherein the migration of HeLa cells was inhibited even at non toxic concentration (1 µM). Thus compound Y8A has antiproliferative and anti invasive characteristics required in an antimetastatic antitumor compound.

Although screening programs do not always result in the discovery of new compounds, this study yielded a few novel aromatic polyketides which can be taken up in a drug development program wherein they may be chemically modified to further increase their activity. These can be subsequently evaluated in clinical trials rendering valuable chemotherapeutic compounds in future.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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ORIGINAL ARTICLE

Culturable rare actinomycetes from Indian forest soils: Molecular and physicochemical screening for biosynthetic genes

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ABSTRACT

Background and Objectives: Rare actinomycetes are a promising source of novel metabolites of pharmaceutical importance. The current study focussed on selective isolation of specific genera of rare actinomycetes and screening the isolates for biosynthetic genes particularly polyketide synthases (PKS) and non ribosomal peptide synthetases (NRPS).
Materials and Methods: The soil samples were subjected to various pre-treatments like 1.5% phenol treatment, 0.3% chloramine T treatment, benzethonium chloride treatment, etc. and plated on selective media supplemented with specific antibiotics targeting rare genera of actinomycetes. The putative rare actinomycete isolates were screened for bioactivity using agar cross streak method and agar well diffusion method. The ability of the isolates to produce anti-quorum sensing compounds was tested against *Serratia marcescens*. The isolates were also screened for the presence of biosynthetic gene clusters associated with PKS-I, PKS-II and NRPS pathways using the degenerate primer sets K1F-M6R, KSα/KSβ and A3F-A7R, respectively. The expression of these gene clusters was tracked by physicochemical screening of the extracts of isolates using spectroscopic and chromatographic techniques.
Results: In this study, 1.5% phenol treatment was found to be the most promising followed by heat treatment and chloramine treatment. Our studies showed that ISP5 agar was the best for isolation of rare genera followed by ISP7, Starch Caesin agar and ISP2 supplemented with antibiotics like gentamicin, nalidixic acid and streptomycin. *Micromonospora* was the most abundant genus followed by *Dactylosporangium. Actinomadura, Nocardiopsis* and *Actinoplanes* were almost equal in number. Primary screening showed that 92% of the isolates were active against one of the test organisms. Thirty seven isolates were found to produce anti-quorum sensing (QS) compounds. NRPS sequences were detected in thirty nine isolates (42.8%), whereas PKS-I and PKS-II sequences were detected in seventeen and twenty eight strains (18.6% and 30.7%), respectively.
Conclusion: Nine type I and type II polyketide-producing isolates as well as six peptide-producing isolates were found. The peptide extract of isolate KCR3 and a polyketide extract of isolate NCD10 were found to possess anti-tumor activity exhibiting an IC_{50} value of 3 µg/ml and 2.5 µg/ml against HeLa cells.

Keywords: Rare actinomycetes, Polyketide synthases, Non ribosomal peptide synthetases

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INTRODUCTION

Actinomycetes have a proven capacity to produce novel antibiotics, and many screening programs have been carried out leading to the discovery of numerous new bioactive molecules, which have subsequently found their way into various clinical uses ranging from control of infections to cancer treatment (1). However, the chances of discovering commercially potent secondary metabolites from well-known actinomycetes is becoming increasingly difficult due to the practice of wasteful screening that is leading to rediscovery of the known bioactive compounds (2). This emphasizes the need to isolate and screen the undiscovered representatives of the less explored actinomycetes. Recent evidence has demonstrated that rare actinomycete species, which are often very difficult to isolate and cultivate, might represent a unique source of novel biologically active compounds (3) and methods designed to isolate and identify a wide variety of such actinomycetes have been developed (4). These methods include a variety of pretreatment techniques in combination with appropriately supplementing selective agar media with specific antimicrobial agents.

Although bioactivity guided screening is the oldest and most common screening strategy, in the recent years, PCR based approaches have been used successfully to amplify genes associated with secondary metabolite biosynthesis (5). Polyketide synthases and non-ribosomal peptide synthetases are the major enzymes of secondary metabolite synthesis. A few examples of classes of antibiotics produced through these biosynthetic pathways include ansamycins, tetracyclines, polyenes and glycopeptides (6). In the present study, degenerate primer sets were used to screen for the presence of biosynthetic gene clusters associated with PKS-I, PKS-II and NRPS pathways in genomic DNA of one hundred and seventeen rare actinomycete strains.

Though the presence of the biosynthetic genes in isolates can be proved by molecular screening, it can not confirm the production of the compounds. Hence, expression of these gene clusters was tracked by physicochemical screening of the isolates using spectroscopic and chromatographic techniques for the analysis of crude extracts and prediction of the bioactive compounds. Such studies have been carried out previously on *Streptomyces*, a genus of actinomycetes (7, 8). However, to the best of our knowledge, these methods have not been used for screening non-*Streptomyces* rare actinomycetes, the focus of this study.

Research on actinobacteria is still in its infancy in India. Hence the aim of the present study was to determine the diversity of culturable bioactive rare actinomycetes from Indian forest soils and screen them for the presence of biosynthetic genes using PCR. The metabolic profile and anticancer activity of potent and promising isolates was also studied.

MATERIALS AND METHODS

Test organisms and cell lines. The target strains used for screening antimicrobial activity were procured from microbial type culture collection and gene bank (IMTECH, Chandigarh, India) and were: *Micrococcus luteus* MTCC 106, *Bacillus subtilis* MTCC 441, *Escherichia coli* MTCC 443, *Pseudomonas aeruginosa* MTCC 741, *Serratia marcescens* MTCC 4822, *Candida albicans* MTCC 227, and *Aspergillus niger* MTCC 282. The cell lines were purchased from NCCS, Pune, India.

Chemicals and media. All chemicals and solvents were of analytical grade and purchased from Merck, Germany and culture media were obtained from Hi-media, Mumbai, India. Standard doxorubicin was obtained from Sigma-Aldrich.

Collection of soil samples. Soil samples were collected at depths of 3-5 cm below the surface from various forest areas in and around Nagpur, India. The samples were placed in sterile polyethylene bags, closed tightly and stored at 4°C until required.

Treatment of soil samples and selective isolation of rare actinomycetes. Approximately 1 g of each sample was suspended in 10 ml sterile distilled water from which three dilutions (10^{-2} to 10^{-4}) were prepared. The diluted samples were divided into equal aliquots, and were subjected to various treatments like 1.5% phenol treatment, 0.3% Chloramine T treatment, benzethonium chloride treatment, heat treatment, air drying and a combination of these treatments before plating on appropriate isolation media (9). Several media such as starch casein agar, humic acid vitamin agar (HVA), actinomycetes isolation agar (AIA), yeast extract-malt extract-dextrose

agar (ISP2), glycerol-asparagine agar (ISP5), and tyrosine agar (ISP7) were used for isolation (10, 11). All media were supplemented with sterile antifungal (cycloheximide 100 µg/mL, nystatin 25 µg/mL) and antibacterial (gentamicin, vancomycin, streptomycin, and nalidixic acid 25 µg/mL) antibiotics to facilitate the selective isolation of slow-growing rare actinomycete genera.

Inoculated plates were incubated at 30°C for up to six weeks, and all leathery colonies were identified and sub-cultured on starch casein agar. Preliminary identification of rare actinomycete colonies were done by microscopic observation with a long working distance microscope. Single colonies were successively transferred onto potato dextrose agar and incubated until pure isolates were obtained.

Characterization of non-streptomycete actinomycetes. The growth of rare actinomycete cultures was examined at 7, 14 and 21 days on ISP2 and starch casein agar. The presence of aerial mycelium, the color of aerial and substrate mycelium and the formation of soluble pigments were recorded. Cover slip culture method was used for the microscopic characterization. The mycelium structure, arrangement of conidiospores and arthrospores on the mycelium were observed by high power (400X). The diaminopimelic acid (DAP) isomer in the cell wall was determined by the method of Becker et al. (12). The whole cell sugar pattern (WCSP) was obtained by the method of Staneck and Roberts (13). Lysozyme sensitivity of the isolates was determined to differentiate between Streptomycetes and non-streptomycetes (14).

Screening for bioactivity. The rare actinomycete isolates were assessed for their capability of producing bioactive compounds by agar cross streak method against test organisms (15). Isolates that showed activity in the primary screening were selected for secondary screening. These isolates were grown in submerged culture in 250 ml flasks containing 50 ml of PDB (Potato Dextrose Broth) medium. The cell free supernatant, sterilized by filtration and vacuum concentrated five-fold in Vacufuge Plus (Eppendorf, North America) was used for extracellular antimicrobial activity by agar well diffusion method against test microorganisms (16).

Anti-Quorum sensing activity. For the anti-QS screening, the rare actinomycetes were first central streaked onto the PDA plates and incubated for 2-3 days. The plate was then overlaid with soft LB agar seeded with the indicator strain *Serratia marcescens* and incubated overnight. A positive QSI result was indicated by a lack of pigmentation of the indicator strain around the vicinity of the test organisms. Negative results were indicated by no pigmentation inhibition (17).

PCR detection of PKS-I, PKS-II, and NRPS sequences. Three sets of degenerate primers were used for the amplification of genes encoding polyketide synthases I and II (PKS-I and PKS-II) and nonribosomal peptide synthetases (NRPS) (Table 1) (6, 18). The PCR reaction mixture that consisted of 20-200 ng genomic DNA, 10.0 µL of 2X GoTaq Green master mix (Promega, USA), 10 pmoles of different primer sets, and sterile ultrapure water was added to final volume of 20 µL. The PCR was performed using the Bio-Rad thermal cycler with the following cycling conditions: (i) 94°C for 5 min; (ii) 30 cycles of 94°C for 1 min, 57°C (for K1F-M6R and KSα/KSβ) or 62°C (for A3F-A7R) for 1 min, and 72°C for 2 min; and (iii) 72°C for 5 min. The PCR amplification products were resolved using electrophoresis

Table 1. PCR primers used in this study

Primers	Primer Sequence	Gene recognized	Product size (bp)	Reference
K1F	TSAAGTCSAACATCGGBCA	PKS I	1200	6
M6R	CGCAGGTTSCSGTACCAGTA			
KSα	TSGCSTGCTTCGAYGCSATC	PKS II	613	18
KSβ	TGGAANCCGCCGAABCCGCT			
A3F	GCSTACSYSATSTACACSTCSGG	NRPS	700	6
A7R	SASGTCVCCSGTSCGGTAS			
27F	AGAGTTTGATCMTGGCTCAG	16S rRNA	1400	45
1492R	AGAGTTTGATCMTGGCTCAG			

in 1% agarose gel (Promega, USA) and stained with ethidium bromide (0.5 μgmL^{-1}) and viewed using Molecular Imager. *Streptomyces nogalater* was used as a reference strain for the presence of PKSII gene and *Streptomyces avermitilis* for NRPS and PKS I genes.

DNA extraction, sequencing and analysis. Total genomic DNA from seven potent isolates was extracted using standard method (19). The 16S rRNA gene was amplified by PCR using the primer pair 27F-1492R (Table 1). PCR was carried out under the following conditions: initial denaturation at 94°C for 3 min; 30 cycles of 94°C for 30 sec, 60°C for 30 sec, and 72°C for 1 min; and a final extension at 72°C for 10 min. The PCR products were purified and sequenced using a ABI PRISM® BigDyeTM Terminator Cycle Sequencing Kits with AmpliTaq® DNA polymerase (FS enzyme) (Applied Biosystems).

The resultant 16S rRNA gene sequences were compared with those of other closely related taxa retrieved from the GenBank database. The program MUSCLE 3.7 was used for multiple alignments of sequences (20). The resulting aligned sequences were cured using the program Gblocks 0.91b. Finally, the program PhyML 3.0 aLRT was used for phylogeny analysis and HKY85 as substitution model. The program Tree Dyn 198.3 was used for tree rendering (21).

Physico-chemical screening. The absorption spectra of bioactive crude organic extracts in methanol were recorded in the UV-visible region (190-1100 nm) by using a biospectrophotometer (Model BL 198, Elico, India) and observed for peaks in 230-280 nm range and 400-500 nm range for detection of aromatic polyketides (22), 215-270 nm for complex polyketides like polyenes compounds (7) and in 210-230 and 270-280 for peptides (23). Doxorubicin, an anthracycline; nystatin, a polyene and nisin, a peptide were used as standards.

Chemical screening of the crude extracts was carried out by the method described by Taddei (8). TLC screening was performed on readymade silica gel plates (Merck, Germany, Cat # 1.05554.0007). All samples were spotted manually with a 5-µl micropipette. Each TLC plate (20 × 20 cm) was spotted with samples of the various microbial crude extracts and the chromatograms were developed using chloroform: methanol: aq ammonia (85:14:1), or benzene: acetone: methanol (100:10:1), methanol: chloroform: acetic acid: water (80:20:2:0.2) chloroform: heptane: methanol (10:10:3) as the solvent systems.

Detection of secondary metabolite patterns was performed using a UV lamp at 254 and 365 nm, as well as by direct staining using coloring reagents like magnesium acetate reagent, formaldehyde- H_2SO_4 reagent, naphthoresorcinol reagent and chlorine o-dianisidine (8, 23).

Anticancer activity. The effect of bioactive extracts on HeLa was determined *in vitro* by MTT assay (24). The adherent cells were exposed to a concentration gradient of 1-10 µg/ml.

RESULTS

Effect of pretreatment & antibiotics for selective isolation of rare actinomycetes. Using different soil treatment methods, selective media and cultivation conditions, organisms putatively identified as actinobacteria were selected on the basis of characteristic colony morphology, notably the ability to form aerial hyphae and substrate mycelia.

1.5% phenol treatment of soil suspension yielded the maximum number of colonies, sixteen, on ISP5 supplemented with gentamicin followed by ISP7 with the same antibiotic. Air dried samples gave maximum colonies, nine, on starch casein agar (SCA) supplemented with gentamicin followed by five colonies on ISP 7 with streptomycin. With heat treatment, AIA, ISP5 and ISP7 with vancomycin yielded three, five and two colonies. However, maximum colonies nine, were obtained on ISP2 with gentamicin. Chloramine treatment was found to be most successful on ISP7 with vancomycin and nalidixic acid (Table 2).

A total of one hundred and seventeen actinobacterial strains were isolated from five forest soil samples and one hundred and six isolates were found to have meso-DAP indicating that they are rare actinomycetes.

Identification of rare actinomycetes. The isolates were grouped on the basis of colour series, the main colours being white (45.83%), gray (35.41%), red (6.25%), and yellow (4.16%); while 8.33% isolates were without any distinct colour (hyaline). Whole cell sugar pattern of isolates containing meso-DAP

showed that fifty strains had xylose either alone or with arabinose. Eighteen strains showed the presence of madurose and thirty two, galactose. Using a polyphasic approach, on the basis of phenotypic, microscopic and chemotaxonomic criteria, the isolates were classified into twelve genera as shown in Table 3. The isolates were renamed as per their generic name for further studies.

Seven potent isolates were identified on the basis of 16S rRNA gene sequencing. The sequences have been submitted in Genbank and accession numbers obtained as shown in Table 4.

Primary screening. When the isolates were subjected to primary screening using agar cross streak method, ninety eight isolates showed antimicrobial activity against one or the other test organism. Sixty two isolates showed only antibacterial activity, twelve isolates showed only antifungal activity and the remaining twenty four isolates showed both antibacterial and antifungal activity. Of the isolates with antibacterial activity, fifty isolates were active only against Gram positive bacteria whereas twelve isolates were active against both Gram positive as well as Gram negative bacteria. Thirty seven (36.2%)

Table 2. Recovery of rare actinomycetes colonies using selective isolation methods

Treatment	Media	Antibiotics used	No. of colonies	Reference
1.5% phenol	ISP 5	Gentamicin	16	46
1.5% phenol	ISP 7	Nalidixic acid/gentamicin	10	47
Air dry	SCA	Gentamicin	9	48
Air dry	ISP 7	Streptomycin	5	49
Heat treatment	ISP 2	Gentamicin	7	50
Heat treatment	ISP 5	Kanamycin	5	51
Chloramine treatment	ISP 7	Streptomycin	4	52

Table 3. Grouping of isolates into genera on the basis of morphological and chemotaxonomic properties

Genus	No. of isolates (%)	Cell wall amino acid	Cell wall type	Whole cell sugar pattern	Substrate mycelium	Aerial mycelim	Spores
Micromonospora	22 (20.75)	Meso- DAP, glycine	II	Ara, Xyl (D)	Yellow/brown	-	Spherical to oval
Dactylosporangium	16 (15.09)	Meso- DAP, glycine	II	Ara, Xyl (D)	Yellow brown/ orange	-	Single row of 3-4 oblong spores
Actinoplanes	12 (11.32)	Meso- DAP, glycine	II	Ara, Xyl (D)	Orange/yellow	-	Spherical or short rods
Nocardiopsis	11 (10.3)	Meso-DAP	III	No (C)	Creamish yellow	Grayish white	Long chain of spores
Actinomadura	10 (9.43)	Meso-DAP	III	No (C)	Grayish white	white	Short chain of conidia on aerial mycelium, often curled
Microbispora	9 (8.49)	Meso-DAP	III	Ara, Gal, Mad	Yellow/orange	Pink white	Chains of conidia with 2 spores
Catellatospora	7 (6.6)			Ara, Xyl, Gal	Bright yellow	No	Short chain of conidia
Planobispora	6 (5.66)	Meso-DAP	IV	Ara, Gal, Mad (B)	Brownish white	White with rose tinge	Spornagia with 2 spores
Kocuria	5 (4.71)					-	
Spirilliplanes	4 (3.77)	Meso -DAP		Xyl, Gal, Mann	Yellow/orange	white	Oval or short rods
Spirillospora	3 (2.83)	Meso -DAP	III	Mad (B)	yellow	white	Rod shaped or curved
Saccharomonospora	1 (0.94)	Meso-DAP	III	Ara, Gal (A)	white	Grayish green	Spores in pairs or short chains

Table 4. Similarity of the rare actinobacterial isolates to the closest cultivated species and their Genbank accession numbers

Isolate	Genbank accession No.	No. of nucleotides sequenced	Query cover	Similarity	Closest cultivated species (GenBank accession no.)
ACM1	MG372011	1167	100%	79%	*Actinobaculum schaalii* strain NML 070171 16S ribosomal RNA gene, partial Sequence (FJ711188.1)
KCR3	MG430204	938	100	100	*Kocuria kristinae* partial 16S rRNA gene, strain SZ22 (LT600550.1)
ATP10	MG388286	1163	100%	79%	*Actinomyces* sp. VUL8 16S ribosomal RNA gene, partial sequence (KX389558.1)
MMS16	MG372012	1203	94%	81%	*Micromonosporaceae* 16S rRNA gene, isolate SR 53 (X87321.1)
MBS9	MG388285	1191	100%	78%	Actinomycetales bacterium AB1007 16S ribosomal RNA gene, partial sequence (JQ924089.1)
ACM9		1427	100	99%	*Glutamicibacter arilaitensis* strain Re11716S rRNAgene, partial sequence (NR074608.1)
MMS8	MG407702	1143	96	98%	*Micromonospora auratinigra* strain RLFI_1037 16S rRNA gene, partial sequence (KY580811.1)

isolates showed anti-quorum sensing activity when tested against *Serratia marcescens.*

Secondary screening. All the ninety eight bioactive isolates selected in primary screening were subjected to secondary screening against *B. subtilis, E. coli* and *C. albicans*. Only ninety one isolates showed antibacterial or antifungal activity in secondary screening. The extracts of fourteen isolates were observed to have a remarkable antibacterial activity of which isolate MMS17 was found to be the most potent with a zone of inhibition of 7.3 cm against *B. subtilis* and 4.5 cm against *E. coli*. Similarly, the extracts of ten isolates showed remarkable antifungal activity, with isolates SMS and MMS16 being more active against *C. albicans* and isolate DCT11 and ATP10 against *A. niger.* Of the eleven isolates which showed anti QS activity against *S. marcescens*, five isolates namely, isolate KCR3, MMS14, MMS16, SMS and NCD10 showed remarkable activity. Two isolates, isolate MMS16 and SMS exhibited all the three activities that is, antibacterial, antifungal and anti QS activities.

Detection of PKSI, PKSII & NRPS genes. A total of eighty four (92.3%) strains were found to possess at least one of the PKS and NRPS systems. NRPS sequences were detected in thirty nine isolates (42.8%), whereas PKS-I and PKS-II sequences were detected in seventeen and twenty eight strains (18.6% and 30.7%), respectively. Thirty six isolates showed the presence of two genes. All three target genes were detected in five isolates (MMS1, MMS9, MMS14, DCT14, MMS16).

Physicochemical screening. Out of the twenty eight bioactive isolates which also showed the presence of the PKS II gene, the extracts of twenty one isolates showed UV absorption maxima in the range 208 and 288 nm indicating the presence of an aromatic nucleus. When the extracts of these twenty one isolates were chemically screened, nineteen showed a color reaction with formaldehyde-sulphuric acid reagent confirming the presence of an aromatic nucleus in their structure. The UV- Visible spectra of at least seventeen extracts showed an additional peak in the 400-500 nm range, which could indicate the presence of an extended chromophore as seen in aromatic polyketides. Chemical screening using naphthoresorcinol reagent showed the presence of sugars in the extracts of these seventeen isolates. Of the seventeen isolates which showed amplification of PKSI gene, the extracts of nine isolates showed characteristic peaks in the range of 215-270 indicating their capability of producing type I polyketides.

Results of physicochemical screening using absorption measurement at 254 nm and 366 nm and

reaction with chlorine o-dianisidine showed that twenty four isolates could be recognized as peptide producing strains. None of the spots reacted with ninhydrin reagent. The UV spectral data for the ethyl acetate extracts of selected active fermented broth, antimicrobial activity and presence or absence of biosynthetic genes are shown in Table 5.

Anticancer activity. On the basis of potency and diversity of bioactivity, the extracts of eight isolates (KCR3, MMS14, MMS16, SMS, MMS17, DCT14, MBS9, NCD10) were tested for anticancer activity against HeLa cell line using MTT assay. The extracts of isolates KCR3 and NCD10 were found to be the most potent with IC_{50} value of 3 µg/ml and 2.5 µg/ml respectively and other extracts in the range of 4.5 to 6.5 µg/ml.

DISCUSSION

A large number of actinomycetes have been isolated and screened from soil in the past several decades, accounting for 70-80% of secondary metabolites available commercially (25). Consequently, the possibility of isolating new actinomy-

Table 5. Summary of culturable rare actinomycete isolates from Indian forest soils

Isolates	Aerial mycelim	Diffusible pigment	λ max	Antimicrobial activity[a]			Anti QS activity	Biosynthetic genes[b]		
				B. subtilis	*E. coli*	*C. albicans*	*S. marscenes*	PKS I	PKS II	NRPS
ACM7	Yellow	Yellow	235, 377, 420	+	+	+	+	-	-	-
MMS6	Orange		241, 380, 445	+	+	-	-	-	-	-
MMS8	Orange	Orange	252, 317, 460	++	+	+	+	-	+	+
MMS9	Pale yellow		291, 299, 362	++	+	+	-	+	+	+
MMS10	White		217, 289	++	-	-	+	+	-	+
KCR3	Pale orange		280,293	+	-	+	+++	+	-	+
MMS13	White		303, 330	-	-	-	+	-	+	+
MBS6	Yellow		342, 358, 377,	++	-	-	+			
MMS14	Orange	Orange	266, 276	+	-	-	+++	+	+	+
MMS15	Pale yellow		288, 342, 378, 405	++	-	+	+++	+	+	-
MMS16	Yellowish orange	Yellow	352, 363, 377,	+++	++	++	+++	+	-	-
SMS	White		337, 345	+++	++	+++	+++	-	-	+
ATP6	White		338, 377, 417, 438	+	-	-		-	+	-
MMS17	White		340, 377, 420, 445	+++	++	-	+	+	+	-
DCT11	Reddish brown		296, 351	+++	++	-	+	+	+	-
ACM9	yellow		347, 333, 358, 378	-	-	++	-	+	+	-
ATP10	Yellowish orange		347, 437	+	-	++	-	-	+	+
DCT12	Pale yellow		327, 400	+	-	-	-	+	-	-
MMS20	Dark yellow		363, 375, 417, 438	+	+	+	-	+	+	-
MBS8	Orange	Yellowish	317, 343, 362,	-	-	++	-	-	+	+
MMS22	White		242, 352	-	-	+	-	-	-	-
DCT14	White		335, 340, 375, 403	+	-	-	++	+	+	+
DCT15	Bright orange		342, 377, 333	-	+	-	-	+	-	-
MMS21	White		317, 332, 342	+	+	-	-	+	-	-
MBS9	Yellow		330, 358, 412	++	++	-	++	-	+	-
NCD10	Yellow		291	++	+	+	+++	-	-	+
NCD11	White		338, 358, 400	++	+	-	++	+	+	-

[a] +++ inhibition zone >15mm, ++ inhibition zone 5-15mm, + inhibition zone 0-5mm, - No inhibition

[b] + Present, - Absent

cete strains has diminished so that the search for novel products has now switched to rarer genera of actinomycetes.

Selective isolation of rare actinomycetes. Non-Streptomycete actinobacteria can be isolated using chemical and physical pretreatment of the samples, specific selective media, fine-tuning of culture conditions and other genus-specific methodologies (9), including the use of anti-Streptomyces antibiotics (Table 2). Streptomycin or nalidixic acid and kanamycin in combination have been used for isolation of *Actinomadura* by Hayakawa and others (10, 26). Gentamicin has been specifically used for that of *Dactylosporangium* previously (27).

In this study, 1.5% phenol treatment was found to be the most successful method resulting in isolation of almost 40% of the total rare actinomycetes. Four genera, *Micromonospora, Actinoplanes, Actinomadura* and *Microbispora*, that could resist the germicidal effect of phenol were isolated by this method. Our results were in agreement with that of Hayakawa et al. and Istianto et al. (28, 29).

Genera *Micromonospora, Actinoplanes, Actinomadura* and *Saccharomonospora* were recovered by using dry heat pretreatment. Similar results were obtained by Hayakawa and Kavitha et al. (9, 30), who showed that heating air dried soil samples at 120°C reduced the numbers of filamentous bacteria and streptomycetes on isolation plates, resulting in the selective isolation of various rare actinomycetes genera.

In this study, *Micromonospora* was the most abundant genus followed by *Dactylosporangium*. *Actinomadura, Nocardiopsis* and *Actinoplanes* were almost equal in number. Jose and Jebakumar have reported *Micromonospora* as the second most dominant group after *Streptomyces* accounting for 23% of total actinomycetes in their study (31). *Micromonospora* was also the major genera of rare actinomycetes in both mangrove and soggy soils (32). In Indian scenario too, research on actinobacterial diversity from terrestrial ecosystems has led to the isolation of *Micromonospora, Actinomadura* and *Microbispora* (33).

Bioactivity. Our results using cross streak method indicated that almost 92% of the isolates were active against one or more of the test organisms which was much higher than that reported by Qin et al. and Lee et al. (3, 34).

Almost 26.5% of the bioactive isolates, in this study, were found to be broad spectrum showing both antibacterial and antifungal activity. Most of the antibacterial isolates were found to inhibit only the Gram-positive bacteria (81.2%). Many authors working on bioactive actinomycetes have reported similar results (3, 35).

A few isolates (7.14%) which showed activity in primary screening did not show activity in secondary screening. This is in line with results reported earlier by some researchers (36). In this screening project, we found that thirty seven isolates obtained from soil showed anti-QS activity against *Serratia marcescens*. We followed the 'soft agar overlay protocol' developed by McLean et al. based on pigmentation inhibition to rapidly screen for the presence of potential QSI by rare actinomycete isolates (37). However, in our assay, instead of *Chromobacterium violaceum* we used *Serratia marcescens*, which produces a red pigment controlled by AHL-mediated QS systems, as an indicator organism for the screening of QSI (17).

Detection of PKSI, PKSII & NRPS genes. The bioactive actinomycete isolates from soil samples were screened using degenerate primers for the presence of PKS-I, PKS-II and NRPS genes. NRPS sequences were detected in 42.8% isolates, which is similar to that reported by Yuan et al. but more than Qin et al. and Lee et al. and less as compared to that of 68% reported by Pathom Aree et al. In this study, PKS I sequences were detected in 18.6% which is in agreement with that of Qin et al., Lee et al. and Pathom Aree et al., but much less than that reported by Yuan et al. Also, PKSII detection was observed in 30.7% isolates, slightly lower than that found by Yuan et al. and Lee et al. but higher than Qin et al. (3, 34, 35, 38).

Some isolates such as MMS9, KCR3, MMS16, MMS17, DCT14, and MBS9 exhibited antibacterial activity against test organisms and these correlated well with successful amplification of either one or more of the targeted genes from the genomes of the isolates. It can be inferred that these isolates contain at least one complete biosynthetic gene cluster for bioactive secondary metabolite production.

In this study, some actinomycete isolates such as ACM7, MMS6, DCT11, MMS22 and NCD9 exhibited antimicrobial activity but no amplification products. The absence of PCR amplicons in these isolates suggests the lack of the biosynthetic genes

although this assumption can not be conclusive. According to Wood et al. (39) this might be as a result of variations in primer target sequences preventing the primers from binding efficiently. A limitation in this kind of study is that the design of degenerative primers is based on the available sequences in the GenBank of more abundant and well-studied organisms such as *Streptomyces*, unlike the rare actinomycetes that have few available sequences on their biosynthetic gene clusters in database library. Some isolates such as MMS12, DCT7, DCT13 and CTS5 did not exhibit activity but there was amplification of the biosynthetic gene cluster. Not all biosynthetic gene clusters are involved in the biosynthesis of bioactive secondary metabolites (40, 41). It is also possible that the genes detected by PCR are non-functional or the isolates in question might have different nutritional requirements for the production of bioactive secondary metabolites (3). Also, Wood et al. concluded that positive PCR amplification does not indicate that the genes are expressed nor does it show that the strain possesses the full suite of biosynthetic gene cluster for the biosynthesis of that class of antibiotic. The detection of all the three genes in some isolates such as MMS1, MMS9 and DCT14 are indicators of their potential natural product diversity and divergent genetic evolution.

Physicochemical screening. Physico chemical screening using UV-visible spectroscopy and TLC was used to detect the ability to produce polyketides and peptides by rare actinomycetes. A λ max of 417 nm, 447 nm and 532 nm indicates the polyketide nature of the bioactive compounds. An additional peak of 288 nm is indicative of an aromatic nucleus in the structure indicating that the polyketides may be Type II polyketides (22). UV-visible spectral studies have been used to predict the nature of compounds by comparing data with available literature. On this basis isolates MMS8, MMS10, MBS6, MMS16, ATP6, ATP10, MMS20, MBS8 and MBS9 were found to be aromatic polyketide producers. Almost all the types of aromatic polyketides contain sugars attached to their chromophore in their structure (42). Thus the presence of sugars in the metabolite fingerprinting of these isolates indicates that they might be potential aromatic polyketide producing species. Also the extracts of isolates MMS8, MMS10, MBS6, MMS16, ATP6 and MBS9 were found to be pH sensitive further confirming that they may be anthracyclines, a class of type II polyketides (22). The extracts of ATP10, MMS20 and MBS8 were not pH sensitive indicating that they can be other type II polyketides like tetracenomycins or tetracyclines. Except isolate MMS10, in all these isolates the amplification of gene for PKS II was also observed.

Many researchers have used this technique to screen organisms for polyenic antifungal compounds, which are type I polyketides (7). The spectral data of the extracts of isolates MMS9, MMS13, MMS15, DCT11, ACM9, DCT12 and DCT15, MMS21 and NCD11 was consistent with those obtained by Maleki et al. and Ilic et al. (43, 44). UV spectral data of the extracts of isolates KCR3, MMS14, SMS, MMS17, PBS4 and NCD10 exhibited strong absorption maxima at 250-270 nm, which corresponds to the characteristic absorption of a peptide bond. A peptide antibiotic cerein, obtained from *B. cereus* shows UV absorption maxima at 198, 255 and 273 nm and weak absorbance peak at 250 and 273 nm. Further, chlorine o-dianisidine that reacts with peptides was used to find peptide-producing strains. Positive reaction of TLC spots of extracts of isolates KCR3, MMS14, SMS, MMS17 and NCD10 with chlorine o-dianisidine reagent suggested they are peptides and the absence of coloration of the TLC spots with ninhydrin further suggested that they are cyclic (23).

CONCLUSION

This study led to the isolation of nine strains each of type I and type II polyketide producers, and six strains of peptide producers. The combined strategy of molecular and physicochemical screening along with bioactivity guided screening was found to be an effective approach in looking for polyketide and peptide producing rare actiomyceytes. The extract of isolate KCR3, a peptide and that of isolate NCD10, a polyketide was found to possess anti tumor activity exhibiting an IC_{50} value of 3 µg/ml and 2.5 µg/ml against HeLa cells. These compounds can serve as potential candidates for development as chemotherapeutic drugs for the future.

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CORYNANDRA CHELIDONII VAR. *PALLAI* (REDDY AND RAJU) V.S. RAJU; - NEW ADDITION TO THE ANGIOSPERMIC FLORA OF MAHARASHTRA, INDIA.

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ABSTRACT:
Field survey resulted in collection of *Corynandra chelidonii* var. *pallai* (Reddy and Raju) V.S. Raju, of family Cleomaceaeas a new addition to the flora of Maharashtra State with recent literature of classification system. The paper also envisages brief citation, description, flowering and fruiting time followed by ecological notes.

Keywords: *Corynandra chelidonii*, diversification, taxonomic literature and Phenology.

INTRODUCTION:

In the recent years there are some new additions were reported to the Flora of Maharashtra State such as *Juncus bufonius* L. (Lekhak et al., 2011), *Premna mollisima* Roth. (Paithane andBhuktar 2013); *Hedychium flavescens* Carey ex Roscore (Jadhao *et al.*, 2014); *Physalis pruinosa* L. (Somkuwar *et al.* 2014); *Amomum maximum* Roxb. And *Zingiber capitatum* Roxb. var. elatum (Roxb.) Baker.(Govekar and Sardesai 2015); *Opilia amentacea* Roxb. (Somkuwar *et al.* 2015); *Amorphophallus longiconnectivus* Bogner. And *Phyllodium longipes* (Craib) Schindl. (Gadpayale *et al.*, 2016) etc.

The genus Cleome was first described by Linnaeus in Species Plantarum, Vol. 2 (1753: 671) of family Cleomaceae is almost universally accepted from the past 140 years (e.g. Hooker and Thomson 1872, Cooke 1903, Sundararaghavan 1993, Reddy and Raju 2001 and Kers 2003) with approximately 250 accepted species (Mabberley 2008 and The Plant List 2018) in the world (Cooke 1903).

Recently available literature of Iltis and Cochrane (2007, 2014) represents the division of Cleome s.l. into a number of segregate genera. According to Cochrane and Iltis (2014), the genus *Corynandra* Schrad.exSpreng., based on *Corynandra chelidonii* (L. f.) Cochrane and Iltis (Cleome chelidonii L. f.) which is re-established with other four combinations as *C. felina* (L. f.) Cochrane and Iltis, *C. flava* (Banks ex DC.)Cochrane and Iltis, C. viscosa (L.)Cochrane and Iltis and C. viscosa subsp. nagarjunakondensis (Sundararagh.)Cochrane.

In relation to this some worker as Russell L. et. al. (2017) in resolving generic boundaries in Indian-Australasian Cleomaceae: Circumscription of Areocleome, Arivela, and Corynandra as distinct genera and Feodorova, T. A. *et al.* (2010) provides molecular data for the diversification and the origin of C4 in Cleome (Cleomaceae) which also explore and concrete the opinions of Cochrane and Iltis (2014) which is represented by 18 species in India (Sundararaghavan 1993) and 12 species in Maharashtra state (Flora of Maharashtra state by BSI, Vol-I, 2000) including recent discovery of *Corynandra elegans* Chandore, U.S. Yadav and S.R. Yadav (2016).

In the present work *Cleome chelidonii* L. f. is now considered as *Corynandra chelidonii* (L. f) Cocharane and Iltis. (2014) which is also consider by Subhash Sirangi and Ajmeera Ragan (2017) in their study of Dormancy and in-vitro seed germination of *Cleome chelidonii* var. pallai C.S. Reddy and V. S. Raju (2001) as *Corynandra chelidonii* var. pallai (reddy

and raju) V.S. Raju, ined. [(V.S. Raju, per. comm.) (2017)].

There is no any information in any regional flora and taxonomic literature about the occurrence of this species in Maharashtra State; hence this article is about the first time reporting of *Corynandra chelidonii* var. pallai (Reddy and Raju) V.S. Raju for the Angiospermic flora of Maharashtra State, India.

METHOD AND MATERIAL:

Field explorations were made in Eastern region of Maharashtra State, India to collect specimens in different seasons (2015 to 2018) in order to record the actual and essential key characters of specimens in reproductive and vegetative phases. Herbarium specimens were prepared and all relevant data were recorded in a field book along with photographs.

Taxonomic treatment for *Corynandra chelidonii* var. pallai (reddy and raju) V.S. Raju (SubhashSirangi and Ajmeera Ragan 2017; Reddy, C.S. and Raju, V.S 2001, a new variety of *Cleome chelidonii* L. f. Cleomaceae, Journal of Economic and Taxonomic Botany 25: 217–218).

RESULTS AND DISCUSSION

Erect, annual herb, much branched up to 1.5 m high; internodes to 12 cm. Basal leaves 3–5 foliate; leaflets up to 4-7 x 0.3-0.7 cm. lanceolate, cuneate at base, acute or rounded at apex margin crenate to crenate-serrate. Petiole 4- 8 cm, upper leaves 1–3 foliate; leaflets linear, base cuneate or rounded, apex acute, serrate. Petiole 2-4 cm. Flowers showy, pinkish or rosy in lax terminal corymbose racemes. Bracts foliaceous 1.5 mm long. Flower buds ovoid. Sepals elliptic, acuminate 1.5-2 mm. Petals ovate, 1.4- 1.7cm, rosy (pink). Stamens numerous (120–160); filaments 1.5- 1.8 cm, purple tinged. Ovary sessile, 8-10 mm long, glabrous.Capsule linear-cylindrical, narrow at the base, beak 5-10 mm long.Valves striate, parallel nerved, glabrous. Seeds many asymmetrical ovoid, comma shaped, compressed. 1.3–1.8 mm in diam. dark brown, central portion paler and smooth, cleft narrow, slightly coloured, about 0.5- 0.7 mm deep. Testa with scattered scales, bearing waxy coating, elaisome absent.

CONCLUSION:

Habitat: Margins of Lake and Stream.

Distribution: Kondha, Bhuyar, Shahapur, Kardha, and Khapari (Chichal) Dist.- Bhandara (Maharashtra) India.

Phenology: Flowering and fruiting: July–December.

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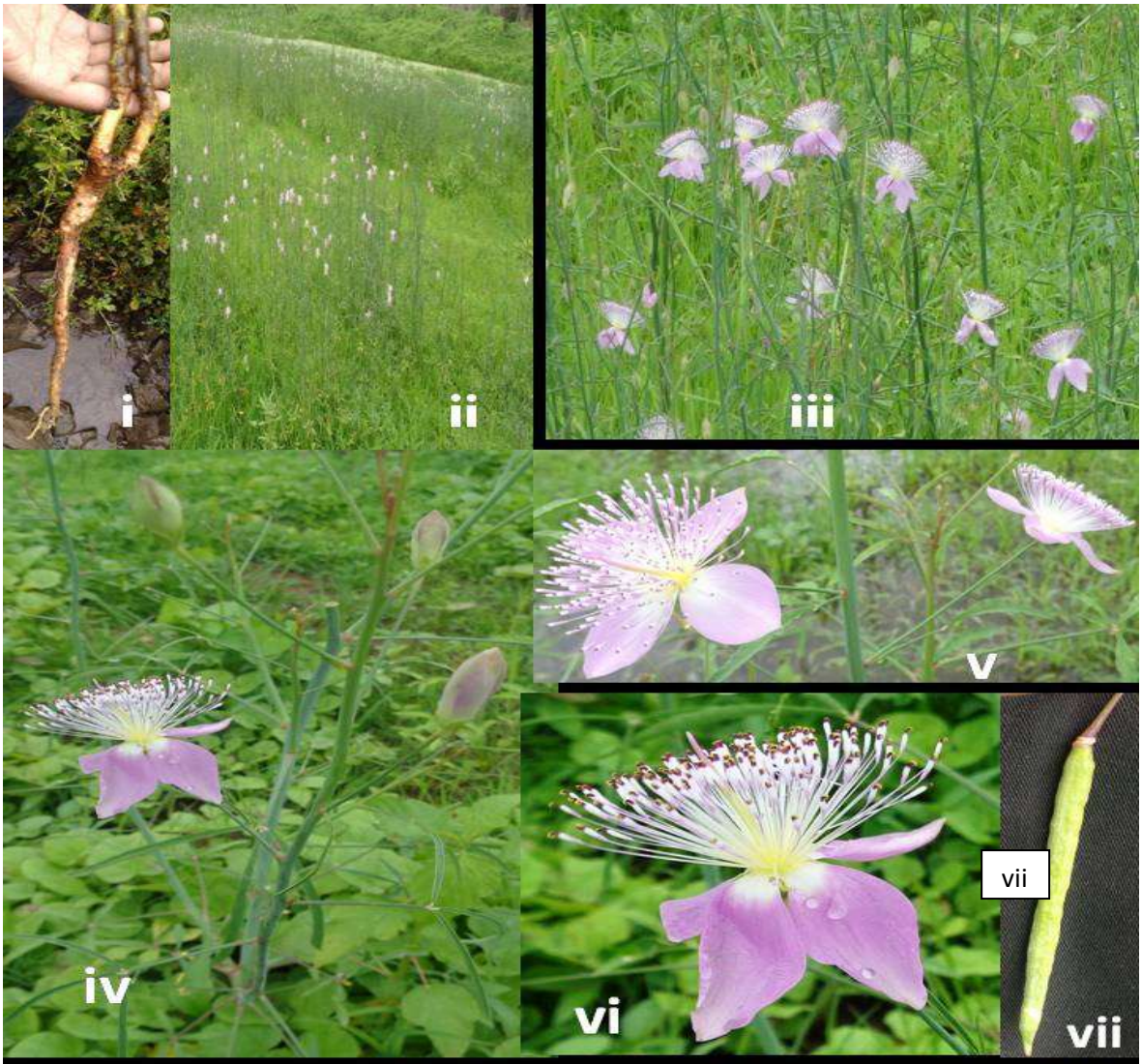

FIG.1- *Corynandra chelidonii* var. *pallai* (Reddy & Raju) V.S. Raju; i-Root view, ii- in habitat, iii- Flowering, iv- single twig with buds, v- flowering mode at node, vi- single flower, vii- fruit.

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PHYTOCHEMICAL SCREENING OF ROOT OF *ORTHOSIPHON RUBICUNDUS* (D. DON) BENTH

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Key Words: *Orthosiphon rubicundus* (D. Don) Benth, Phytochemical Screening, Lamiaceae.

Secondary metabolites in the plants are chemically active compounds (*viz.* flavonoids, alkaloids, terpenoids, steroids, saponins etc.), which are produced in response to stress. They are known for complexity in the structure with restricted distribution in various plant parts (Keeling and Bohlmann, 2006; Visweswariet. et al., 2013). Present communication deals with the occurrence of phytochemicals present in the root of *Orthosiphon rubicundus* (D.Don) Benth, a well-known medicinal plant.

Roots of *Ortthosiphon rubicundus* were collected from wild habitat of Chandrapur. The roots were dried under shade. It was pulverized to a coarse powder and its extract was prepared using Soxhlet extractor, using hexane, ethyl acetate, dicholoromethane, ethanol and methanol as solvents. Presence of phytochemicals *viz.* volatile oils, alkaloids, glycosides, flavonoids, tannins and polyphenolic compounds, carbohydrates, terpenoids, fixed oils/fats, saponins, coumarine, gum and mucilages and cartenoids in the root samples of *Ortthosiphon rubicundus* were assessed following Trease and Evans (2002) and Sharaibi and Osuntogun (2017).

The results showed presence of flavonoid, steroid, alkaloid, volatile oils and carotenoids in ethyl acetate extract. Flavonoid, steroid, alkaloid and volatile oils were extracted in non polar hexane. Highly polar methanol solvent extracted phenol, tannins, flavonoid and steroids. Flavonoid, alkaloid and caretonoids were extraced in dichloromethane. Phenol, flavonoid and steroids were extraced in ethanol. Thus, *Orthosiphon rubicundus* showed presence of phytochemicals such as flavonoids, steroids, alkaloids, volatile oils and cartenoids through extractions in various non-polar to polar sovents.

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Table 1. Phytochemical screening of *Orthosiphon rubicundus* in different solvents.

Solvent/ Phytochemical	Hexane	Ethyl Acetate	Dicholoromethane	Ethanol	Methanol
Phenols	×	×	×	√	√
Tannins	×	×	×	×	√
Flavonoid	√	√	√	√	√
Steroids	√	√	×	√	√
Terpenoids	×	×	×	×	×
Alkaloids	√	√	√	×	×
Saponins	×	×	×	×	×
Coumarins	×	×	×	×	×
Mucilage	×	×	×	×	×
Volatile oils	√	√	×	×	×
Fixed oils & fats	×	×	×	×	×
Carotenoids	×	√	√	×	×

√ **:**Present; **× :** Absent.

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DEVELOPMENT AND CHARACTERIZATION OF CHEMICALLY IMPREGNATED BIO-ADSORBENT FROM *TAMARINDUS INDICA* SEED

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Abstract: A new bioadsorbent material was prepared by impregnation of carbonized *Tamarindus indica* seed in H_2SO_4 and NaOH followed by microwave treatment (MACTIS). Developed bioadsorbent was characterized using proximate and ultimate analysis. The element analysis of prepared bioadsorbent of *Tamarindus indica* seed shows 78.01 % carbon, 1.90 % hydrogen and 2.70 % nitrogen. The surface morphology and the chemical composition of MACTIS was analysed by SEM and EDX, respectively. EDX results of acid-base impregnated bioadsorbent of *Tamarindus indica* seed have 78.25 % of carbon by weight. The surface chemical nature of bioadsorbent and functional groups on the surface of the active carbon was studied by FT-IR and XRD. The Brunauer–Emmett–Teller (BET) surface area under nitrogen adsorption at -196^{0}C of prepared adsorbent was found 57.164 m^2/g. The present research work shows that acid-base impregnated bioadsorbent of *Tamarindus indica* seed could be employed as low cost bio-adsorbent in bioengineering process in the removal of toxic pollutants from waste water.

Keywords: Bio-adsorbent, Characterization, Impregnation, *Tamarindus indica*

INTRODUCTION:

In industrial processes, activated carbon is widely used as adsorbent due to its microporous, homogenous structure with high surface area and radiation stability [1, 2, 3]. The practice for producing efficient activated carbon is not fully investigated in developing countries. Moreover, there are several problems with the regeneration of used activated carbon [4]. At the moment, there is a great interest in finding inexpensive and effective alternatives to the existing commercial activated carbon (CAC) [5]. Development of effective and inexpensive activated carbon may add to environmental sustainability and put forward benefits for future prospect in commercial applications [6, 7]. The expenses of activated carbon prepared from bio waste materials are very low compared to the cost of CAC [8].

Many researchers[9-13] have been discussed the removal of pollutants such as dyes, heavy metals, phenols, pyridine, nitrobenzene, pesticides, biological active agents, dissolved and non-dissolved chemicals, radioactive substances, detergents, polychlorinated biphenyls and other organic hazardous chemicals plant and tree based waste materials. Plant/tree based waste materials that have been successfully used to manufacture activated carbon in the recent past include waste wood, bagasse, coir pith, orange peel, Moringa oleifera tree, coffee husk, pine cone, mango peels, rice husk, periwinkle shell, coconut shell, Imperata cylindrica leaf, rubber seed coat, banana stalk, groundnut hulls, ackee apple (Blighia sapida) seeds, oil palm fruit fibre, coconut tree, sunflower seed hull, pine-fruit shell, hazelnut husks, rice hulls, oil palm shell, Coconut husk, Tea leaves, Ficusreligiosa (peepal) leaves, Mangrove plant leaf, Azadirachta indica leaves, Manilkara zapota leaf, Manilkara zapota leaf, Polyalthia Longifolia leaf, lemon leaves, Curly Kale Leaves, Eucalyptus leaves, Polyalthia longifolia leaf, Acacia arabica leaves, Aloe vera leaves, biomass of Tinospora cordifolia plant, Eichhornia crassipes Biomass, Tridax procumbens leaves, Tridax procumbens leaves, Terminalia chebula leaf, Shorearobusta leaf, Tamarindus indica fruit shell, Citrus limetta peel, Arachis hypogaea shell, Lagenaria Siceraria shell, Citrus documana fruit peel, Citrus medica fruit peel, Citrus aurantifolia fruit peel, Banana peels, Walnut Shell, cashew nut shell, palm kernel-shell, Betel nut coir, Lapsi (Choerospondias axillaries) seed, Phyllanthus emblica seed, Seed extracts of Moringa Oleifera, Guava seeds, Punica granatum seed, Phoenix Dactylifera (Date Plam) seeds, Cuminum cyminum seeds, Almond tree (Terminialia cattapa) bark, Vitex negundo plant bark, Drumstick (Muringa odecifera) tree bark, Acacia nilotica tree bark, Morringa Indica bark, Acacia Auriculiformis scrap wood char, stalks of Sorghum and Canola [14-18].

Tamarindus indica, belongs to the family Leguminosae (Fabaceae), commonly known as Tamarind tree, is one of the fruit tree species that is used as traditional medicine [19]. Tamarindus indica (T. indica) is evergreen tree that can reach 24 m height and 7 m girth that has pale yellow and pink flowers [20]. Tamarind tree is found especially in the Indian subcontinent, Africa, Pakistan, Bangladesh, Nigeria and most of the tropical countries. Every part of Tamarindus indica plant (root, body, fruit and leaves) has rich nutritional value and broad medicinal usage. It also has industrial and economic value. World Health Organization report specifies, tamarind fruit is an optimal source of all essential amino acids except tryptophan (82%) [21, 22] and it also contains phenolic compounds like, procyanidin B2, mucilage, catenin, tartaric acid, arabinose, xylose, galactose, pectin, epicatechin, glucose, triterpen and uronic acid [23].

Present investigation marks the characterization of treated Tamarindus indica seed. The objective of this paper is to develop and analyze the bulk density, moisture content, volatile matter, ash content, pH, fixed carbon content by proximate analysis and by elemental, BET surface, EDX, SEM, FTIR and XRD analysis.

MATERIALS AND METHODS :

Preparation of adsorbent

All the chemicals used were of analytical reagent grade purchased from Merck. India Pvt. Ltd. and Sd. Fine Chemicals, and all solutions were prepared by using double distilled water throughout this study. Tamarindus indica seeds were collected from the local area and washed several times with water to remove dust and other impurities. Then air drying, it was ground using domestic mixer and sieved to 300 mesh size. The sample was washed with distilled water to remove colour and dried in an oven at 80^0C for 24 hours. The dried Tamarindus indica seed powder was carbonized on muffle furnace for 5 Hours at 500°C. This carbonized seed powder again activated in domestic microwave (900MW) by one minute intervals for 30 minutes. The microwave assisted carbonized Tamarindus indica seed then impregnated with 0.5 N sodium hydroxide and 0.5 N sulphuric acid for 24 hours respectively and washed with deionised water to remove colour and other impurities. This MACTIS was dried at 110^0C in vacuum oven for 24 hours, grind well and kept in air tight plastic bottles for further use.

Physico-chemical Characterization of adsorbent

Proximate analysis

Physico-chemical parameters such as pH, bulk density, moisture, ash, volatile matter, fixed carbon, water and acid soluble matter of MACTIS were analysed. The results of ultimate analysis obtained were presented in Table 1. The pH for the activated MACTIS bio-adsorbent was determined using the Elico pH meter, model LI-120, other parameters were analyzed by using standard test methods [24-26].

Ultimate analysis

The Brunauer-Emmett-Teller (BET) surface area pore characteristics were determined using computer-controlled nitrogen gas adsorption analyzer at -196^0C by Quanta Chrome Nova-1000 surface analyser instrument. The elements C, H, N and S were analysed by using Elementar Vario EL III model (C-H-N Analyser). The examination and analysis of microstructure morphology of MACTIS was recorded by using Scanning Electron Microscopy (SEM), (JEOL Model JSM - 6390LV). Electron dispersive X-ray (EDX) (JEOL JSM-7600F FEG-SEM model) was used for the element and chemical characterization of the activated MACTIS. The spectral analysis was done by Fourier Transform Infrared Spectrophotometer (FTIR) (Thermo Nicolet, Avatar 370) with KBr. FTIR spectra were recorded between 4000 and 400 cm^{-1}. The FTIR spectra give information about the characteristic functional groups on the surface of activated MACTIS bio-adsorbent. The Structural integrity of the bio-adsorbent samples was checked by Powder X-ray diffraction (XRD) by Bruker AXS D8 Advance difractometer using Cu Kα radiation (λ=1.5406 A°).

RESULTS AND DISCUSSION :

Physico-chemical characterization

The physico-chemical characterization i.e. proximate and ultimate analysis results of chemically activated microwave assisted carbonized Tamarindus indica seed (MACTIS) are presented in Table 1 and 2. The moisture, ash and volatile matter contents tended to be low and the lower values of ash content, water soluble and acid soluble matter results favour the good adsorbent characteristics showing that bio-adsorbent was properly prepared. During carbonization and activation processes, organic substances become unstable as a result of the heat causing the molecules to break their bonds and linkages. During activation process, volatile matter is released as gas and liquid by-products which evaporate off leaving a material with high carbon content [27]. The results of proximate analysis and elemental analysis indicated that the chemical activation has successfully increased the carbon content and decreased volatile matter. The Brunauer-Emmett-Teller (BET) surface area, average pore diameter and total pore volume were found to be 57.164 (m^2/g), 63.433 (A^O) and 0.172 (cc/g) indicated that MACTIS biomaterial should be an excellent adsorbent. The pH of MACTIS bio-adsorbent has slightly acidic nature (6.85).

Table-1 : Proximate analysis

Sr. No.	Parameters	Values
1	Bulk density (gm/cm^3)	0.5992
2	Moisture content%	2.87
3	Ash content %	6.24
4	Volatile matter content %	9.36
5	Fixed carbon content %	81.53
6	pH	6.85
7	Water Soluble Matter (%)	0.76
8	Acid soluble matter (%)	1.54

Table -2 : Ultimate analysis

Sr. No.	Parameters	Values
1	Carbon %	78.01
2	Hydrogen %	1.90
3	Nitrogen %	2.70
4	Sulphur %	ND
5	Oxygen %	17.39
6	Surface Area (m^2/g)	57.164
7	Average Pore Diameter (A^O)	63.433
8	Total Pore Volume (cc/g)	0.172

Scanning Electron Microscopy (SEM) study

SEM micrographs were studied for surface and morphological characteristics of MACTIS bio-adsorbent (Fig.-1 and 2). The assessment of the SEM micrographs showed that in micrographs, dark areas indicated pores and grey areas indicated the carbon matrix and showed rough surface of the adsorbent that provided large surface area for adsorption. The surface structures of precursor were rough and uneven. Largely, a well-built porous surface was observed at higher magnification, and further, randomly distributed pore size was observed in the micrographs due to the modification using an activating agent and microwave treatment.

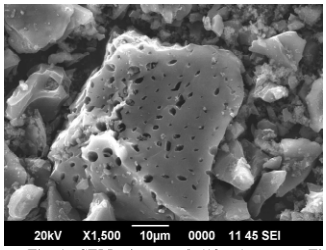


Fig.-1 : SEM micrograph (10µm)

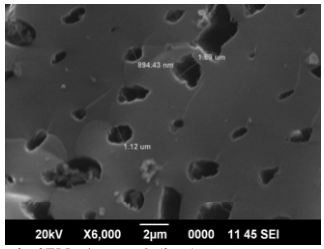


Fig.-2 : SEM micrograph (2µm)

Electron Dispersive X-ray (EDX)

The EDX analysis highlighted the presence of elemental percentage compositions of carbon, oxygen and other elements in the MACTIS bio-adsorbent. The EDX result of MACTIS reported in Tables 3 showing amount of different elements in the samples. The sample with the highest amount of carbon and the least amount of oxygen is said to be the most effective. It was observed that the MACTIS bio-adsorbent has the highest amount of carbon by weight (78.25%) and (85.19%) by atom and the lowest amount of oxygen by weight of carbon. Hence MACTIS can use as an efficient adsorbent for the removal of pollutants from aqueous solution.

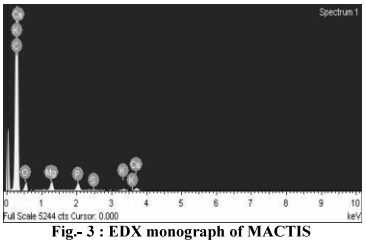


Fig.- 3 : EDX monograph of MACTIS

Table-3 : EDX analysis results

Element	Weight %	Atomic %
C K	78.25	85.19
O K	14.25	11.64
Mg K	2.24	1.20
P K	2.32	0.98
S K	0.32	0.13
K K	1.11	0.37
Ca K	1.51	0.49

Fourier Transform Infrared (FTIR) spectra

The FTIR technique is an important tool to identify the characteristic functional groups present in the adsorbent. The different functional groups in MACTIS bio-adsorbent were observed by FTIR spectra (Fig.-4). The number of peaks represents the adsorptive nature of MACTIS. The peaks in the region 3700 to 3400 cm^{-1} is due to the presence of –O-H and –N-H stretching vibrations. The peaks in the region 2900 to 2500 cm^{-1} represents the $–CH_2$ symmetrical and asymmetrical stretching. The peak region from 1700 to 1400 cm^{-1} indicates the presence of –C=O group of ketones, esters and –C-O-C- of ether. The peaks due to –N-H deformation and bending were observed in the region 1400 to 1500 cm^{-1}. Around 1200 to 500 cm-1 region, peaks observed due to the presence of –C=S, -C-N, -C-O, -C-C- and –C-H stretching vibrations. On the basis of the FTIR, one can confirm the potential applicability of MACTIS as a bio-adsorbent material.

Powder X-ray diffraction (XRD)

Figure-5 shows the XRD pattern of the MACTIS bioadsorbent material. The activated carbon exhibited peaks at around $2\theta = 25^0$ to 29^0 which correspond to the peak of graphite [28]. The powder XRD signals exhibits noise, reveals that a predominantly amorphous structure of carbon. In this result, it can be explained that the pyrolytic reaction of organic compounds consists of the breaking of chemical bonds with temperature and condensing further into active compounds. These compounds form typical graphitic layers and stacks of planes during carbonization [29]. Thus, the MACTIS carbon material has a completely amorphous structure, which is expected for organic materials.

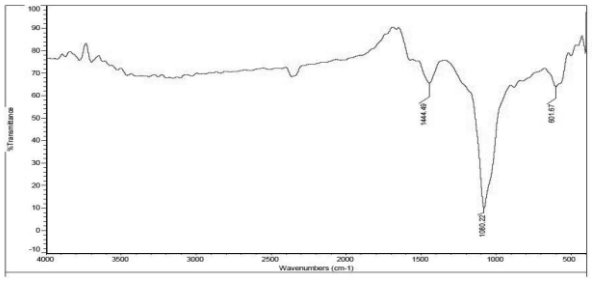
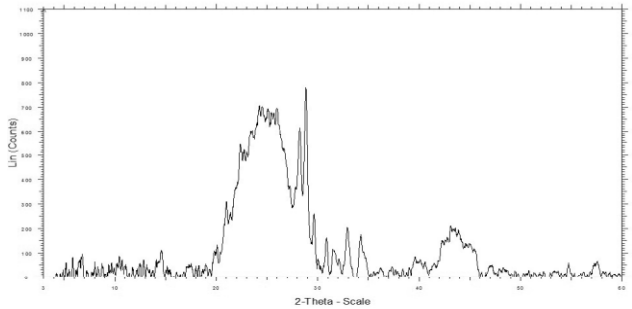


Fig. 4 : Fourier Transform Infrared (FTIR) spectra of MACTIS



Fi . 5 : Powder X-ra diffraction XRD of MACTIS

CONCLUSION :

: In this article, a new chemically impregnated and microwave assisted carbonized Tamarindus indica seed (MACTIS) activated carbon prepared. The developed bio-adsorbent material was characterized by proximate analysis such as bulk density, moisture, ash, volatile matter, fixed carbon content, water soluble and acid soluble matter and ultimate analysis such as elemental analysis, BET surface area, average pore diameter, total pore volume, EDX, SEM, FTIR and XRD. Tamarindus indica seed (MACTIS) is a potential precursor adsorbent due to its high carbon content, low moisture and ash content. The irregular pores are presents on the surface of bio-adsorbent indicate the feasibility of binding sites. The FTIR analysis confirmed the presence of different functional groups on the surface of adsorbent. The results of the present investigation show that MACTIS is a good precursor for preparation of potentially useful low cost adsorbent. In conclusion, Tamarindus indica seed can suitably considered as an alternative material for the removal of pollutants such as dyes, heavy metals, organic pollutants, biological active agents and other hazardous chemicals.

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RESEARCH ARTICLE

Analysis of Groundwater Quality Parameters in Selected Villages of Arvi Region of Wardha District, Maharashtra

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ABSTRACT:
Water is extremely essential for survival of all living organisms. Groundwater is one of the most useful water sources for drinking and domestic uses. Contamination of such water sources is a big problem for health. Ten groundwater samples were collected from ten different villages from Arvi region of Wardha District of Maharashtra. The physico-chemical parameters such as temperature, pH, electrical conductivity (EC), total dissolve solid (TDS), total alkalinity, calcium hardness, magnesium hardness, sodium, potassium, chloride, sulphate and nitrate were analyzed and the results were compared with water quality standards prescribed by ISI and WHO.

KEYWORDS: Physico-chemical parameter, Groundwater, Open well, Arvi.

INTRODUCTION:

Water is one of the most important natural resources and a prerequisite for sustenance of life. Exploitation of water resources to meet the demand of agricultural products with the exponential population growth and equally supported by industrialization and urbanization put ground water resources under great threat both in terms of quality as well as quantity [1]. Water pollution are mainly due to contamination by foreign matter such as microorganism, chemicals, industrial or other wastes or sewage which deteriorate the quality of the water and render it unfit for its intended uses[2].

The groundwater quality in any area is a function of its physical and chemical parameters which in turn are highly influenced by geological formations, climatic conditions and anthropogenic activities [3]. Hence determination of groundwater quality is important to observe the suitability of water for particular use. A number of water analysis experiments are regularly conducted by different groups of chemists and biologists across the country [4, 5, 6, 7, 8, 9]. The present groundwater quality analysis focused to examine the groundwater quality parameters such as temperature, pH, electrical conductivity (EC), total dissolved solids, chloride, total alkalinity, calcium and magnesium hardness, sodium, potassium, sulphate and nitrate from well water samples collected from ten villages of Arvi region of Wardha district, Maharashtra.

MATERIAL AND METHOD:

All the chemicals used were of AR grade. Double distilled water was used for the preparation of reagents and solutions. In this study ground water (open well

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water) samples from ten different villages (Table-1) located in Arvi region of Wardha district were collected in polyethylene containers of 1 L capacity for physico-chemical characterization [10].

Table 1 : Description of water sampling sites

Water Samples	Water Source	Location (Villages)
S_1	Open well	Dhanoli
S_2	Open well	Choramba
S_3	Open well	Dighi
S_4	Open well	Wadgaon
S_5	Open well	Gaurkheda
S_6	Open well	Bothali
S_7	Open well	Bodad
S_8	Open well	Rohna
S_9	Open well	Salphal
S_{10}	Open well	Verul

The major groundwater quality parameters considered for the analysis in this study are temperature, pH, electrical conductivity (EC), total dissolve solid (TDS), total alkalinity, calcium hardness, magnesium hardness, sodium, potassium, chloride, sulphate and nitrate [11]. Temperature, pH, T.D.S. values were measured by water analysis kit and manual methods. Calcium and magnesium hardness of water was estimated by complexometric titration method [11]. Chloride contents were determined volumetrically by silver nitrate titrimetric method using potassium chromate indicator [12]. Sodium and Potassium values were determined by Flame photometer. Sulphate and Nitrate contents were analyzed by UV-Visible spectrophotometer.

RESULTS AND DISCUSSION:

The groundwater (well water) samples of all ten experimental sites were analyzed for various physico-chemical parameters viz. temperature, pH, electrical conductivity (EC), total dissolve solid (TDS), total alkalinity, calcium hardness, magnesium hardness, sodium, potassium, chloride, sulphate and nitrate at all ten study sites, which are described groundwater quality can be seen in Table 1. The results of the samples vary with different collecting places because of the different nature of soil contamination [12]. All metabolic and physiological activities and life processes of aquatic organisms are generally influenced by water temperature. In the present study temperature ranged from 26.2-27.3^{0}C. The pH values of drinking water is an important index of acidity, alkalinity and resulting values of the acidic-basic interaction of a number of its mineral and organic components. In the present study pH ranged from 7.6 to 8.5, which lies in the range prescribed by APHA and ISI [13, 14]. Electrical conductivity (EC), values were observed in the range of 0.52 to 1.56 mmhos/cm. EC values were found within ISI limit except sampling site S8 indicating the presence of high amount of dissolved inorganic substances in ionized form. According to WHO and Indian standards, TDS values should be less than 500 mg/L for drinking water. In the present study TDS ranged from 272 mg/L to 889 mg/L. In the present study four samples S2, S3, S4 and S8 exceed the range suggested by WHO and Indian standards [14, 15]. Total Alkalinity is a total measure of substance in water that has "acid-neutralizing" capacity. The main sources of natural alkalinity are rocks which contain carbonate (CO_3^{2-}) , bicarbonate (HCO_3^{1-}) and hydroxide(OH^{1-}) compounds; silicates(SiO_4^{3-}) and phosphates(PO_4^{2-}) may also contribute to alkalinity. Total alkalinity values for all ten tested samples were found to be greater than the value prescribed by ISI [14]. In the present study total alkalinity ranged from 268-528 mg/L. The limits of calcium and magnesium have been prescribed in the range 75-200 mg/l and 50-100 mg/L respectively [16]. In the present investigation, calcium concentration ranged from 21 mg/L to 360 mg/L and found above prescribed limit in sample S2 according to ISI. Calcium is needed for the body in small quantities, though water provides only a part of total requirements [16].

Magnesium content in the investigated water samples was varied from 89 mg/L to 157 mg/L, which lies in the range prescribed by ISI. Sodium and potassium contents in the investigated water samples were varied from 16.7 mg/L to 102.8 mg/L and 0.6 mg/L to 3.1 mg/L respectively. The chloride content in the samples is in between 8.5 to 263.7 mg/L. Natural water contains low chloride ions. The findings indicate that all water samples were within the desirable limits of chloride in drinking water, prescribed by Indian Standard Index [15]. The concentration of sulphate in water sample is observed to be within the limit prescribed [14] for sulphate content and it varies from 13.3 mg/L to 28.3 mg/L. The high concentrations of sulphate may induce diarrhea [4]. Nitrate nitrogen is one of the major constituents of organism along with carbon and hydrogen as amino acids, protein and organic compounds in the ground water [5]. In the present study, nitrate nitrogen levels show within the prescribed values ranging from 0.67 mg/L to 2.13 [14].

CONCLUSION:

The values of all groundwater quality parameters were found within the permissible limits of the WHO and ISI guideline for drinking water and also within Indian standard limits but in some villages ground water were found to have even higher as compared to standard limit. In conclusions from the results of the present study it may be said that the ground water of Arvi region is though fit for domestic purpose but drinking water need treatments to minimize the contamination. Hence, regular and quantified monitoring of water quality parameters of groundwater will be useful for sustainable water management.

Table 2 : Groundwater quality parameters of villages located in Arvi region of Wardha district.

Water Parameters	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
Colour	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Temperature ^{0}C	26.2	27.2	26.5	26.8	27.3	26.8	27.1	26.5	27.3	27.3
pH	8.1	7.6	8.3	8.5	7.7	7.6	7.4	7.8	7.6	8.2
EC (mmhos/cm)	0.75	0.95	0.98	1.06	0.52	0.63	0.86	1.56	0.87	0.65
TDS (ppm)	376	525	504	565	272	342	442	889	443	286
Total Alkalinity (ppm)	413	341	483	528	277	341	407	410	332	268
Ca-Hardness(ppm)	163	360	158	94	171	155	129	21	192	144
Mg-Hardness(ppm)	128	103	98	134	121	89	134	157	146	89
Sodium (ppm)	49.1	43.7	97.4	102.8	25.8	21.6	69.3	16.7	23.6	19.8
Potassium (ppm)	2.4	3.1	0.8	1.3	0.8	1.8	0.6	2.8	0.8	1.9
Chloride (ppm)	35.4	70.9	39.7	59.3	8.5	14.5	53.8	263.7	57.4	17.3
Sulphate(ppm)	21.7	13.3	28.3	13.9	22.5	17.6	16.6	21.7	23.1	15.5
Nitrate (ppm)	0.67	1.12	0.96	2.13	1.97	0.82	1.94	0.93	1.13	0.88

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ADSORPTION OF PHOSPHORIC ACID ON PULSES HUSK BIO-ADSORBENT AND VERIFICATION OF FREUNDLICH AND LANGMUIR ADSORPTION ISOTHERMS

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Abstract : *A* — This paper reports an investig ation on the adsorption of phosphoric acid onto activated carbons prepared from Pulses husk. The activated carbons were prepared by chemical activation method. The adsorption data were well described by the Langmuir and Freundlich adsorption methods. . A variety of adsorbents are available naturally- bagasse, rice husk, neem bark, clays etc. that can be used to remove acids from the discharged waste. In this review, we look at the various adsorbents available particularly Pulses husk and see how effectively they can be utilized to meet our requirements. The acid removal process followed Freundlich isotherm in most of the cases and in few investigations, it followed Langmuir.

Key words: Adsorptions, Phosphoric acid, Pulses Husk , bio-adsorbent, Freundlich, Langmuir isotherm .

INTRODUCTION:

Water pollution is the contamination of water bodies such as lakes, rivers, oceans, and groundwater caused by human activities[1], which can be harmful to organisms and plants which live in these water bodies.[2] Adsorption appears to be good for the treatment of effluents.[3] The first thing for an efficient adsorption process is the search for a low cost adsorbent with high adsorption capacity and second it should be biodegradable.[4] The activated carbon has been till now the most used adsorbent but is expensive to use on a large scale[5] and the idea of using natural. Acids include maleic and oxalic acids which results due to partial oxidation of phenol and its derivatives [6]. It has been reported that high levels of maleic and oxalic acids in potable water cause health problems to humans like kidney stones, Erosion of enamel and mouth, vomiting and hematemesis [7]. In that case elimination or lowering the levels of these acids in wastewaters is not optional. Adsorption method in the removal of lower aliphatic carboxylic acids from wastewater is, however, overwhelmingly recommended by the literature [8].Unfortunately the choice of a cost-effective adsorbent is big challenge. A good adsorbent is supposed to be cheap, abundant, with high carbon content. Activated carbon widely reported as a suitable adsorbent for the acids. Unfortunately it is expensive. In an effort to reduce the cost, an attention is now directed towards the use of agro wastes as sources of the activated carbons [9]. They are used in water treatment and in industrial applications such as in the extraction of metal ions, air handling, and purification,[10] the discoloration of food in the food industry and in the pharmaceutical industry. [11] Activated Pulses Husk Ash (RHA) were used as adsorbents for decolourisation. ARH Activated Pulses Husk was prepared from treated with nitric acid and RHA was collected directly from mill.[11] There adsorption capacity was evaluated for the decolourisation and adsorption of wastewater containing Phosphoric acid, The effect of system variables such as pH, contact time, initial concentration and adsorbent dose were investigated.[12] The result shows that efficient varies with the variation in adsorbate concentrations and adsorbent. [13] Color removal efficiency was found to be 88 % to 94 % at the dose of 20 g/l for ARH and 80 % to 95 % at the adsorbent dose of 2.5 g/l for RHA. The studies were carried out at Phosphoric acid concentration of 50 mg/l, 30 mg/l and 10 mg/l. On the basis of adsorption isotherm graphs, R-square values were determined and found to fit the adsorption data. The Linear, Langmuir and Freindlich adsorption isotherms are good fitted for the experimental data.[14]

Freindlich adsorption isotherm:

$$\log\left(\frac{x}{m}\right) = \log k + \frac{1}{n}\log p$$

Log(x/m) vs. log p is a straight line with slope= 1/n

Langmuir Adsorption Equation:.

$$\theta = \frac{KP}{1+KP}$$

Langmuir Adsorption Equation
This is known as **Langmuir Adsorption Equation.**

Calculation of Equilibrium Constant:

Langmuir proposed that dynamic equilibrium exists between adsorbed gaseous molecules and the free gaseous molecules. Using the equilibrium equation, equilibrium constant can be calculated.

$$A(g) + B(S) \underset{K_d}{\overset{K_a}{\rightleftharpoons}} AB$$

where K_a represents equilibrium constant for forward reaction and K_d represents equilibrium constant for backward direction.

According to Kinetic theory,

Rate of forward reaction = K_a [A] [B]

Rate of backward reaction = K_d [AB

The above equation represents the equilibrium constant for distribution of adsorbate between the surface and the gas phase.

MATERIALS AND METHODS :

Preparation of Adsorbent:

A weighed amount of Pulses husk charged into the furnace at a temperature of 300, 400, 500 and 600^{0}C for 0.5, 1.0, 1.5 and 2 h. The resulting charred material was collected and cooled at room temperature. The domain of variation of these factors is defined according to Bornemann *et al.,* [18]. A known amount of Pulses husk charcoal (10 g) was transferred in a beaker (250mL) and added 100 mL distilled water to it and continued adding water to it up to 200mL to completely soak the charring rice straw in beaker. When the charring Pulses husk completely settled down then decanted the distilled water and repeated this process for several times until the decanted water become cleared. Pulses husk charcoal was then filtered through ordinary filter paper and washed again with distilled water. Cleaned Pulses husk charcoal was dried in an oven to get a constant weight and stored as Pulses husk bio adsorbent.

Methods:

0.1 N phosphoric Acid solution was prepared by dissolving required amount of Phosphoric acid in 250 ml conical flask. **The given** NaOH solution was Standardize using phenolphthalein indicator. 6 clean reagent bottles with number from 1 to 5 were taken.1 g finely ground activated Pulses husk was taken in each bottle. These bottles were shake vigorously and kept for one hour. Filter each solution through filter paper and titrate 10 ml of each of them with 0.1N NaOH solution.

RESULTS AND DISCUSSION :

In our work we have try to determine adsorption of phosphoric acid on activated Pulses husk as a bio adsorbent. Different concentration of phosphoric acid solution we are prepared and determine the adsorption for 1 hr. contact time. From the table 1 we have determine the values of log x/m and log Ce the graph 1 of freindlich adsorption isotherm of phosphoric acid on Pulses husk the straight line is obtained. From the graph R^2, n, k values were determined. From the values it was observed that Freindlich adsorption is verified. Similarly, from graph 2 Ce/x/m vs. Ce of Phosphoric acid on activated Pulses husk , straight line is obtained. From the graph a, b, R2 were determined. This value shows the Langmuir adsorption is verified. Also, from table 3 the values of % adsorption vs. concentration graph 3 were plotted. From the graph it was observed that as the concentration of acid solution decreases % adsorption decreases. From graph 1 and 4 the Freindlich adsorption isotherm can be said to be good fit for the given experimental adsorption data, since the linear regression of log x/m is log Ce gave R^2value in the range of 0.99 for the different concentration of Phosphoric acid with Pulses husk adsorbents. Application of adsorbents for different effluents amplest understand the actual application of this adsorption method on the results obtained the experiments were conducted on different waste water samples collected from different industries. The activated Pulses husk and Pulses husk ash can be used as good adsorbent for selected effluent having specific concentration adsorbate (color/organic matter). Similarly, from graph 2of the Langmuir adsorption isotherm can be said to be good fit for the given experimental adsorption data, since the linear regression of Ce/x/m is Ce gave R^2 values in the range of 0.80 for the different concentration of Phosphoric acid with Pulses husk adsorbents. Application of adsorbents for different effluent samples. To understand the actual application of this adsorption method on the results obtained the experiments were conducted on different waste water samples collected from different industries. The activated Pulses husk and Pulses husk ash can be used as good adsorbent for selected effluent having specific concentration adsorbate (color/organic matter). From the table 3 Freindlich constant for phosphoric acid 'n' having value 0.950 and 'K' having value 22.80 and Langmuir constant 'a' having value 0.4822 and 'b' having value 37.03 indicate that both Freindlich and Langmuir adsorption isotherm is verified. From graph 3, it is concluded that the adsorption of acids decreases with decrease in concentration of acid. As the concentration of acid decreases from system 1 to 5 the adsorption of acid on Pulses husk adsorbent also get decreases. From the above all graphs we can conclude that having R^2 value greater than 0.70 indicate the adsorbent gives better adsorption of acids.

CONCLUSION :

The result of present study clearly shows that acid treated Pulses husk are effective in adsorption of acids. It is evident that experimental adsorption data for the adsorption of color in this research can be explained by more than one adsorption isotherms. The result shows that the R^2 values are closer to 1 for all adsorption isotherm plots. Thus, Linear, Langmuir and Freindlich isotherm models are good fitted to the experimental data. Thus full utilization of agro-waste and treatment of wastewater is one of the good prospective for good environment. The Pulses husk can be proved as good, effective and eco-friendly adsorbent. Pulses husk are cheap, less expensive in market. As it is a waste material of pulses after threshing of Pulse, generally it is available in free of cost. It gives better adsorption of acids so instead of activated carbon it is more beneficial for adsorption as an adsorbent.

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Table 1: Observation table for phosphoric acid.

Bottle No.	Vol. Of phosphoric acid sol. V (ml)	Vol. Of water (ml)	Amt of charcoal (mg)	Initial conc. Of phosphoric acid Co	Vol. Of filtrate taken V1 (ml)	Vol. Of NaOH sol required V2 (ml)	Eqn conc. Of phosphoric acid Ce	Phosphoric acid adsorbed X (g)	X/M	Log (x/m)	Log Ce
1	50	0	1	10	10	38.6	0.364	9.8471	9.8471	0.946	-0.4553
1	50	0	1	10	10	38.6	0.364	9.8471	9.8471	0.946	-0.4553
2	40	10	1	8	10	34.2	0.358	7.9857	7.9857	0.844	-0.4909
3	30	20	1	6	10	24.6	0.268	5.2491	5.2491	0.720	-0.6878
4	20	30	1	4	10	16.4	0.171	3.5144	3.5144	0.545	-0.8912
5	10	40	1	2	10	8.3	0.087	1.7385	1.7385	0.240	-1.0597

Table 2: Percentage adsorption for phosphoric acid on Pulses husk .

Concentration	Co	Ce	Co-Ce	Co-Ce/Co	% adsorption
0.5	10	0.3843	9.6157	0.98157	95.15
0.4	8	0.3381	7.6619	0.967738	94.77
0.3	6	0.2583	5.7417	0.94695	93.69
0.2	4	0.1617	3.8183	0.934575	93.45
0.1	2	0.08715	1.90785	0.923925	93.39

Table 3: Calculation of Freindlich and Langmuir constant.

	Phosphoric acid	constant	Phosphoric acid
N	0.920	A	0.4522
K	23.80	B	36.03
R^2	0.97	R^2	0.750

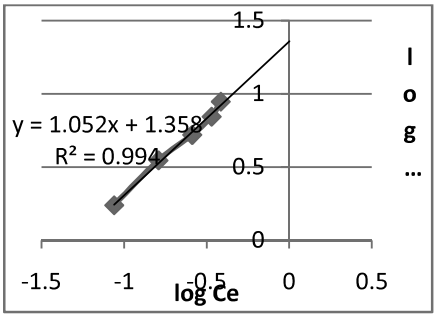


Figure 1: Verification of Freindlich adsorption isotherm of phosphoric acid on Pulses husk .

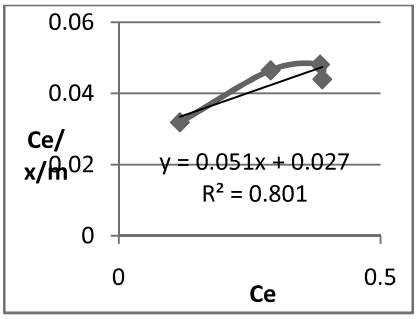


Figure 2: Verification of Langmuir adsorption isotherm of Phosphoric acid on Pulses husk adsorbent.

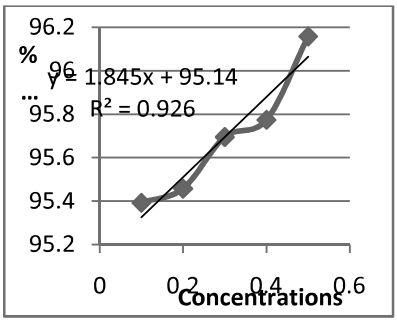
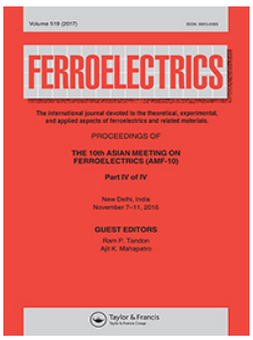


Figure 3: % adsorption vs. concentration of Phosphoric acid on Phosphoric Acid adsorbent



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Structural and magnetic properties of Al substituted nickel ferrite synthesized by sol-gel auto combustion method

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Structural and magnetic properties of Al substituted nickel ferrite synthesized by sol-gel auto combustion method

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ABSTRACT

Nanoparticals of Al substituted nickel ferrite were synthesized by microwave assisted sol-gel auto combustion method and characterised using X-ray diffraction (XRD), transmission electron microscopy (TEM) and vibrating sample magnetometer (VSM). The XRD revealed that the powders obtained are single phase with spinel structure belongs to Fd3m. The average crystallite size calculated using Debey-Scherrer formula found to be in the range of 11–18 nm which were counter verified by using TEM. The magnetic parameters of the synthesized samples were characterised by using VSM. The saturation magnetisation (M_s), coercivity (H_c) was found to decrease with the substitution.

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KEYWORDS
Nickel ferrite; sol-gel; XRD; saturation magnetization; coercivity

1. Introduction

Nickel ferrites have been under intense research as it possesses attractive properties for application as soft magnet and low loss material at high frequencies [1]. Aluminium substituted nickel ferrites are technically important due to their high electrical and low eddy current losses making them more suitable for microwave devices [2].

The structural and magnetic properties of substituted nickel ferrites have been studied by several investigators. Amiradadizadeh et al [3] have reported the decrease in saturation magnetisation and coercivity with increasing aluminium content in nickel cobalt ferrite. It is observed that the decrease is due to replacement of Fe^{3+} by Al^{3+} which weakens the sub lattice interaction. Pissurlekar observed the increase in magnetisation with increase in Zn concentration upto $x = 0.5$ and then decrease for higher Zn concentration in nickel ferite [4]. Singhal et al [5] reported increase in saturation magnetisation and decease in coercivity with increase in cobalt concentration in nickel chromium ferrite.

The present work deals with the synthesis of nanoparticles of aluminium substituted nickel ferrites via sol-gel auto-combustion method and investigation of their structural and magnetic properties by means of X-ray diffraction, TEM and VSM measurements.

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2. Experimental method

Nanoparticles of $NiAl_yFe_{2-y}O_4$ (y = 0.5, 1.5) have been synthesised by sol- gel auto combustion method. The stoichiometric amount of AR grade nickel, iron and aluminium nitrate was used while urea was used as fuel. The mixture of metal nitrate was dissolved in distilled water and the solution was then heated with constant stirring on the magnetic stirrer at 60°C. The wet gel produced fired in a specially designed microwave oven to get the resultant ash powder. The ashes of raw substances obtained were grinded in a pestle mortar for 4 hrs. Finally these samples were annealed at 800°C for several hours at a heating rate of 100° C/hr to get desired nano powder.

The structural characterization of the synthesized samples was carried out by Philips X-ray diffractometer (Model 3710) using Cu K_α radiation of wavelength $\lambda = 1.54$ Å at room temperature.

TEM micrographs were recorded by using transmission electron microscope (Philips model CM 200) to investigate powder morphology as well as grain size.

Magnetic measurements were performed by using commercial Lake – shore vibrating magnetometer (VSM). Magnetic hysteresis was measured at room temperature with maximum applied fields upto 15 KOe. The saturation magnetisation (M_s) and coercivity (H_c) were found from hysteresis loops.

3. Results and discussion

3.1. XRD analysis

The X-ray diffraction patterns of the samples were shown in Figure 1 and 2. The XRD pattern analyzed using X- Powder software and the crystalline phases were identified by comparison with reference data from the JCPDS card No. 520278 for Nickel ferrites ($NiFe_2O_4$). The XRD pattern reveals the single phase cubic spinel structure without any impurity peaks belonging to the space group Fd3m. The particle size of the synthesized ferrite samples has been calculated from the most intense peak corresponding to (311) using the classical Debey-Scherrer formula [6]. The values of the particle size, lattice constant deduced from the X-ray data are given in Table 1.

It was found that the lattice constant decreases with Al^{3+} substitutions. The decrease in the value of the lattice constant with Al^{3+} ion substitution can be explained on the basis of ionic radii. As the larger Fe^{3+} ions (0.67 Å) are replaced by smaller Al^{3+} ion (0.51 Å), the lattice parameter decreases. Similar trend were reported by K. V. Kumar [7].

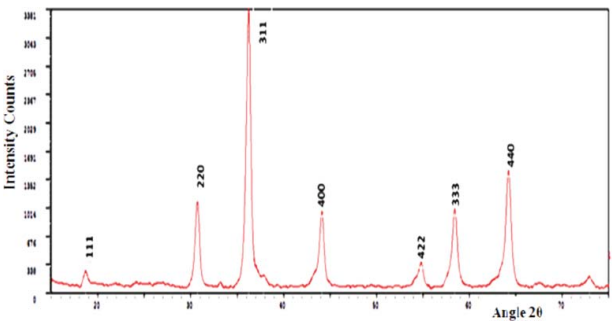

Figure 1. XRD pattern of Ni $Al_{0.5}$ $Fe_{1.5}$ O_4.

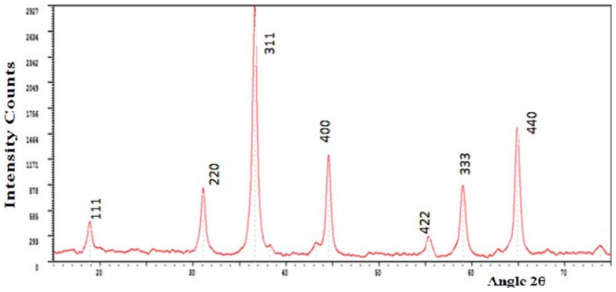

Figure 2. XRD pattern of Ni $Al_{1.5}$ $Fe_{0.5}$ O_4.

Table 1. Lattice parameters, particle size, coercivity and saturation magnetisation of $NiAl_yFe_{2-y}O_4$ (y = 0.5, 1.5).

Sr. no.	Compound	Lattice parameters a (Å)	Particle size (nm)	Coercivity H_c [O_e]	Saturation magnetisation on M_s (emu/g)
1.	Ni $Al_{0.5}$ $Fe_{1.5}$ O_4	8.2487	11.7	230.54	0.0861
2.	Ni $Al_{1.5}$ $Fe_{0.5}$ O_4	8.1243	18.2	234.66	0.0222

3.2. Transmission electron microscope (TEM) analysis

The particle sizes and morphology of $NiAl_{0.5}Fe_{1.5}O_4$ is shown in Figure 3. The particle size determined from TEM was found to be in close agreement with that obtained from XRD studies.

3.3. Magnetic properties

Figure 4 and 5 shows the hysteresis loops for Al^{3+} doped Nickel ferrite with the applied field of 15 KOe. The main magnetic data like saturation magnetisation (M_s), coercivity (H_c) are tabulated in Table 1. It is evident from fig and table that both saturation magnetisation and

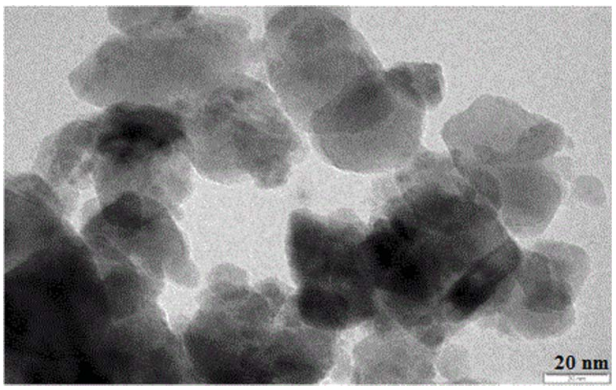

Figure 3. TEM photograph of Ni $Al_{0.5}$ $Fe_{1.5}$ O_4.

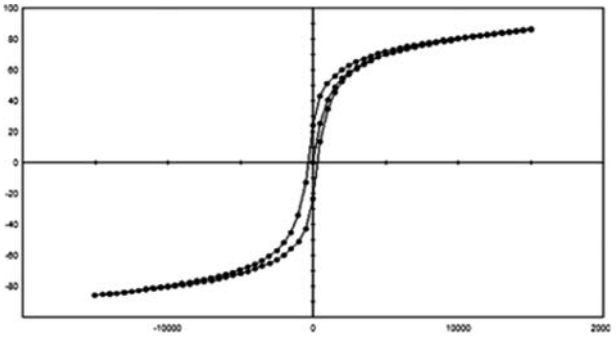

Figure 4. VSM of Ni $Al_{0.5}$ $Fe_{1.5}$ O_4.

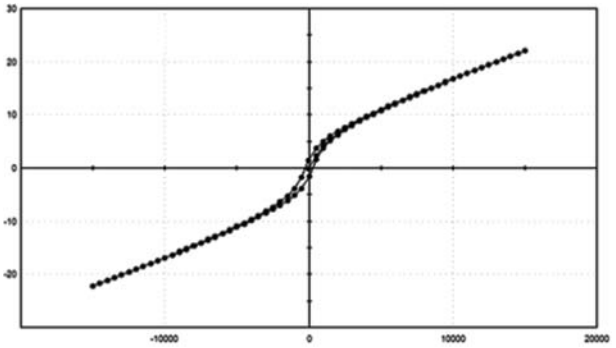

Figure 5. VSM of Ni $Al_{1.5}$ $Fe_{0.5}$ O_4.

coercivity decreases with the increase of Al^{3+} content.The observed decreased in saturation magnetisation could be explained on the basis of cation distribution and exchange interaction between tetrahedral (A) and octahedral (B) sites. Verma et al[8] using Mossbaure's experiment showed that on increasing Al^{3+} concentration, Al^{3+} ion goes to B-site of spinel structure replacing the Fe^{3+} ions from B-site to A-site. According to Neel's two sublattice model, there are three kinds of super exchange interactions in spinel ferrite i.e. A–A, B-B and A-B interaction. The A-B interaction strength is large than A-A and B-B. The net magnetic moment $M = M_B - M_A$ and large M results in higher saturation magnetisation. The substitution of non-magnetic Al^{3+} ion, which has a preferential B site occupancy result in the reduction of super-exchange interaction between A and B sites. The decrease in saturation magnetisation is due to migration of Fe^{3+} ions from B site (M_B) decreases. Therefore the net magnetisation on ($M_B - M_A$) decreases as observed by G. R. Kumar et al [9]. Coercivity decreases with increase in Al^{3+} ion concentration. It could be due to decrease in anisotropy field which is in turn decreases the domain wall energy [10].

4. Conclusion

Al substituted nickel ferrites with the chemical formula $NiAl_yFe_{2-y}O_4$ (y = 0.5, 1.5) have been successfully synthesized by sol-gel auto combustion method. The X-ray diffraction analysis confirmed the formation of single phase spinel structure. The crystallite size was found in the range of 11nm to 18 nm. The lattice parameter decreased with increase in Al

concentration. TEM analysis confirmed the measurements of nanosize by XRD data. The incorporation of non-magnetic Al^{3+} ions in nickel ferrite resulted in decrease of saturation magnetisation and coercivity because replacement of Fe^{3+} by Al^{3+} ions weakens the sub lattice interaction and lowers the magnetic moment of the unit cell.

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Impact of Al doping on structural and Magnetic Properties of Co-Ferrite

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Abstract

Nanocrystaslline Al doped cobalt ferrite CoAlyFe2-yO4 (y = 0.5, 1.5) powders have been synthesized by microwave assisted sol-gel auto combustion method and characterised using X-ray diffraction (XRD), transmission electron microscopy (TEM) and vibrating sample magnetometer (VSM). The XRD revealed that the powders obtained are single phase with spinel structure and crystallises to Fd3m space group. The calculated grain size from XRD data have been verified using TEM. TEM photograph shows that powder consists of manometer sized grains. It was observed that as Al^{3+} content increases the grain size and lattice constant decreases which attributed towards the influence of non-magnetic Al3+ concentration on the grain size. The magnetic properties of the synthesized samples is characterised by using VSM. The saturation magnetisation (Ms), coercivity (Hc) were found to decreases with increases of aluminium content which is due to nonmagnetic Al^{3+} ion and weakened interaction between sub lattices.

Selection and Peer-review under responsibility of INTERNATIONAL CONFERENCE ON NANOTECHNOLOGY (ICNANO-2016).

Keywords: Sol-gel, grain size, XRD, VSM

1. Introduction

Extensive work has been carried out on spinel nano-ferrite because of potential application in science and technology which include electronic devices, magnetic fluids, data storage devices, medical diagnosis, magnetic resonance imaging, targeted drug delivery, hyperthermia for cancer treatment, heterogeneous catalysis, magnetic

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separation[1-3]. Spinel ferrites exhibits interesting physical and chemical properties because of their ability to distribute the cations amongst the tetrahedral (A) and octahedral sites(B) [4].Cobalt ferrite have been under intense research as it possess high coercively, moderate magnetisation, good magnetostrictive properties, excellent thermal and chemical stability, good mechanical hardness, large permeability of high frequency, remarkable high electrical resistivity [5,6]. These properties make it suitable for many application such as high density digital recording information storage, ferrofluid, magnetic drug delivery, as sensor, magnetic optics devices [7].Many efforts have taken by researcher to manipulate the magnetic properties of cobalt ferrite by substituting magnetic and non magnetic cation at A and B site. Ahmad Amirabadizaded et al(2013) [8] have reported the decrease in saturation magnetisation and coercivity with increasing aluminium content in nickel cobalt ferrite. It is observed that the decrease is due to replacement of Fe3+ by Al3+ which weakens the sub lattice interaction. Mamill et et al (2016)[9] also reported decreases in magnetic properties Ms, Mr and Hc with increase in concentration of Cr3+.Sonal Singhal et al(2007)[10] suggested that Al3+ ion enters into A and B site in 2:3 ratio and a decrease in lattice parameter and saturation magnetisation with the aluminium content. S. J. Azhagushnmugam et al (2013)[11] used the chemical co-precipitation method and reported the decrease in saturation magnetisation with decrease in size which is explain in terms of exchange interaction of A and B sites . K. Vijaya Kumar et al [12] reported decrease in magnetic behaviour with increasing Al concentration and one of the ferrite appears to exhibiting super paramagnetic nature.Lawrence Kumar et al (2013)[13] reported a decrease in lattice parameter and saturation magnetisation with increase in Al content which was attributed to the smaller ionic radius and weakening exchange interaction respectively.

The present investigation was carried out to study the impact of Al3+ ion on structure and magnetic properties of Cobalt ferrite synthesised by sol-gel Auto combustion method.

2. Experimental

2.1. Synthesis Technique

Nanoparticles of CoAlyFe2-yO4 (y=0.5 & y=1.5) have been synthesised by sol- gel auto combustion method. The Stoichiometric amount of AR grade cobalt nitrate Co(NO3)2.6H2O, iron nitrate Fe(NO3)2.9H2O, aluminium nitrate Al(NO3)2.9 H2O were used while urea was used as fuel. The mixture of metal nitrate was dissolved in distilled water. The solutions as prepared were mixed together to form a homogeneous transparent aqueous solution. The aqueous solution was then heated and continued stirred on the magnetic strirrer at 600C, till aqueous solution get converted into wet gel by evaporating the water. Further, the wet gel fired in a specially designed microwave oven, to get the resultant ash powder. The ashes of raw substances obtained were grinded in a pestle mortar for 4 hrs. Finally these samples were annealed at 8000C for several hours at a heating rate of 1000 C/hr to get desired nano powder.

2.2. X-ray Diffraction Studies

The structural characterization of the synthesized samples was carried out by Philips X-ray diffractometer (Model 3710) using Cu Kα radiation of wavelength λ=1.54 ˚A at room temperature. The average crystalline size of the ferrites was determined from the most intense peak (311) pattern using Debye Scherer,s formula,

$$D = (0.9\,\lambda)/(\beta \cos\theta) \quad (1)$$

Where, β is the full width half maximum (FWHM) in radians and θ is the Bragg,s angle for the actual peak. Being cubic spinel, the lattice parameter (a) for the samples were calculated using the formula:

$$d = a/\sqrt{(h^2 + k^2 + l^2)} \quad (2)$$

Where, d_{hkl} is the inter-planner spacing, a is lattice parameters. h k l are the Miller indices of the crystal planes. The cell volume (V) were calculated from following equation using XRD data

$$V = a^3 \quad (3)$$

The X-ray density (ρx-ray), bulk density (ρm) and porosity (P) were also calculated using following formulae,

$$\rho_{x\text{-}ray} = \frac{ZM}{NV} \quad (4)$$

$$\rho_m = \frac{m}{(\pi r^2)h} \quad (5)$$

$$P = 1 - \frac{\rho_m}{\rho_{x-ray}} \quad (6)$$

Where Z is the number of formula units in a unit cell which is 8 for spinel ferrite, M is the molecular mass of the sample, N is the Avogadro's number, m is the mass of the pellet, r is the radius of the pellet and h is the height of pallet.

2.3. TEM

TEM micrographs were recorded by using transmission electron microscope (Philips model CM 200) to investigate powder morphology as well as grain size.

2.4. Magnetic measurements

Magnetic measurements were performed by using commercial Lake – shore vibrating magnetometer (VSM). Magnetic hysteresis were measured at room temperature with maximum applied fields upto 15 KOe. The saturation magnetisation (Ms) and coercivity (Hc) were found from hysteresis loops.

3. Results And Discussions

3.1. XRD Analysis

The X-ray diffraction patterns of the samples were shown in **Figure 1.** The XRD pattern analyzed using X-Powder software and the crystalline phases were identified by comparison with reference data from the JCPDS card No. 221086 for Cobalt ferrites ($CoFe_2O_4$). The XRD pattern reveals the single phase cubic spinel structure without any trace of impurity which confirms that Al^{3+} ions have been incorporated into the cubic spinel lattice. The particle size of the synthesized ferrite samples has been calculated from the most intense peak corresponding to (311) using the classical Debey-Scherrer formula. The values of the particle size, lattice constant, X-ray density, measured density deduced from the X-ray data are given in **Table 1**

It was found that the lattice constant decreases with Al substitution. The decrease in the value of the lattice constant with Al^{3+} ion substitution can be explained on the basis of ionic radii. As the larger Fe^{3+} ions (0.67 Å) are replaced by smaller Al^{3+} ion (0.51 Å) the lattice parameter decreases. X-ray density decreases with Al substitution and this is attributed due to decrease in lattice constant and particle size. Similar trend were reported by R.A.Bugad et al (2013) [14] and S. S. Suryawanshi et al (1999) [15].

Table 1: XRD parameters of $Co\ Al_yFe_{2-y}O_4$ (y=0.5 & y=1.5)

Sr. No.	Compound	Lattice Parameters a (Å)	Cell Volume (Å)^3	Bulk Density (D) gm/cm^3	X-Ray Density (Dx) gm/ cm^3	Porosity (%)	Particle Size (nm)
1.	$Co\ Al_{0.5}\ Fe_{1.5}\ O_4$	8.3387 A^0	579.822	2.7349	5.0447	48.48915	25.6
2.	$Co\ Al_{1.5}\ Fe_{0.5}\ O_4$	8.1466 A^0	540.666	2.4995	4.7009	55.94791	17.8

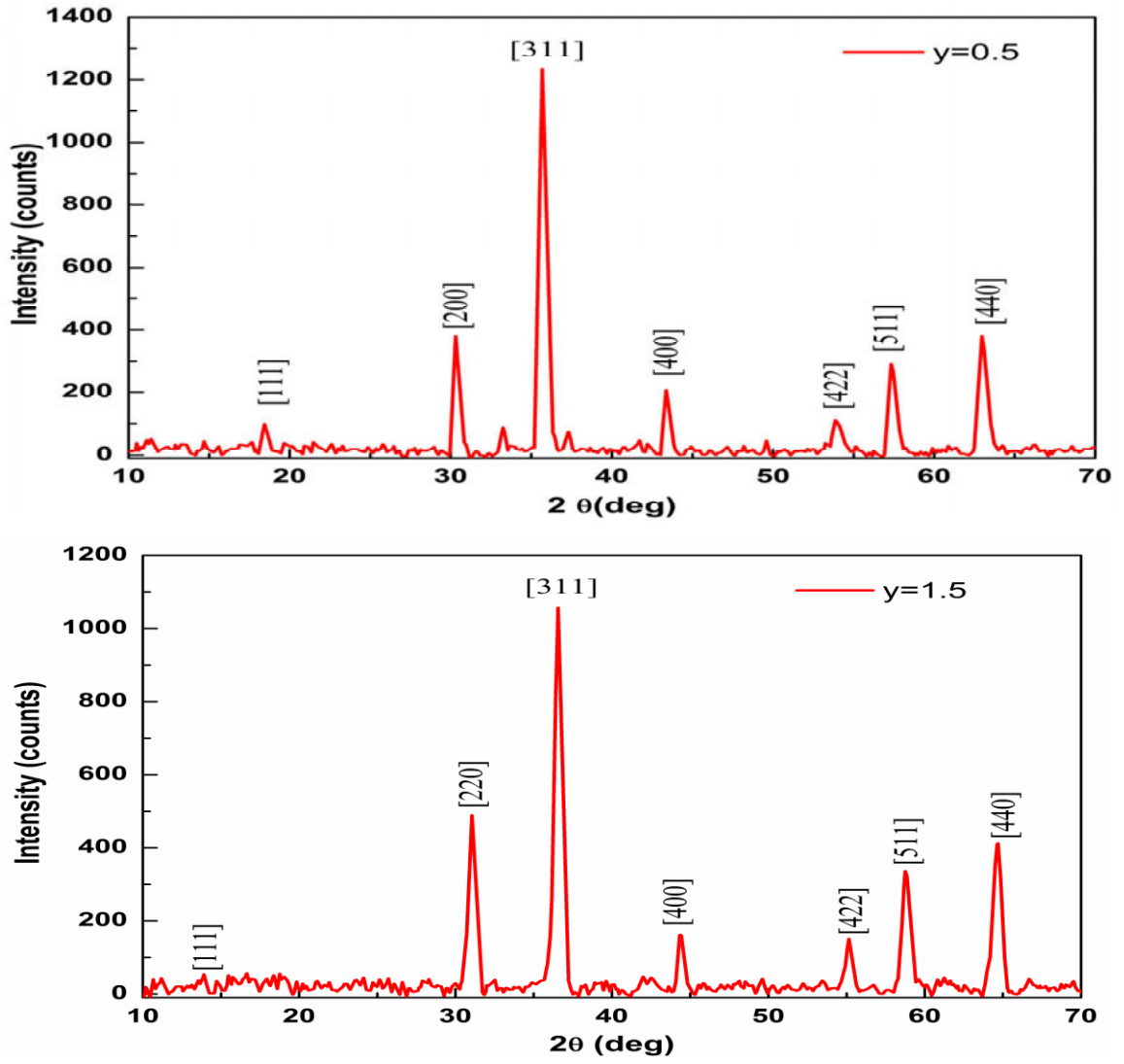

Figure 1: X-ray diffraction pattern of Co $Al_yFe_{2-y}O_4$ (y=0.5 & y=1.5)

3.2. Transmission Electron Microscope (TEM) Analysis

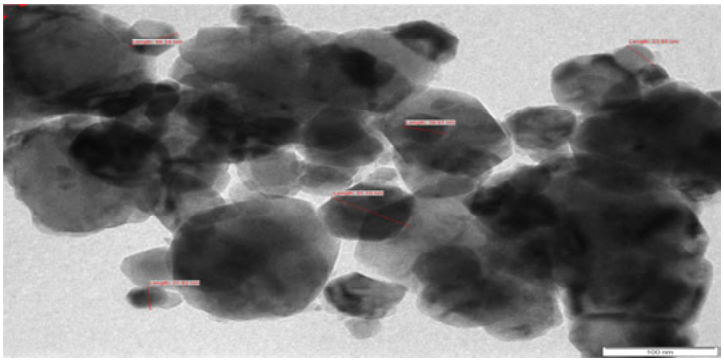

Figure 2: TEM photograph for Co $Al_{0.5}Fe_{1.5}O_4$

Figure 2 present the TEM photograph of y = 0.5 sample which show that the particle sizes in nanometres agree with XRD data

3.3. Magnetic Properties

Figure 3 shows the hysteresis loops for Al^{3+} doped cobalt ferrite with the applied field of 15 KOe. The main magnetic data like saturation magnetisation (Ms), coercivity(Hc), remanence magnetisation (Mr) and squareness ratio (Mr/Ms) are tabulated in Table 2. It is evident from fig and table that both saturation magnetisation and coercivity decreases with the increase of Al^{3+} content. This decrease is related to the decrease of grain size[16]. Further the decrease in magnetisation with increase of aluminium content may also explain on the basis of cation distribution between tetrahedral (A) and octahedral (B) sites. The substitution of non-magnetic

Al^{3+}, replaces Fe^{3+} and occupies octahedral site rather than tetrahedral site.

This may weakens the A-B interaction as Al^{3+} ion will not take part in the exchange interaction due to its non magnetic nature. Hence the saturation magnetisation decreases with increase of Al^{3+} content. Similar results have been reported by Lawrence Kumar et al (2013)[13] and Ramesh C. et al(2015) [17].Coercivity decreases with increase in Al^{3+} ion concentration. It could be due to decrease in anisotropy field which is in turn decreases the domain wall energy[18].

Table 2: VSM (Hysteresis loop) Magnetic properties

Composition of y	VSM OF CoAlyFe2-yO_4			
	Coercivity Hc [Oe]	Saturation Magnetisation Ms (emu/g)	Remancance Magnetisation Mr (emu/g)	Squareness Ration Mr/Ms
y = 0.5	550.52	0.85402	0.31481	0.3686
Y = 1.5	535.43	0.054072	0.01238	0.2289

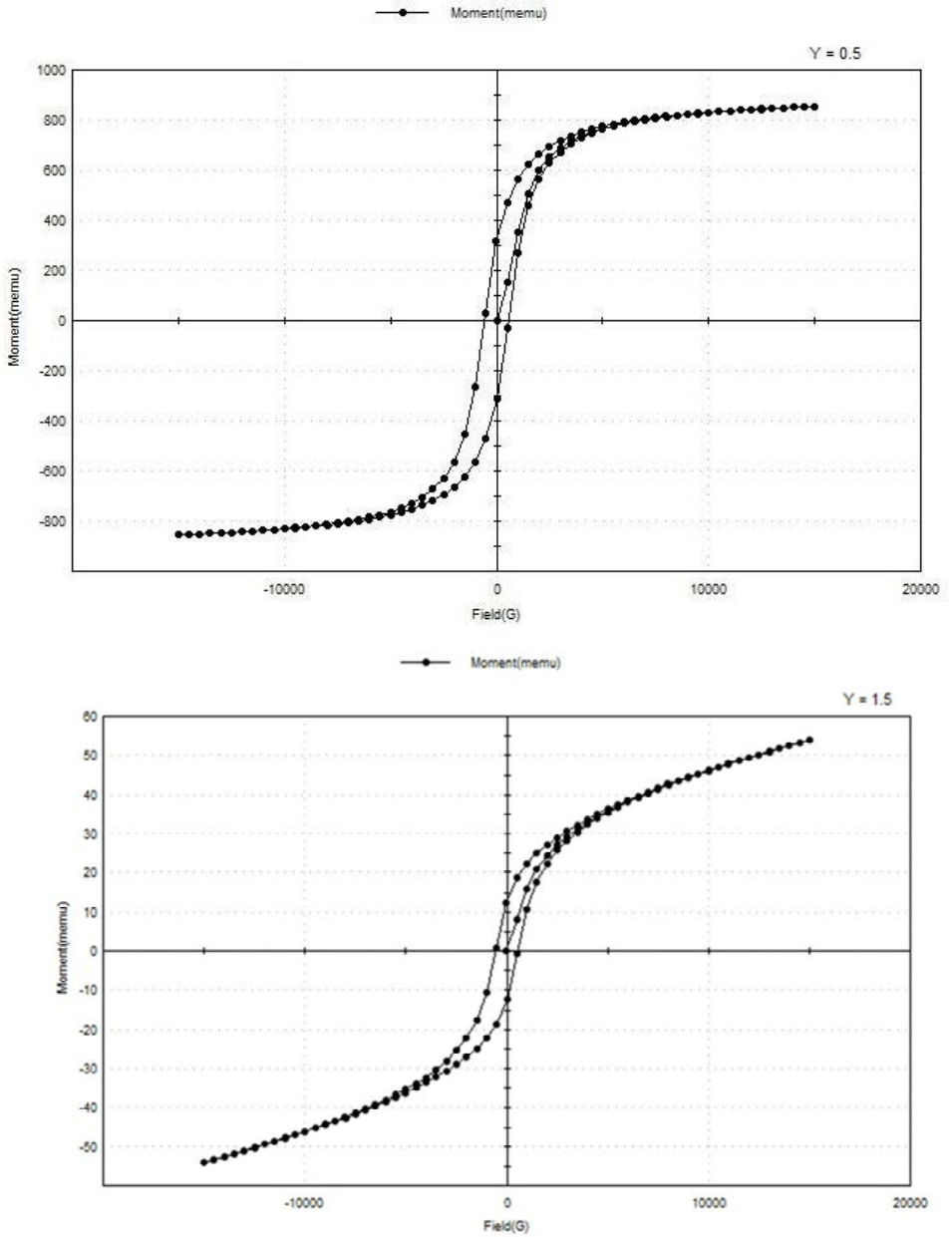

Figure 3 M-H curves for Co $Al_{0.5}Fe_{1.5}O_4$ (y = 0.5 and 1.5) nano particles synthesized by sol-gel autocombustion technique.

4. Conclusions

Al substituted Co ferrites with the chemical formula $CoAl_yFe_{2-4}$(y=0.5,y=1.5) synthesized by sol-gel auto combustion method. The X-ray diffraction analysis confirmed the formation of single phase spinel structure. The lattice parameter and the grain size were found decreasing by XRD data.The incorporation of non-magnetic Al^{3+} ions in cobalt ferrite resulted in decrease of saturation magnetisation and coercivity because replacement of Fe^{3+} by Al^{3+} ions weakens the sub lattice interaction and lowers the magnetic moment of the unit cell.

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RESEARCH ARTICLE

Physico-Chemical Characterization of Farmland soil Samples of nearby Villages of Hingna Taluka, District Nagpur, Maharashtra India

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ABSTRACT:
This Physico-chemical analysis of soil was carried out for the studies of various parameters like pH, Electrical conductivity (EC), Total organic carbon, Available nitrogen (N), Available phosphorus (P), Available Potassium (K) and Calcium carbonate $CaCO_3$). This study leads us to the conclusion of the nutrient's quantity of farmland soil of nearby villages of Hingna Taluka, District Nagpur, and Maharashtra State. The important observation during the study is that the parameters were fluctuating for farm to farm of nearby villages. The present analysis will help farmers to decide the problems related to soil nutrients and amount of fertilizers to be added to soil to make production economic.

KEYWORDS: Soil, Physico-chemical, Soil fertility, Soil pollution.

INTRODUCTION:

Soil is one of the most important resources of the nature. Every living is straight and lastly dependent on soil for the human food is derivative from the earth. Creation plan for have strong and soil is essential to human being survival. Soil has composite role which is useful to human and other living organism. The industrialization and development in agriculture are necessary to meet the basic requirement of people; at the same time it is necessary to preserve the environment [1]. The modern concept, the soil quality is the ability to sustain plant and animal productivity, to increase water and air quality and to contribute plant and animal health [2-3] although all Physico-Chemical properties are involved in soil functioning, bio chemical properties tend to react most rapidly to get change in the external environment [4-5].

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Soil fertility is an important factor, which determines the growth of plant. It is depends on the concentration of N, P, K organic and inorganic materials, micronutrients and water. In general soil chemical fertility and in particular lack of nutrient inputs is a major factor in soil degradation [6]. The yield and quality of crop depends upon the fertilizers and presence of micronutrients. The soil condition is of great importance because it is a universal medium for plant growth, which supplies essentials nutrients to the plants [7]. But due to excess use of fertilizers, the physico-chemical status in soil is being changed [8]. Physico- chemical characteristics of different soils vary in space and time due to variation in topography, climate, physical weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic variables [9]. Present study is an attempt to find out the nutrient's quantity in farmland soil of nearby villages of Hingna taluka, Nagpur district, Maharashtra. This information will help farmers to decide the amount of fertilizer to be added to soil to make the production economic. The objective of this paper was to analyze the trend in pH, EC, OC, N, P, K and $CaCO_3$ status of farmland soil of nearby villages of Hingna Taluka, Nagpur district, Maharashtra.

MATERIAL AND METHOD:

Collection of soil samples:

Ten soil samples were collected from the surface of farmland soil from nearby villages of Hingna Taluka, Nagpur District, Maharashtra in the month of January 2017. Soil samples were collected at a depth of 0-30cm in polythene bags and were labelled as S_1 to S_{10}.

Chemicals and Apparatus:

All chemicals used were of analytical reagent grade chemicals. The experimental solutions were prepared by using doubly distilled water. All glass wares used in the present study were made from Borosil glass.

Physico-Chemical Characterization:

The collected samples were analyzed for major Physical and Chemical soil quality parameter like pH, Electrical Conductivity (EC), Organic Carbon (OC), Nitrogen (N), Phosphorus (P), Potassium (K) and Calcium carbonate ($CaCO_3$) [10]. The pH of the soil suspension was determined using pH meter (Elico pH meter, model LI-120). Electrical conductivity (EC) of the soil was determined in the filtrate of the water extract using Conductivity meter (Elico model CM-180). Percentage organic carbon (OC) was determined by chromic acid wet digestion method as standard procedure of Walkley and Black method, available nitrogen was estimated by alkaline Permanganate method, available phosphorus determined by Olsen's volumetric method. Available potassium content in the soil was determined by neutral ammonium acetate extractable method and calcium carbonate was determined by Rapid titration method with standard NaOH solution.

RESULT AND DISCUSSION:

The physico-chemical properties of farmland soil samples of nearby villages of Hingna Taluka, District Nagpur, and Maharashtra are given in Table 1. Variation of physico-chemical parameters of farmland soil samples are shown in figures 1 to 7.

pH:

Soil pH is an important consideration for farmers and gardeners for several reasons, including the fact that many plants and soil life forms prefer either alkaline or acidic condition [11]. Soil pH denotes soil's acidity or alkalinity and is the measure of hydrogen ions (H^+) in the soil solution. A study on soil pH revealed that the soil samples collected from the farmer's field were slightly alkaline and pH ranged from 7.62 to 7.91.

Electrical conductance (EC):

Electrical conductance (EC) is a good sign for the crops as it helps in the absorption of the nutrients [12]. Greater the ion concentration in soil solution; more is the EC [13]. The EC study of soil shows variation in conductivity values between 0.16 mS to 0.54 mS these values of EC suggest normal soil.

Table : Physico-chemical characterization of farmland soil samples of nearby villages of Hingna Taluka, District Nagpur, Maharashtra, India

Soil Samples	pH	EC (mS)	% OC	N (Kg/ha^{-1})	P (Kg/ha^{-1})	K (Kg/ha^{-1})	% $CaCO_3$
S_1	7.62	0.21	0.71	456	20.56	1142.40	4.53
S_2	7.71	0.26	0.55	376	2.40	860.16	7.48
S_3	7.65	0.54	0.69	497	34.27	672.00	8.61
S_4	7.73	0.37	0.46	314	6.45	443.52	3.79
S_5	7.86	0.16	0.32	219	33.47	376.32	5.14
S_6	7.68	0.39	0.47	338	12.90	483.84	6.75
S_7	7.81	0.45	0.63	456	4.84	564.48	5.12
S_8	7.74	0.51	1.07	736	31.05	604.80	4.56
S_9	7.88	0.42	0.93	624	35.08	688.44	3.63
S_{10}	7.91	0.46	0.62	415	7.26	658.56	4.22

Organic carbon (OC):

Soil organic carbon is the seat of nitrogen in soil and its determination is often carried out as an index of nitrogen availability. If the soil organic carbon is present in soil then this soil is useful for the agricultural practices. Organic carbon may be added in the soil in the form of animal manures, compost, etc. Organic carbon in the present study varies from 0.32 % to 1.07 % and shows medium to high organic carbon content in the soil samples.

Available Nitrogen (N):

Nitrogen is a most important fertilizer element. It is the most important major nutrient required by plant for proper growth and development. It is a part of all living cells, which is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy [14]. Available nitrogen in the present farmland soil samples varies from 219 kg ha^{-1} to 736 kg ha^{-1}, which is medium to very high nitrogen content.

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Available Phosphorus (P):
Phosphorus is an essential element because of the large amount of phosphorus required for plants growth. Phosphorus is most often limiting nutrients remains present in plant nuclei and act as energy storage. In the present farmland soil samples, available phosphorus ranges from 2.40 kg ha^{-1} to 35.08 kg ha^{-1} indicates low to very high content of phosphorus.

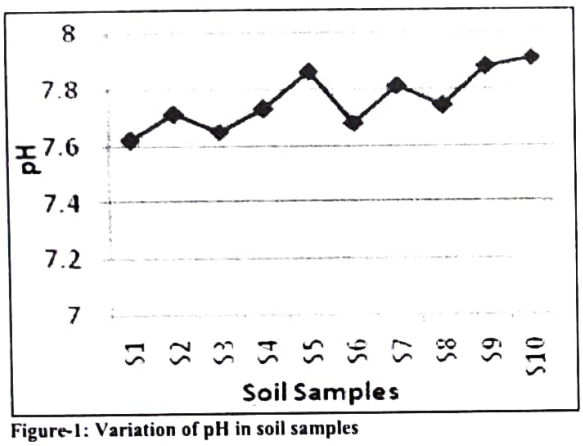

Figure-1: Variation of pH in soil samples

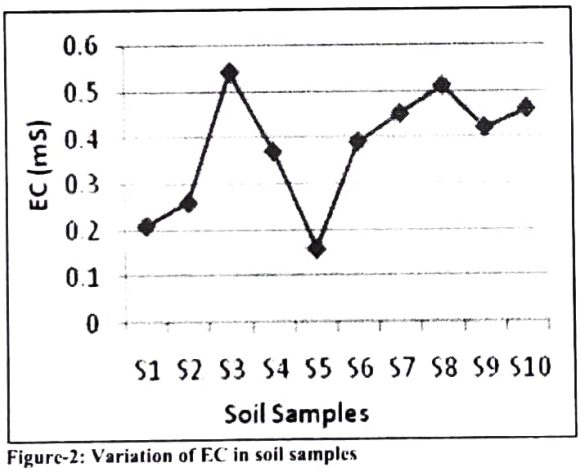

Figure-2: Variation of EC in soil samples

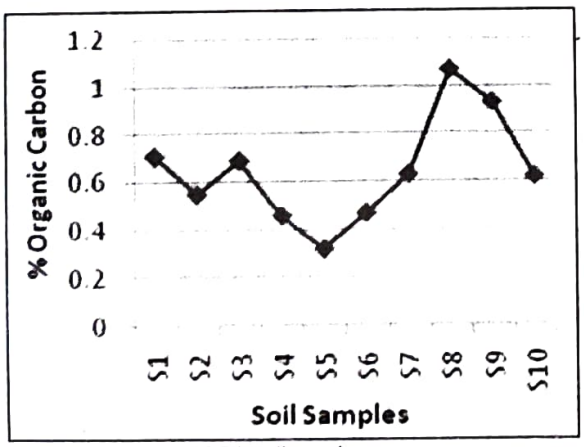

Figure-3: Variation of OC in soil samples

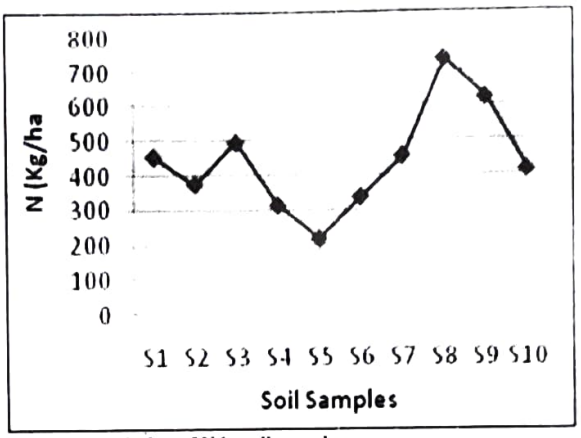

Figure-4: Variation of N in soil samples

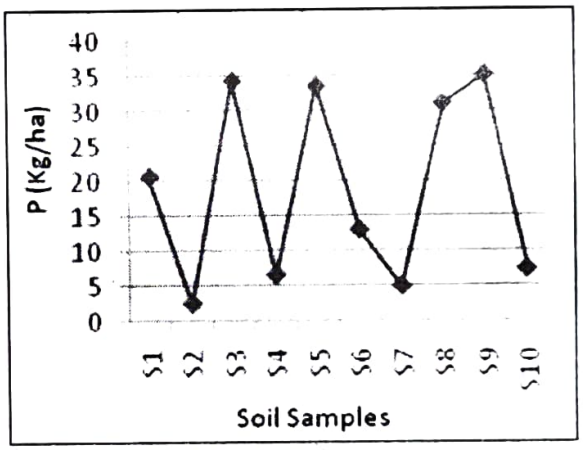

Figure-5: Variation of P in soil samples

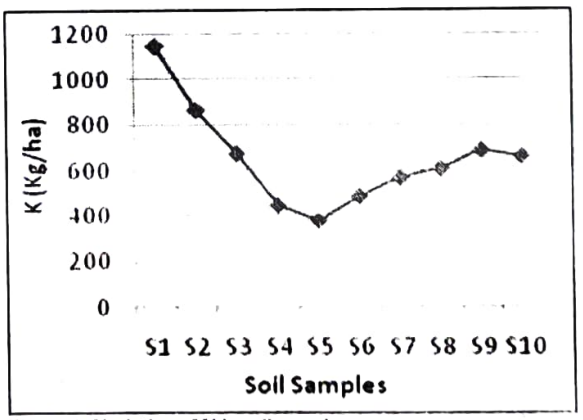

Figure-6: Variation of K in soil samples

Available Potassium (K):
Potassium plays a key role in a vast array of physiological process and vital to plant growth from protein synthesis to maintenance of plant water balance [15]. Soils that have adequate potassium allow plants to develop rapidly and outgrow plant disease, insect damage and protect against winter freeze damage [16]. Potassium was found in the range of 376.32 kg ha^{-1} to

1142.40 kg ha^{-1}, which shows very high potassium content in all ten farmland soil samples.

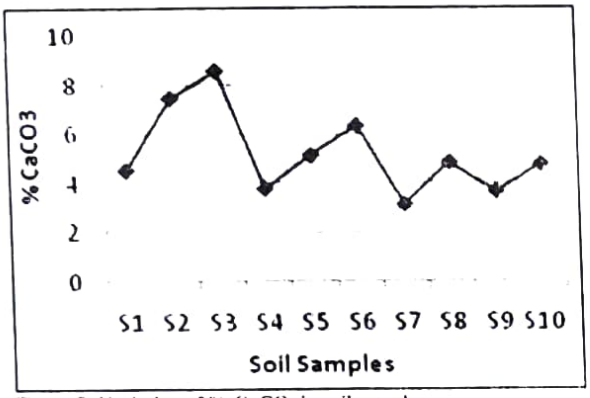

Figure-7: Variation of % $CaCO_3$ in soil samples

Calcium carbonate ($CaCO_3$):

In the irrigation soils calcium carbonate occurs in natural state. Soil fertility is not uniformly affected by the presence of carbonates. Calcium carbonate values in the present soil samples ranged from 3.12 to 8.61 %.

CONCLUSION:

Physicochemical characterization of farmland soil is important to agriculture for plants growth and soil management. A physic-chemical studies of ten farmland soil samples from nearby villages of Hingna Taluka, show different values for various sites. This study gave information about very low, low, medium, moderate, high and very high content of physico-chemical parameters and nutrients in farmland soil. By using this information farmer can manage necessary fertilizers and nutrients needed for farmland soil in order to increase the percentage yield of crops.

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CERTIFICATE

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Mr./Mrs. Dr. Durga Puttewar

of Dr. Ambedkar college, Deeksha Bhoomi, Nagpur

has attended Interdisciplinary National Seminar on

Demonetisation - Its impact on Indian Economy, Society, Politics and Mob Psychology

ORGANISED BY DEPARTMENT OF COMMERCE

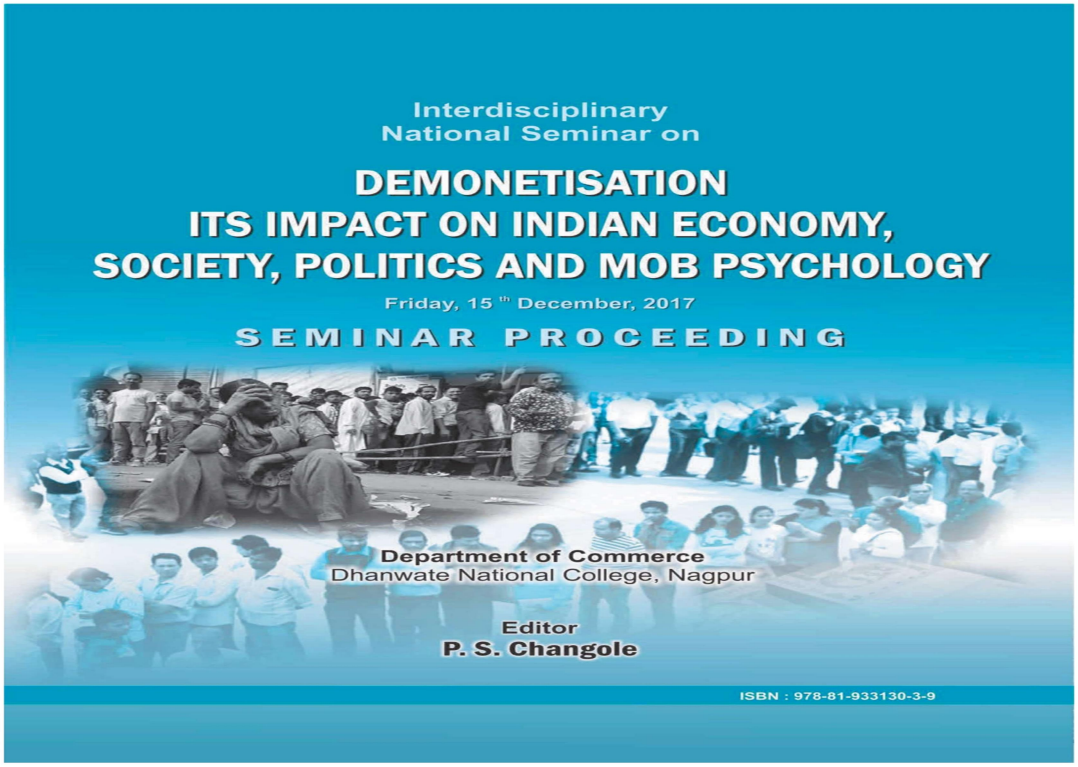
on Friday 15th December 2017.

He/She also Presented the research paper entitled

"Impact of Demonetisation on realestates Business in India".

Dr. P. S. Changole
Head, Dept. of Commerce
and Organising Secretary

Dr. B. B. Taywade
Principal
and Organiser



Impact of Demonetization on the Real Estate Sector in India

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Nagpur

Abstract

The demonetisation step taken by the government is one of the most bold and sudden steps that is bound to impact every Indian and every sector of the economy. This cathartic step is targeted at cleansing our system from deep rooted corruption and the maladies of a parallel economy, run primarily on unaccounted cash. This paper focuses on impact on the demonetization on the real estate.

Keywords *:Demonetisation, Real Estate*

Introduction :

With companies such as Sobha and the entry of established industrial houses of the likes of TATA, Mahindra, Godrej, L&T, ShapoorjiPalonji etc. in this sector, the primary real estate market is getting more organized and matured. It is going by rules, getting all clearances in place, offering good quality products at the most reasonable price points and on time delivery.

The recent demonetisation step taken by the government is one of the most bold and sudden steps that is bound to impact every Indian and every sector of the economy. This cathartic step is targeted at cleansing our system from deep rooted corruption and the maladies of a parallel economy, run primarily on unaccounted cash. While the majority of the people have welcomed this bold step by the government, there are few opposition parties and a small section of the media, who have been opposing it.

A sudden ban on the existing Rs. 500 and Rs. 1000 currency notes shook the Indian economy and real estate sector which was evident after the third quarter of the financial year 2016-17. The announcement of demonetization and implementation of the Benami Properties Act for unregulated properties took place in the same year. Economists predicted the growth rate of the real estate sector to slow down more than ever as a result. The sector has been ridden with many challenges for the past few decades owing to lack of a uniform framework. Demonetization brought about many challenges but also alleviated some of these issues. For instance, the industry was predicted to face losses of up to Rs. 1 billion during the year, but the

demand has been surprisingly steady due to many factors. This paperis an attempt to review some of the benefits and challenges faced by India's real estate sector due to demonetization.

Glance on Demonetisation and its impact on Real Estate Sector in India:

It will not be wrong to say that the Real Estate Sector of our country has seen a lot of developments in a short span of time. While demonetization did stump the sector for a while, The Real Estate (Regulation and Development) Act, 2016 (RERA) & Goods and Services Tax (GST) soon gave it the strength to be functional in an efficient way. Highlighting the three biggest initiatives, Demonetization, RERA & GST together are stimulating the existing uncertainty in the market. It is ensuring transparency, efficiency, promote growth of buyer's confidence and boosting investments in the real estate industry.

Demonetisation was a difficult move for many to deal with. However, it has greatly contributed in the standardisation of the pricing in the sector. There is so much transparency now. From a developer standpoint it has immensely helped us in sourcing funding from the banks and we are assured that the source of our funding is genuine. Many people out there believe that demonetisation had an adverse effect on sales, but that's not true. It was the negative sentiment that due to demonetisation the property costs will go down and that's exactly what the people kept waiting for instead of investing. Beyond this it has also helped in creating a cleaner image for Real Estate.

Last year on 8th November, 2016, demonetization was introduced and demonized for bringing a prolonged slowdown in the real estate sector. True motive of demonetization coupled with GST and RERA was to weed out these malpractices. However, initially monetization gave a detrimental ripple effect.

The demonetization speculation around real estate has moved on to RERA regulation and the effects are substantial. As real estate sector reflects realism after the initial turbulence of demonetization, it is serving as a great opportunity for investors and will benefit the overall economy.

Sales in real estate have been tepid in the recent past as compared to previous years. The sentiment that immediately followed demonetization resulted in even bullish buyers sitting on the fence. Demonetization was to impact primary market sales via bank financing the least, and give larger impact on secondary market transactions and land deals.

Demonetization was expected to impact primary market sales, but had a larger impact on secondary market transactions, luxury segment and land deals. The beginning of 2017 saw buyer sentiment improve with encouraging budgetary reforms.

We have come a long way and this ripple effect has started to fade with time. It has been exactly a year, 8th Nov, 2017 marks the first anniversary of demonetization. The realty-preneurs who followed the best practices have gradually benefitedfrom the policies. According to world bank report, India's rank on the 'ease of doing business' scale has risen from 130 to 100 this year, boosted by a slew of reforms including demonetization, RERA and GST.

Since November 8, 2016, "demonetisation" has probably become the most-repeated word used by an entire nation. It is time to tame the wild rumours and uniformed angst about its impact - and other macro-economic and policy changes in 2016 - on the Indian real estate sector.

Pre-demonetisation:

The Indian real estate sector has been facing significant challenges in the past few years when it comes to sales and overall growth. With a lot of measures, the sector was clearly pointing towards a slow and gradual, but sure recovery.

- **Sales and Prices**: After stagnating or even declining sales for past couple of years, the first half of the year saw some upward movement on the back of many positive factors. Prominent among these were the overall growth in the Indian economy, attractive deals and discounts being offered by developers, and the high potential of schemes such as Smart Cities, AMRUT and Housing for All by 2020 initiated by the Government. The positivity these factors induced, coupled with increasing incomes and lowering of prices, encouraged buyers to begin finalising deals that were previously put on hold. Importantly, it was not only investors but also end-users who started coming back in the market.
- **Unsold Inventory**: Except for a few pockets in Delhi-NCR, most of the prominent real estate markets - including some NCR micro-markets - saw a gradual decline in the unsold inventories that had been choking up liquidity for builders. One of the reasons was the residential market being flooded with projects that were expensive, against the demand for more affordable ones - in simple terms, a classic supply-demand mismatch. To liquidate their holdings and ensure financial stability, developers became amenable to negotiating more and offering attractive deals. They also tied up with financial institutions to offer affordable loans, and announced other schemes to help buyers take decisions. This had started paying off.
- **New Launches**: New launches reduced markedly in the current FY 2016-17, owing to higher unsold inventory; this means the developers were focusing their resources on

disposing off the developed projects. Also, catering to the demand of affordable housing, new launches started focusing on that segment instead of catering to the high-end residential sector.

Post-demonetisation:

Owing to its uniqueness as an economic event, demonetisation brought a lot of confusion, uncertainty – and, most of all, rumour-mongering - especially when it came to the realty sector. No doubt, everyone was affected by this radical measure, and initially all possible economic activities slowed down to a large extent. However, the dust soon settled and economic activity resumed. Unfortunately, this quick return to relative stability is not something that has been adequately captured by the more disaster-focused media channels. Every critic and observer took the easy way out to describe this event as the death of the real estate sector as we know it. Obituaries were written, the market was more or less written off, builders were expected to shut shop and prices were seen as headed for a terminal nose-dive into next to nothing. Such was the vision of untrained eyes' imaginations. This is not to say that the real estate sector has not been affected by the demonetisation move; however, it is important to understand where the pinch really lies, and where the silver lining is. The Indian real estate sector contributes 5-6% of the country's GDP, and any misinformation in a sector that is largely sentiment-driven can lead to chaos. To get a clear picture, let us examine how demonetisation affected the residential market:

- **Secondary Market**: This market definitely got affected, considering the structure of the deals involved often take here. With scarcity of cash, a large corpus of buyers went off the market and sellers can do little but wait. This will also result in the reduction of prices, thereby benefitting buyers. However, the pricing reduction might take time - and the magnitude of reduction cannot be predicted at this stage.
- **Primary Market**: This is the area that has been overlooked and bundled with the rest of the real estate sector. The rumored decline in this segment is very far from reality, because the primary market - consisting of ready-to-move homes and new projects – caters to end-users whose primary sources of funding are banks and other financial institutions. Simply put, it is home loans which finance the purchase of such properties, so this segment is effectively insulated from the currency ban. It was not expected to be affected, and in fact was not – other than in terms of the initial confusion-induced decline in sentiment. The trend emerging now points towards a recovery in buying sentiment, with serious buyers already returning to the primary markets. This positive development is adequately illustrated by the performance of the JLL Residential (JLLR) division, which has had a phenomenal year and doubled its profits in 2016 over 2014-15 with 60% revenue growth. Such a performance in what has been one of the

toughest phases for the real estate sector in more than a decade could not have happened in a declining market environment. Above all else, these readings vouchsafe the faith that buyers have in developers with credible reputations. Real estate developers with transparent business practices have not been affected by demonetisation, and have instead witnessed sales growth. Such Grade A developers continue to launch new projects, partnering with corporatized consultancies to market them ethically to a highly responsive end-user clientele. The fact is, demonetisation has already resulted in a major reduction of home loan rate interest rates, and they are expected to reduce further. Developers offering good deals and discounts are maintaining their position in a market which is now ideal for serious end-users. While the demonetisation initiative by the Central government means further delays in ongoing real estate projects due to the massive cash crunch, it also paves the way for a cleaner and more transparent real estate industry in the times to come. Developers will now look for alternative funding arrangements while end-users or investors will wait for more certainty before making any move. Let's delve deeper into the impact of this change on real estate sector in short to long term.

Short-term: Market to undergo a slowdown

The sudden ban on Rs 500 and Rs 1000 currency notes has resulted in a situation of limited or no cash in the market to be parked in real estate assets. This has subsequently translated into an abrupt fall in housing demand across all budget categories in the short term. While a share of this dwindled demand could be attributed to distractions caused by the move, many industry experts opine that this is a result of a trust deficit in the market. Money has become dearer, leading to cautious spending and minimal transactions.

The slowdown owing to this announcement has been more severe in NCR particularly Gurgaon, Mumbai Metropolitan Region (MMR) and certain Tier II markets such as Surat and Vadodara. Minimal impact of demonetisation has been felt in markets such as Bangalore, Pune and Chennai, which are primarily end-user driven and rely on bank funding.

Liquidity has been severely impacted and this would result in a deflation with limited sales over the next three months. In short, the move has taken the real estate sector by a storm, and it would take time for all stakeholders in the sector – brokers, buyers, owners and developers - to assess its repercussions on their businesses and decisions. In particular, transactions in the premium housing sector and the residential land category – overtly dependent on the cash component - would come to a standstill in the short term.

In the short term, buyers and sellers in the middle of transactions might be impacted as cash component would be involved in such deals.

There would be intermittent delays in the execution of ongoing residential and commercial projects primarily owing to the massive cash crunch and minimal trading in the economy.

Mid-term Impact: Reduced inflation, better home ownership appetite, improved rental landscape

With limited money floating in the economy, the inflation rates are expected to fall in the next 2-3 quarters. This, coupled with key policy developments such as speculative repo rate cuts by the Reserve Bank of India (RBI), could mean a better home ownership appetite. However, this could be restricted to the affordable housing category. The heavily cash-dependent secondary market could bear a colossal brunt of the demonetisation move. With the gap between circle rates and market rates bridging, owners would reduce 'ask' prices, impacting the average housing prices across cities. Resale properties would, thus, become cheaper and this could pressurise the primary market, as well. Developers might offer new projects at discounted rates or propose incentives to magnetise buyers.

The dwindling demand for housing could benefit the rental market across metros but the change might take a year or so to manifest its impact on the rental price points. Both commercial and residential markets could see rentals going north by 10-20 percent. In the midst of all these developments, affordable housing will remain largely unaffected due to their non-dependence on the cash component. In fact, the demand for this category might witness an uptrend due to improved purchasing power.

Long-term impact: Transparency, revived trust and capital inflows in the realty sector

The real estate sector is expected to get cleansed of its ailments in the due course of time owing to the elimination of black money clubbed with multiple regulatory changes such as the Goods and Services Tax Act, Real Estate (Regulation and Development) Act and amendment of the Benami Transactions (Prohibition) Act. Subsequently, project approvals will be quicker, resulting in a substantial reduction in the total cost of construction, thereby, the 'per unit' cost. Fair pricing would mean a revived demand for new projects in the market.

Demonetisation could also mean fresh sources of funding for developers to complete their projects. Some of the alternate sources may include the following:

- Developers will be forced to clean up their balance sheets so that they can avail funding from legitimate sources, however, this may come at extremely high costs from the Non-banking financial companies (NBFC) segment.
- Developers can avail short-term loans from their existing buyers at market price with

a promise to deliver the project on time and at an interest rate as per the agreement in the sales deed.

• Investments from private equity firms would usher positive sentiment across the market, helping developers to source funding and strengthen end-user demand. The real estate sector could witness a major revolution with cash transactions getting eliminated and a major share of trades going online with the penetration of alternative forms of payment such as E-wallets, apps and plastic money. To sum it up, the demonization of old currency has ushered a new era for the real estate industry in India that would be transparent, corruption-free, organised and veracious.

Some immediate effects of Demonetisation on Real Estate :

- **Low home loan interests due to demonetization**
  The immediate effect of demonetization was increase in cash deposits in banks. Banks which earlier encouraged customers to invest in deposit accounts suddenly found themselves in a huge influx. The next problem was to dispense the cash through various instruments. To encourage loans, the apex bank RBI to cut the interest rate on home loans to attract masses towards real estate investment. This resulted in increased demand for real estate in India. Also the lower interest rate scheme benefited property builders in resuming their projects which were discontinued due to lack of funds. One of the segments which benefited most from the demonetization drive is the affordable housing segment. Affordable housing came with lower EMIs due to various subsidies and became even cheaper after demonetization.
- **Improved stock market performance and FDI**
  The Indian real estate sector attracted all time high foreign investment of US $ 5.7 billion in 2016, despite demonetization. Also the performance of real estate firms on the stock market Bombay Stock Exchange (BSE) improved by 50% during 2016-17, dispelling fears of ill effects of demonetization. The country is on track to becoming the fourth largest economy in the world with a growth rate of 7.5% by the end of 2022. A further increase in private equity from foreign and local investors and other institutional investments in the sector are certainly going to push for more transactions. The outlook for the real estate sector is thus positive.
- **Slow purchases due to contraction in cash**
  Post demonetization there was a severe unanticipated cash crunch in the economy and liquid cash became dearer. The demonetized currency constituted a total of 85% of the total money circulated in India at the time of demonetization. As people were forced to deposit these notes in their bank accounts all cash was flushed out of the system. This restricted the number of transactions they could perform in cash, hence purchase of property slowed down. Purchase of new property fell by up to 40% in major cities, while

new project announcements fell by 11% immediately after demonetization. However the effect lasted only for a short while as buyers only deferred their purchase decision and not discard it.

- **Slow down in construction work**
  The liquidity crunch hit real estate from all sides, even the supply. Construction firms which dealt in cash until then suddenly found themselves unable to meet their operational expenses like wages and raw materials. Wages were until then paid only in cash as most construction workers did not have a bank account. The reform removed cash entirely form the system, therefore constructors also could not meet their expenses. Also they were reluctant to borrow money due to uncertainty in the market. Consequently, most of the under-constructions projects came to a standstill. Metros such as Delhi, Mumbai and Chennai were the worst affected after demonetization.
- **Low rental yield**
  Demonetization also left a huge impact on rental yields in India. This is because of the fall in prices of properties in general and the effect lasted only a few months.

Conclusion :

This is a market that's trying to find its feet. The faster it does so, and the faster we hit the new normal, the better it will be for all stakeholders in the industry. One of the key factors that would enable this would be the "price/data availability" to buyers/sellers alike. The transparency that availability of pricing data, plus supply/demand data brings in would enable buyers and sellers to take decisions more swiftly and with more confidence.

Suggestions:

In parting, here are a few suggestions to market participants.

For buyers,

- It would do well to remember that this is an absolutely great time to be a buyer. Buyers should get more active, shortlist properties they are interested in & negotiate/make offers to sellers – remember that it is a buyers' market and, if you're a serious buyer, you stand a very good chance to negotiate a good deal for yourself.

For builders,

- It would be beneficial to bump up volumes.
- Consider offering "floating prices" in which buyers can buy with confidence that should prices fall, they will get the benefit of lower prices later.
- Sellers should also know that real estate is a very aspirational category, there is a lot of underlying demand, but being obstinate about pricing and allowing volumes to drop is likely to be counter-productive.

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Multifactor Authentication Techniques with Computer Hardware

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ABSTRACT

For quite a long time, the password has been the standard means for user authentication on computers. In any case, as clients are required to recollect more, longer, and evolving passwords, it is apparent that a more helpful and secure answer for client verification is vital. This paper analyzes different authenticators and thinks about these authenticators and their blends. We examine effectiveness against several attacks and suitability for particular security specifications such as compromise detection and non-repudiation. The paper attempts to offer a more blended multifactor authentication technique by introducing computer hardware in the process.

Keywords : Multifactor Authentication, Security tokens, Soft tokens, Mobile Authentication

I. INTRODUCTION

1. Multi-Factor Authentication Concept

In an authentication system, multi-factor implies that there is more than one of the components of verifications being utilized. Multi-factor authentication consists of verifying and validating the authenticity of an identifier using more than one validation mechanism. Authentication factors apply for a special system of verifying a client as the person who is completely allowed get the rights. There are different factor types for authentication: [1]

- Human factors are inherently bound to the individual as for example visible features.
- Personal factors are otherwise physically or mentally allocated to the individual as for example remembered code numbers.
- Technical factors are bound to physical means as for example a pass, an ID card or a token.

Each of the types may apply independently for demanding access according to given guidelines and techniques. The introducing of a factor demonstrates consistence with access to rules and in this way must be affected in a predetermined procedure. In two factor authentication a minimum of two factors compliance is required. [1]

Multi-Factor Authentication provides additional account protection against various forms of online fraud. By adopting the multi-factor authentication, the possibilities of attacks are reduced. The authentication becomes more precise and secure.

An example of multi-factor authentication at the new accounts desk would include performing the following:

Credential validation - The ability to read and validate information encoded within the magnetic stripe and barcodes of government issued identification.

Identity screening - A system to perform positive and logical verification of furnished customer data.

Fraud detection - Comparing customer information to negative files, both internal and external from across industries, which represents known and/or attempted frauds.

One of the motivations of using MFA is to improve the single factor based Authenticated Key Exchange (AKE) by combining two or even more factors in one system . These MFA approaches are based on a single factor and in recent times, MFA has come forward as an active research topic. However, extra caution should be taken as current approaches to MFA are expensive and difficult to deploy.

Integrating the credit card payment system with biometrics in MFA has given support for more efficient verification. This method proposes to employ fingerprint verification with a credit card in a MFA. Doing this would need the installation of additional equipment that would increase the cost. Employing biometrics when using a credit card in authentication as a MFA procedure is another access control approach. This system approaches time that affects the user acceptability for the system and using fingerprint authentication comes at low to medium cost with a medium level of accuracy.

The card reader is an additional level of HW security that can use a One Time Password OTP. The chip on the client user card generates the OTP, with the caveat that the account

Multi-factor authentication has been widely used by more and more people and organizations recently. It is especially popular with Internet business. Compliance acts are also another reason for its growing usage. Multi-factor authentication is going to become the standard method of authentication in the future.

1.1 Multifactor Authentication Technologies

a. Security Tokens

A security token is a small hardware device that the user carries to authorize access to a network service. The device may be in the form of a smart card or it may be embedded in a commonly used object such as a key fob. Security tokens or hardware tokens provide an additional level of security through a strategy, which is known as two-factor authentication: the user has a personal identification number (PIN), which authorizes them as the owner of that particular device; the device then displays a number which uniquely identifies the user to the service, allowing them to log in.

b. Soft Tokens

A soft token is a software-based security token that generates a one time login PIN. Traditionally, a security token has been a hardware device that produces a new, secure and individual PIN for each use and displays it on a built-in LCD display. The system may get activated after the user presses a button or enters an initial PIN. Security tokens are generally used in environments with higher security requirements as part of a multifactor authentication system. While the hardware based frameworks are more secured than others frameworks, they are also costly and are difficult to deploy on a large scale, as is required for online banking and others, for example.

Soft tokens are an attempt to replicate the security advantages of multifactor authentication, while simplifying distribution and lowering costs. A smartphone soft token app mimics the hardware-based security token. Like a hardware token, a smartphone provides on the device itself, an easy-to-protect and easy-to-remember location for secured login information. Smartphones are connected devices, unlike a hardware token, which make them inherently less secure. The extent of their security

largely depends on the device's operating system and client software.

c. Mobile Authentication

Mobile authentication is the verification of a user's identity through the use a mobile device and one or more authentication methods for secure access. Mobile authentication may be used to authorize the mobile device itself or as a part of a multifactor authentication scheme for logging into secure locations and resources. Password entry is clumsy on cell phones, especially when including capital letters, numbers and symbols.

Some alternative methods of mobile authentication include:

- Non-text passwords, where symbols or images might be chosen from a randomly-generated field.
- Digital certificates using public key infrastructure.
- Smartcards with stored authentication data.
- Out of band authentication, where the user places a call to obtain authentication.
- One time passwords (OTP) through phone apps or SMS messages.

Some organizations have a need for extra security beyond ID and password for log in, but added devices and methods can make the procedures too cumbersome for employees. The ubiquity of smart phones can help ease the burden here, however. Most smart phones have a GPS device, enabling reasonable surety confirmation of the login location, a camera for potential facial recognition and iris scans, a microphone for voice recognition; some also have touch screens that can be used for finger scanning.

Mobile devices that use more than one of these capabilities are functionally multifactor tokens. An example is the use of a Smartphone software token app that taps into GPS location and scans a fingerprint, all within a device that the user was probably going to be carrying anyway. For administrators, the main benefit of a software implementation is that there are no extra physical devices to manage.

II. Using Hardware information in Authentication

HW has been used to facilitate authentication for a long time. The idea is that owners/users register their devices based on their MAC address so that, the devices themselves are authenticated, rather than their users. MAC addresses are used in the cryptography of files, authentication and integrity networks to support the security of data transportation. This technique uses the MAC address as a key authentication factor to secure the communication session with the Internet Protocol (IP) address to reach the device destination [2].

Filtering MAC addresses to secure the wireless network is essential in giving users access to the wireless network. Doing so will give precise control to wireless users connected with the Access Point (AP) associated with their MAC address [3]. If this filtering is not applied and the MAC address of the client is not given, the client will not be granted access to the wireless network. So, MAC addresses of the client computer device gives the authorisation needed for a wireless connection which is between the client and server [4].

Spoofing attack is a situation in which one person or program successfully masquerades as another user by falsifying data and thereby gaining an illegitimate advantage [5]. Spoofing of MAC is usually beyond the average wireless user's experience. In order to carry out spoofing on a MAC address, the client needs to be associated with a particular AP. As result, using the MAC address in wireless security depends on filtering the MAC address of the client without determining the user's characteristics.

Another method of HW authentication usage is storage media drivers such as HDDs . Each storage media item has a unique HMSPN as an identifier product code that can be used in profiling [6]. These HMSPNs are already actively used for identification, albeit that they can be modified at firmware level and thus are susceptible to spoofing. For example, Microsoft products send product and HW identifiers during the activation process. So, this HW information provides the opportunity to profile the user's computing environment.

Port security is a mechanism which is used to restrict the MAC addresses that connect via a particular port switch. This tool allows defined and specific access to a particular port to allow a unique MAC addresses, or a range of MAC addresses. To connect to the LAN port, it will allow access of MAC addresses which belong to a range according to a configured list. When a frame arrives to the switch it will compare the MAC addresses with the MAC addresses on the configured allowed list. If the MAC address matches one of items on the list then the packet is allowed to go through. In contrast, if the MAC address does not belong to the configured list the port will drop the packet. So, MAC addresses can be specified to connect to a certain port. This type of firewall can support authentication [7]. This level of information has some characteristics of the user's HW environment which can profile the user activity by using particular HW.

In "Active Directory Integrated Media Access Control" based wireless authentication, the Internet Authentication Source (IAS) needs to be installed on a domain controller to ensure that the domain controller belongs to the Remote Access Service (RAS) and IAS source group. To proceed with this process, a Security Group in Active Directory is created which should have the MAC address of the laptop's Wireless Cards. These are identified as "Wireless MACs".

Users are created by using the MAC address as a USERNAME and the AP is shared by a secret password. These users should be controlled by a security group created earlier by the network administrator. After creating a remote access policy in the IAS, this will permit remote access through the membership in the Windows group that was made previously. This course of action has been taken earlier in "authenticate wireless MAC accounts, based on group membership" [8]. A unique and constant MAC address is transmitted by 802.11 devices and thus are identifiable. It was recently proposed to replace such identifiers with pseudonyms, i.e. temporary names which were unable to be linked to the IT device due to the fact that implicating identifiers or identifying characteristics of 802.11 networks traffic can identify many users with high accuracy [9].

Another profiling technique uses four implicit identifiers visible to the piece of HW to quantify how well a passive adversary can identify users. A lower boundary is placed on how accurately users can be identified implicitly by using the following:

1. Identifying four previously unrecognized implicit identi- fiers: network destinations, network names advertised in 802.11 probes, differing configurations of 802.11 options and sizes of broadcast packets that hint at their contents.
2. Develop an automated procedure to identify users which quantifies how much information is revealed via implicit identifiers, both singularly and in multiples, and which can reveal about several hundred users in three empirical 802.11 traces.
3. The evaluation shows users produce highly discriminating implicit identifiers. Even a small sample of network traffic can identify them, i.e. more than half (56%) of the time in public networks. Moreover, it is most unlikely that they would be mistaken as being the source of other network traffic (1% of the time). Since

adversaries will obtain multiple traffic samples from a user over time, this high level of accuracy in traffic classification enables them to track many users with even higher accuracy than in common wireless networks.

4. It is the first time it has been shown with empirical evidence that design considerations beyond eliminating explicit identifiers, such as unique names and addresses, must be addressed to protect anonymity in wireless networks.

During one research it was [9] noted that by considering a subset of all possible identifiers and a weak, passive adversary, the results only place a lower boundary on the accuracy with which users can be profiled. The efforts are continuing to uncover implicit identifiers exposed in 802.11, such as those exposed by timing channels. The accuracy of the implicit identifiers over longer timescales and across different locations will be evaluative, since this study analysis is limited by the duration and location of the traces.

In 1998 the University of Pittsburgh established a network connection to residence hall students because the number of residence hall beds had increased to 6,000 and the connection rate had continued to increase to 74 percent of resident students. Students were implementing a manual process to assign static IP addresses and record each computer's MAC address. This then required the entry of a username and password each time the user established a connection. After that, the 2000 Dynamic Host Configuration Protocol Automated Teller Machine (DHCPATM) was used to provide IP addresses for each student in conjunction with registration software to record the necessary machine information. This technique, however, was considered to be too time consuming for tracking security activity [10]. Point-to-Point Protocol over Ethernet "PPPoE" technology was used to improve the ability of secure access to the wireless network. So, a single and easy system can be con- figured and used for all users. In spite of this the wireless or traditional wired ports connection must be implemented in order to avoid confusion and to offer users flexibility in public areas without needing to re-authenticate or switch to a different authentication mechanism wireless network [11,12]. Therefore, using additional HW information may support this access control approach to avoid the confusion of roaming from wireless to traditional wired ports in LAN.

Another technique uses specific network security devices. Network security devices are connected between a protected client and a network. The network security device negotiates a session key with another protected client. Then, all communications between the two clients are encrypted. The device is self-configuring and locks itself to the IP address of its client. Thus, the client cannot change its IP address once this has been set and therefore cannot emulate the IP address of another client. When a packet is transmitted from the protected host, the security device translates the MAC address of the client to its own MAC address before transmitting the packet into the network. Packets addressed to the host contain the MAC address of the security device [13].

In order to verify the client's username and password the Secure Remote Password protocol (SRP) [14] modular performs large integer exponentiations. This task requires many operations and consumes a large part of the total execution time of software implementations of the SRP protocol that are affected by HW performance. Modifying or designing a suitable HW environment to accelerate the exponentiations modular in the SRP protocol [15,16] is associated to user's HW and affects in observing user behaviour.

A mouse is a dynamic biometric that is similar to keystroke dynamics. The mouse is very important for graphical user interface (GUI). In contrast, the keyboard is essential for command line based applications. The behaviour of both these devices can

be combined in a common detector. Adapting keystroke technology by addressing issues such as passive and dynamic monitoring could improve the detection [17]. However both detectors may be affected by the keyword and mouse environment that motivate the focus in users' devices which affect user detection. A user's HW can support a reduction in digital identity fraud. However, because of natural or analytic HW authentication, this level of information is related to the user's confidentiality and integrity which are a primary concern and thus, any implementation of a new authentication method will have to be aware of this. In this research, HW information is used as the authentication factor.

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A Non- Invasive Blood Pressure Measurement Using Embedded Technology

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ABSTRACT

A Health care is one of the fast emerging fields today. With the average age of general population increasing each year the credit goes to cutting edge of medical research. New methods are developed almost every month to as a solution to numerous health problems for which accurate diagnosis is the need of the day. The Biomedical equipment provides accurate reproduction of body signals and automated diagnosis and patient monitoring systems. The field of biomedical instrumentation is an integral part of medical research. Sometimes it becomes necessary to monitor physiological events from a distance like monitoring a patient in an ambulance and in other applications away from the hospital, collection of medical data from a home or office and use of telephone links for transmission of medical data.

In this research work it is to study the Non- Invasive Blood Pressure Measurement of patients using embedded technology which has the low cost, reliable, and portable and it is used in many medical laboratories and industries. In present development, the real time blood pressure biomedical signal is measured using an optical measurement circuit based plethysmography technique(PPG) contineously for a long period of time.The detected measured signal amplified using an operational amplifier circuit and interface with the microcontroller. The numerical reading values of systolic and distolic blood pressure remotely recorded and displayed with the help of LCD and stationary computer.

Keywords: Blood Pressure, Wireless, Non-invasive, monitoring system etc.

I. INTRODUCTION

"Health is Wealth", is true not only for an individual, but is perhaps equally important for society in large. A Health care is one of the fast emerging fields today. With the average age of general population increasing each year the credit goes to cutting edge of medical research. New methods are developed almost every month to as a solution to numerous health problems for which accurate diagnosis is the need of the day. The Biomedical equipment providing accurate reproduction of body signals and automated diagnosis and patient monitoring systems. The field of biomedical instrumentation is an integral part of medical research.

Blood Pressure:

Blood pressure is the most often measured and most intensively studied parameter in medical and physiological practice. Pressure measurements are a vital indication in the sucessful treatment and management of critically ill patients in an intensive cardiac care unit or the patients undergoing cardiac catheterisation.

The meaurement of BP are of great importance because it is used for detection of hypertension (high blood pressure). Hypertension is a continuous, consistent, and independent risk factor for developing cardiovascular disease. Hypotension can cause the blood supply to the

brain, heart and other tissues to be too low, and hypertension is strongly correlated with higher risk for cerebral stroke and heart infarct. Blood pressure measurement is also important for particular disease patients, such as hemodialysis patients. Hence, in the daily life, blood pressure measurement and management is very useful for handling health situation and plays a preventive function.

II. METHODOLOGY

Photoplethysmography Unit (PPG):

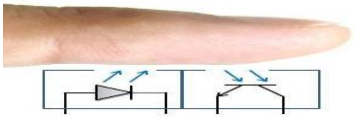

Figure 1. Photoplethysmography Technique

pressure monitors are based on oscillometric method accepted and widely used mobility, they require suitable for home-care and long-term monitoring of BP for homecare inexpensive method that is and does not require These requirements can be which will be designed using technique. method used to measure volume in the tissues. It utilizes contains an infrared light a part of the tissue photo-detector receives the obtained from this technique which can be used to is shown in fig. 1 where used as the source and a phototransistor is used as the detector.

More to the point, a developed technique based on a noninvasive continuous blood pressure measurement using volume oscillometric method and photoplethysmograph technique has been investigated , and the study uses high intensity LED and a LDR (Light Dependent Resistor) and placed them at the edge of a finger. The concept is that the resistance of the LDR changes according to the light intensity received by the LDR. The change in resistance is proportional to the change of blood volume and as well as blood pressure in the finger. The result showed the systolic and diastolic blood pressure on a mini LCD. In addition, a non-invasive blood pressure monitor was developed using photoplethysmograph method.

III. EXPERIMENTAL WORK

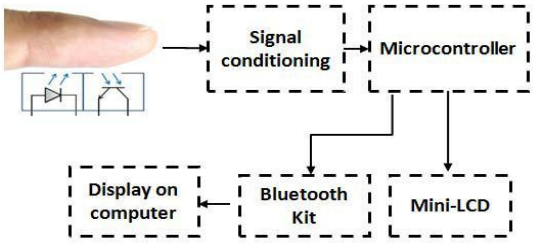

Figure 2. Circuit diagram of system.

A. Sensing Stage

The detection of the blood pressure signal is based on using optical measurement technique called photoelectric plethysmography (PPG). This technique has the ability to detect the volume of blood pressures in the arteries. The PPG basic form utilizes two components: a light source to illuminates a part of the tissue (e.g. fingertip) and a photo detector to receive the light. Transparency of living tissue to light makes it possible for some part of the light from the source to pass through the tissue to the photo-detector.

However, some part of the light is absorbed by the blood, bone, muscle and skin in the tissue. The volume of the blood in the vessel varies while the volume of other part remains constant. Therefore the light absorption is varied only by the change of volume of blood (increases or decreases) and the returning light to the photo-detector changes according to the change of blood volume. The electrical resistivity of the photo-detector changes depending on the amount of light falling on it. This change of resistivity results is the change of electrical current flowing in the detector which is converted into PPG signal.

Figure 3. Optical Sensor

B. Signal Conditioning Stage:

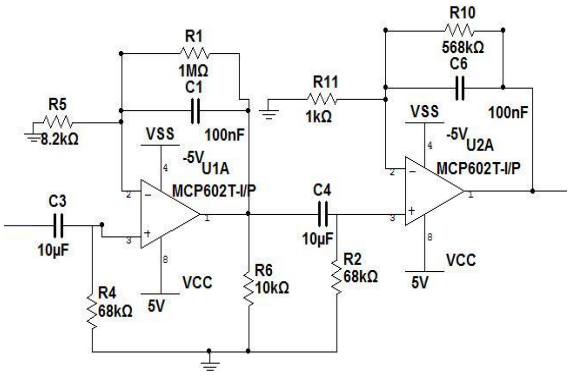

Figure 4. Circuit Diagram

After the sensor detected the changes in the volume of blood pressures, a low frequency and low magnitude biopotential signal is received by the photodiode. As the detected PPG signal is so weak, it must undergo some signal conditioning (e.g. amplifying and filtering) so that it can be used for further processing. Since the output voltage of the photo-detector has a large amount of dc component which requires a filter to suppress out the dc component. A good filter choice will be the use of an active bandpass filter because its first cut off frequency can be used to remove direct current (DC) and its second cutoff frequency can be used to remove unwanted high frequency components in the signal like power line interference (50 Hz). In addition, the filter is also used with a very high gain for amplifying the signal. Two stage bandpass filter are used and each stage has different gain.

C. Microcontroller Stage:

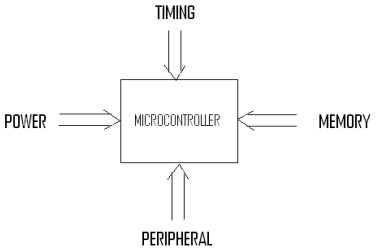

Figure 5. Essential block of microcontroller requirement (PIC18F252)

PIC18F252 is the 28 pin IC, having 10 bit inbuilt A/D converter with five input channels. Operating frequency is DC-40MHz, 32k bytes program memory and data memory is of 1536 bytes. The output of the signal conditioning stage is fed into a microcontroller where it is processed (sampling and quantizing). The PIC18F252 microcontroller is used in this system where it has a built-in ADC. The PIC18F252 device family can operate at speeds up to 12MIPS and has a hardware multiplier for faster calculation of control algorithms. The microcontroller finds out the smallest (represents DBP) and the largest (represents SBP) value form the output voltage using a program written in MPLAB X IDE.

The microcontroller then displays the measured blood pressure information in mini LCD and transmits them through a Bluetooth device to any stationary enabled computer device. Buzzer alert of the system helps the patient itself to be aware of his/her condition and can take necessary steps towards medication. At the same time, physician can also diagnose the patient from a remote location as system provides SMS alert at critical situations. The Bluetooth interface provides a convenient and low power consumption method for data transmission. This system provides users an easy-to-interface interface and simple blood pressure management environment.

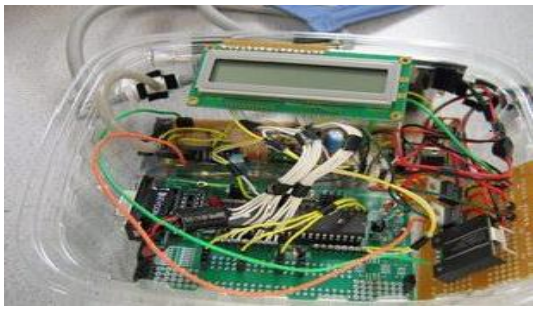

Figure 6. Experimental Work

D. LCD (Liquid Crystal Display) with Driver.

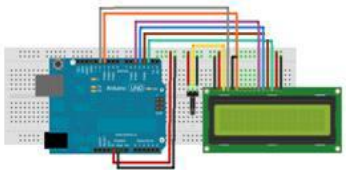

Figure 7 . LCD (Liquid Crystal Display)

A liquid crystal display is a type of display used in digital watches and many portable computers. LCD displays utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them.

E. Bluetooth Technology

By using Bluetooth (SKKCA-21) Remote Control. SKKCA-21 module offers simple yet compact Bluetooth platform for embedded applications. It has a surface mount layout which makes the process of development and application easier. The Bluetooth transmits the reading to the PC equipped with Bluetooth. The display on computer is acquired using special software called Parallax-Serial-Terminal. It is simple terminal software which allows users to display results through predefined serial ports.

F. RF Transceiver Module.

Figure 8. RF Module

An **RF module** (radio frequency module) is a (usually) small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through Radio Frequency (RF) communication. For many applications the medium of choice is RF since it does not require line of sight. RF communications incorporate a transmitter and/or receiver.

IV. RESULT AND DISCUSSION

Age	Gender	PPG(reading)
20	Female	79
26	Female	78
38	Male	84
56	Male	65
60	Male	70

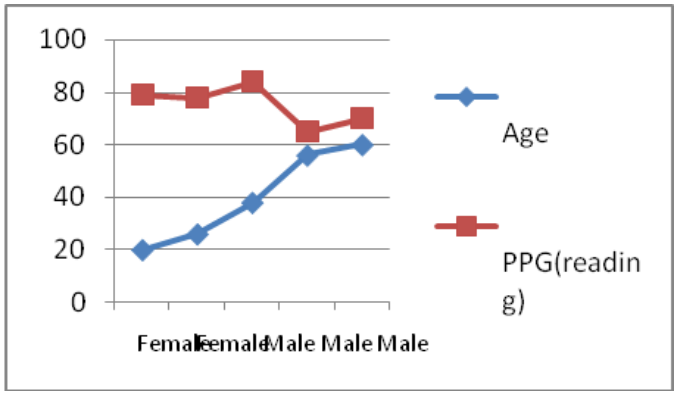

Figure 9. Graph in between Age, Gender and PPG readings.

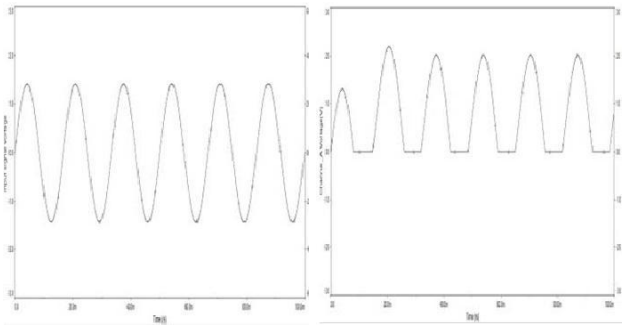

Figure 10. Input and output waveform of amplifier in Multisim

V. CONCLUSION

With this proposed system the blood pressure can be measured continuously for a long period of time and also remotely monitored. The small embedded system can display the systolic and diastolic blood pressure on a mini LCD as well stationary computer which is a Bluetooth enabled device though Bluetooth wireless technology. In case of any abnormal changes in the blood pressure readings, the system alerts using a buzzer and it also send a message to the predefined number(i.e. a physician number) using GSM. Furthermore, the obtained results will be compared with existing devices data like a sphygmomanometer to verify the accuracy of the developed instrument. This system provides users an easy-to-use interface and simple BP management environment. The Bluetooth interface provides a convenient and low-power consumption method for data transmission. This work may further be extended in future to include more number of physiological parameters like heart rate, oxygen saturation, respiration rate etc. to be monitored for a long period of time. GPS

system can be used to spot the exact position of the patient and thus can provide immediate help if required.

VI. FUTURE SCOPE

The Scope of research work intended to design and construct an Non invasive blood pressure measurement using Wireless Technology which has the low cost, reliable, and portable and it is used in many medical laboratories and industries where we can get better and more accurate result as compared to other devices.

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STUDY OF ADAPTIVE FILTERS FOR BIOMEDICAL APPLICATIONS

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Abstract

Adaptive filters are a special class of digital filters, whose characteristics can be modified automatically without the need for intervention by the user. For many applications of the adaptive filtering, the Least Mean Square (LMS) criterion is useful. The LMS algorithm is simple to implement.

In biomedical signal acquisition like Electrocardiography ECG or Electroencephalography EEG one of the main problems is to separate the small input signals from noise and disturbances caused by the 50Hz power supplies, high frequency interference and random body voltages. Adaptive filter techniques are required to overcome this problem. Different adaptive filter types have been analyzed. Finite Impulse Response (FIR) filters are preferred because of their better stability. An adaptive filter was implemented which suppresses known noise sources in an ECG application. Simulations were done with MATLAB A 50 Hz interference on the ECG input signal was attenuated by 50 dB. The convergence time for the adaptive algorithm was less than 3 sec. The filter implementation needed 9500 equivalent gates and worked with 7.2 µW for a filter clock speed of 1.6 kHz. This paper aims to help to reduce the noise interference in the ECG signals and better diagnose results. Some of the most common examples of noise that the ECG filter would need to remove in order to give useful results includes power line interference, motion artifacts, muscle contraction, electrode contact noise and interference caused due other electronic equipment. ECG signals are weak and easily susceptible to noise and interference

In this research work, the LMS algorithm is implemented using MATLAB software and some and biomedical applications are studied.

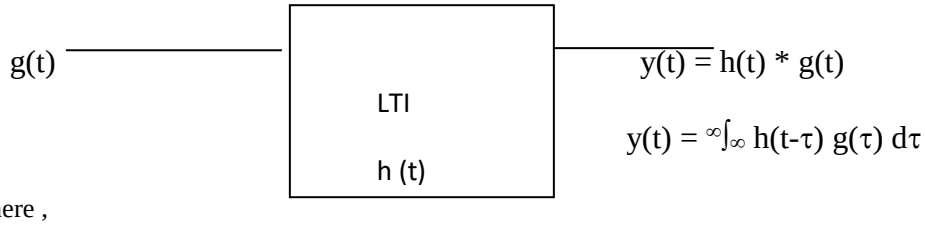
Keywords:- Adaptive filters, LMS algorithm, FIR Filters, ECG, MATLAB etc.

I. INTRODUCTION

A. Digital filters :

Digital Signal Processing is an area of science and engineering that has developed rapidly over the last 40 years. Digital Signal Processing is the processing of signals by digital means. One of the most widely used complex signal processing operation is digital filtering. Filtering is used to pass certain frequency components in a signal through the system without any distortion and to block other frequency components. The system implementing this operation is called filter.

Various filters are defined, depending on the nature of the filtering operation. The operation for the liner system is linear and is described by the convolution integral.



where ,

g (t) is the input signal

y (t) is the output of the filter characterized by the impulse response h(t).

A linear system with frequency response H(w) acts as a filter to signals of different frequencies at input. Filters are usually classified according to their frequency- domain characteristics as Low pass, High pass, Band pass and Band stop or Band elimination filters.

In general digital filters are
IIR [Infinite Impulse Response] filters
FIR [Finite Impulse Response] filters.

B. IIR [Infinite- Impulse Response] filters:

IIR filters are characterized by infinite duration impulse responses. Some of these impulse responses can be modeled by rational system functions or, equivalently, by difference equations. Such filters are termed as auto- regressive moving average (ARMS) or, more generally, as recursive filters. Those IIR filters that cannot be so modeled are called non recursive filters. In DSP, IIR filters generally imply recursive ones because these can be implemented efficiently. Therefore we will always use the term IIR to imply recursive filters.

Since our filters are LTI systems. We need the following three elements to describe digital filters structures.

These elements are
1) Adder
2) Multiplier (gain)
3) Delay element (shifter or memory)

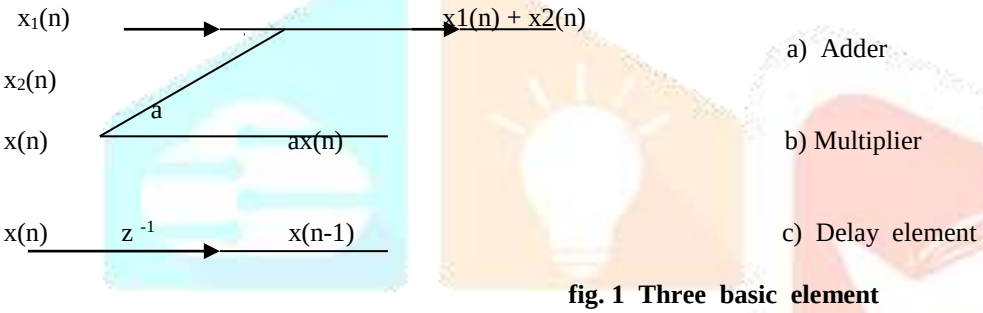


fig. 1 Three basic element

The difference equation representation of an IIR filter is expressed as

$$y(n) = \sum_{m=0}^{M} b_m x(n-m) - \sum_{m=1}^{N} a_m y(n-m)$$

To implement an IIR filter five different structures can be used:

a) Direct form Structures
b) Cascade Structures
c) Parallel Structures
d) Lattice Structures
e) Lattice -ladder Structures

C. FIR [Finite- Impulse Response] filters :

FIR filters are characterized by finite -duration impulse responses. ARMA filters include moving average filters that are FIR filters. FIR filters and IIR filters are linear time-invariant (LTI) systems that can recreate a large range of different frequency responses.

A FIR filter has a system function of the form

$$H(z) = b_0 + b_1 z^{-1} + \ldots + b_{M-1} z^{1-M}$$

$$H(z) = \sum_{n=0}^{M-1} bn\, z^{-n} \quad \ldots (A)$$

Hence the impulse response h (n) is

$h(n) = \{ b(n), 0 \le n \le M-1$

$0, \quad$ else …….. (B)

The difference equation representation is

$y(n)=b_0x(n)+b_1x(n-1)+\ldots\ldots+b_{M-1x}(n-M+1)$ ……..(C)

Which is a linear convolution of the finite support .

The FIR filter structures are always stable, and they are relatively simple compared to IIR filter structures. FIR filters can be designed to have a linear phase- response, which is desirable in some applications.

A FIR filter is a filter structure that can be used to implement almost any sort of frequency response digitally. An FIR filter is usually implemented by using a series of delays, multipliers and adder to create the filter's output.

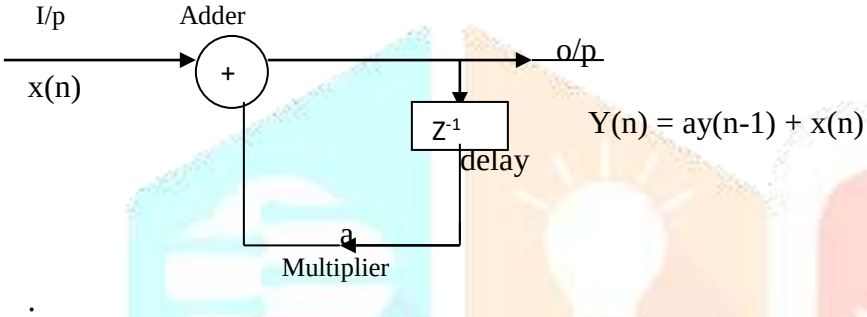


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Fig 2. First order recursive filter

Fig 2. Shows the basic block diagram for an FIR filter of length N .

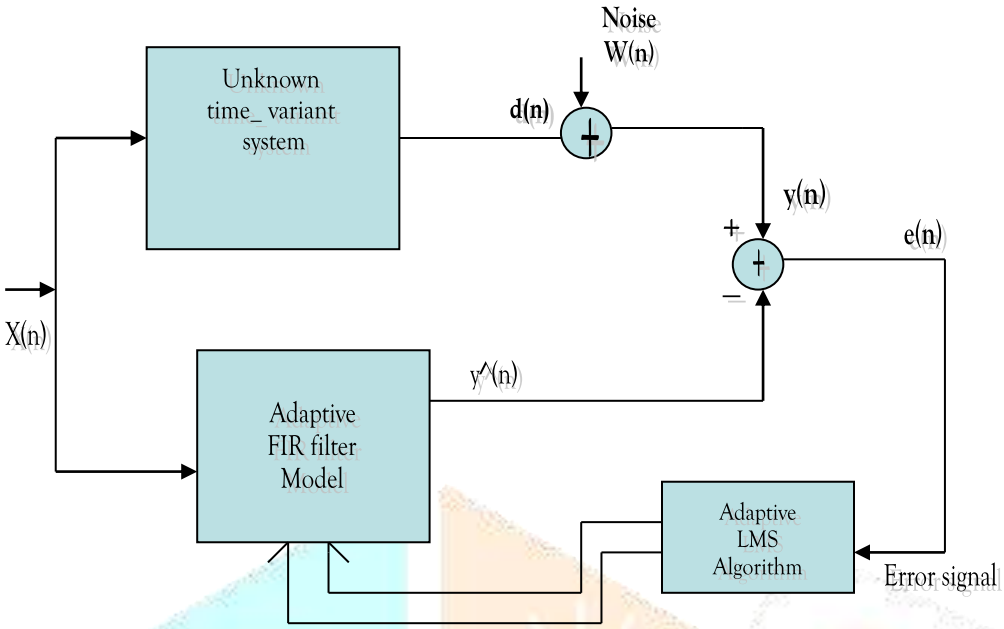
The delays result in operating an prior input samples. The hk values are the coefficients used for multiplication, so that output at time n is the summation of all the delayed samples multiplied by the appropriated coefficients.

The output of a filter Y(n) is expressed in the form of a differential equation.

$$Y(n) = x(n) + ay(n-1)$$

The first order recursive filter shown in figure 2.

D. Adaptive Filters:



Adaptive filters are a special class of digital filters.

An adaptive filter is very generally defined as a filter whose characteristics can be modified to achieve some end or objective, and is usually assumed to accomplish this modification (or "adaptation") automatically, without the need for substantial intervention by the user. While not necessarily required it is also usually assumed that the time scale of the modification is very slow compared to the bandwidth of the signal being filtered. Implicit, in this assumption is that the system designer could (over any particular substantial time window) in fact use a time- invariant, non adaptive filter if only the designer know enough about the input signals to design the filter before its use.

This lack of knowledge may spring from true uncertainty about the characteristics of the signal when the filter is turned on, or because the characteristics of the input signal can slowly change during the filter's operation. Lacking this knowledge, the designer then turns to an" adaptive" filter, which can "learn "the signal characteristics when first turned on and thereafter can "track "slow changes in this characteristics.

In this way, the goal of an adaptive filter is to "find and track "the optimum filter corresponding to the same signal operating environment with complete knowledge of the required statistics.

Adaptive filters have received considerable attention from researchers over the last 25 years. As a result, many computational efficient algorithms for adaptive filtering have been developed.

The analysis and design of three basic classes of adaptive filters are

1) Adaptive Finite-Impulse-Response (FIR) filters
2) Adaptive- Infinite-Impulse-Response (IIR) filters
3) Adaptive Property – Rest oral filters.

Although both IIR and FIR filters have been considered for adaptive filtering, the FIR filter is by far the most practical and widely used .The reason for this preference is quite simple .The FIR filter has only adjustable zeros, and hence it is free of stability problems associated with adaptive IIR filters that have adjustable poles as well as zeros.

Adaptive FIR filters are always stable. On the contrary, the stability of the filter depends critically on the algorithm for adjusting its coefficients.

So, for implementation of the adaptive filters two basic algorithms:

the Least –Mean-Square(LMS) algorithm ,which is based on a gradient optimization for determining the coefficients , and the class of recursive least – squares (RLS) algorithm is used.

The LMS Algorithm, introduced by Widrow and Hoff (1960), is widely used in practice due to its simplicity, computational efficiency and good performance under a variety of conditions.

The basic algorithm, called the Least-Mean- Square (LMS) algorithm, to adaptively adjust the coefficients of an FIR filter. The adaptive filter structure that will be implemented is the direct form FIR filter structure with adjustable coefficients h(0) , h(1) ,…, h(N-1).

The least squares (and MSE) criterion provides a good measures of performance in adaptive filtering applications.

E. Biomedical signal Processing: In many applications for biomedical signal-processing the information-bearing signals are superposed by further components. Thus signals get distorted and the extraction of information is complicated. In electrocardiography interferences may have a technical source, for example a power supply unit, or a biological source, for example respiration. Commonly frequency-selective filters with fixed coefficients are used to suppress a specific frequency range of a signal. If the frequency spectrum of signal and interference overlap or the characteristic of the interference is time dependent or not exactly known, filters with fixed coefficients can hardly meet the demands. Often the filter's transfer behavior can't be specified sufficiently exact or those spectral of the ECG which falls in the filter's cut-off region get lost.

III RELATED WORK

Measurement of Biological activity by means of monitoring electrical discharge, as typified by the monitoring of heart patients, parallel the communications problem: A transmitter (the electrical discharge) radiates energy through a propagation path (the body's tissue) to a receiving antenna.(an electrode) positioned to maximize energy reception. Because the electrical discharge involves very small potential, the received signal is very weak and requires care to prevent degradation of the signal content by added noises or filtering. Probably the strongest source of interference is 50/60 Hz. Pickup and its harmonics emanating from nearby electrical equipment such as lightening and instrument power supplies.

The conventional means for dealing with such strong, spectrally concentrated interference is a fixed, low pass filter which scarifies waveform details associated with spectral components above 50 Hz.

Use of a Notch filter suppressing the energy in the appropriate narrow spectral band represents an improvement; however it still distorts the signal component of interest.

The hum remover uses an adaptive filter to produce an estimate of an interfering signal and then subtract it away from the corrupted signal of interest.

The fig 3 shows the block diag. of the Adaptive Noise Canceller (ANC)

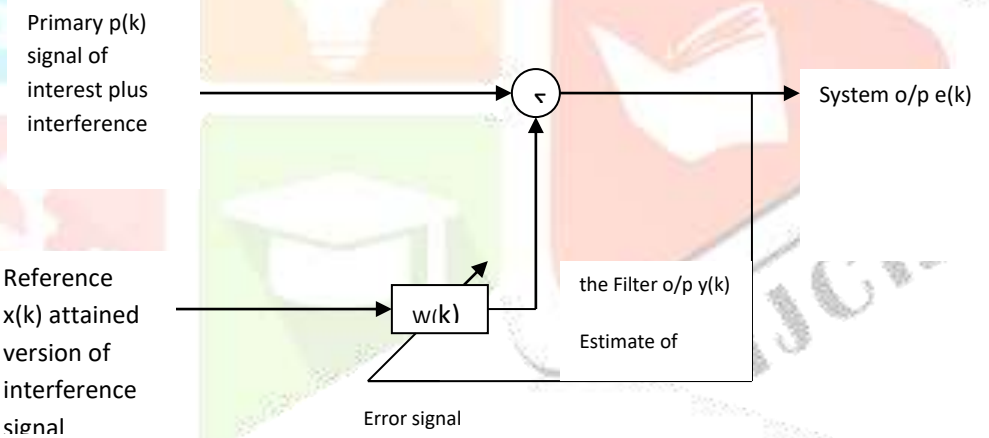


Fig 3. Block diagram of the adaptive noise canceller.

It has two inputs and a single output. The primary input p(k) contains the signal of interest plus one or more interfering signals . The second input, termed the reference input x(k), is applied to the input of the adaptive filer. This reference input should be as rich as possible in the signals interfering with the signal of interest and should contain as little of the single of interest as possible.

The objective in adapting the coefficients of the filter is to produce a filter output y(k) that matches , the exact waveform of the interference signals appearing in the primary input . The filter output is subtracted from the primary input to produce the system output e(k). If the filter can be adjusted to achieve a perfect match between filter output y(k) and the interference present in the primary signal p(k), then e(k) , the system output , contains only the signal of interest . To the extent that the filter cannot be so adjusted, then a certain amount of the interference remains.

Note that the ANC uses the system output e(k) as the error signal to drive the filter's adaptation. When the filter's coefficients are optimally adjusted, the presence of the interference in the error is minimized. By using a adaptive algorithm that minimizes the presence of the interference, the best coefficients can be found. The primary signal is that provided by the medical instrumentation containing both the ECG signal of interest and the 50/60 Hz. interfering signal component received from the room's power system.

The reference input x(k) is obtained from the power mains themselves, thus being reach in the interference signal and containing very little of the medical signal of interest. The difference signal e(k) is both the system output and error signal used to drive the filers adaptive algorithm. The ANC is widely used in practice. While the full range of designed possibilities are available in terms of filter structure, performance functions, and adaptive algorithm, the most common designs use FIR filters, least- squares performance criterion and the LMS approximate- gradient -descent adaptive algorithm.
The LMS algorithm provides as alternative computational method for determining the optimum filter coefficients {h(k)} without explicitly computing the correlation sequences $\{r_{xx(k)}$ and $\{r_{dx}\}$. Algorithms for recursively computing the filter coefficients and, thus, searching for the minimum of E_M, have the form

$h_M(n+1) = h_M(n) + 1/2\ \Delta(n)\ S(n)$,n=0,1,…. ……(1)

Where ,
$h_M(n)$ is the vector of the filter coefficients at the nth iteration,
$\Delta(n)$ is the step size at the n_{th} iteration.
S(n) is the direction vector for the n_{th} iteration.
The initial vector $h_M(0)$ is chosen arbitrarily.

Considering the search methods based on the use of gradient vectors.
The simplest method for finding the minimization of EM recursively is based on a steepest decent search.
In this method of steepest descent, the direction vector S(n)=-g(n),where g(n) is the gradient vector at the nth iteration, defined as

$g(n) = d\ E_M(n)/d\ h_M(n)$ …….(2)

The recursive algorithm based on the method of steepest decent is

$h_M(n+1) = h_M(n) - 1/2\ \Delta(n)\ g(n)$ ……(3)

The algorithm leads to convergence of $h_M(n)$ to h_{opt} in the limit as n $_{\infty}$' provided that the sequence of the step sizes $\Delta(n)$ is absolutely summable , with $\Delta(n)$ 0 as n- ∞ It follows that as n-∞.g(n)-0.

An unbiased estimate of the gradient vector at the nth iteration is given as
$g\hat{}(n) = -2e(n)\ X^*_{M(n)}$ .....(4)
thus , g^(n) substituted for g(n)-0, we have the algorithm

$h_M(n+1) = h_M(n) + \Delta(n)\ e(n)\ X^*_{M(n)}$ ……(5)

This is called a stochastic–gradient-descent algorithm, it has a variable step-size.

In adaptive filtering a fixed step- size-size algorithm is use:
For two reason
The first is that a fixed step size algorithm is easily implemented in either hardware or software.
The second is that a fixed step size is appro0priate for tracking time –variant signal statistics, where as if $\Delta(n)$- 0 as n- 0
For this reason, eq(2.5.8) is modified to the algorithm.

$h_M(n+1) = h_M(n) + \Delta e(n)\ X^*_{M(n)}$
Where ,
Δ is now fixed step-size .
This Algorithm was first proposed by Widrow and Hoff (1960), and is now widely known as the LMS (Least Mean Squares) algorithm .
Cleary, it is a stochastic–gradient algorithm.

IV. RESULTS AND DISCUSSION

The ECG of an healthy adult has a fundamental frequency from about 70 bpm[5] up to 80 bpm. For certain disease patterns fundamental frequencies down to 20 bpm occure. At physical stress frequencies up to 200 bpm are observed. The adaptive filter was tested for ECG signals with different fundamental frequencies. For frequencies up to 160 bpm good results were achieved, whereas the signal quality is downgrading for higher frequencies. Furthermore the filter was applied to ECGs with a power line interference of different frequencies. For interfering frequencies from 30 Hz to 100 Hz the filter turned out to be well suitable. The influence of the amplitude of the superposed signal was also studied. Interfering components with amplitudes from 0,05% to 100% relating to the maximum ECG amplitude can be extracted. Depending on the amplitude of the superposed signal, the interference was damped by 4 dB up to 50 dB. Convergence time of the adaptive algorithm is less than 3 sec. For a VIRTEX E FPGA [3] from Xilinx the filter realization

needs 9500 equivalent gates and the calculated power loss is 7.1 µW . Using a sampling frequency of 256 Hz for the ECG the filter clock speed is 1.8 kHz.

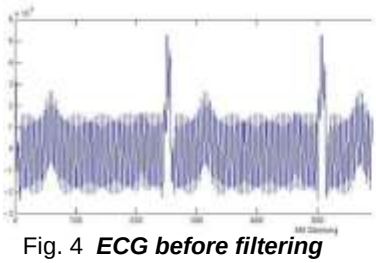


Fig. 4 ***ECG before filtering***

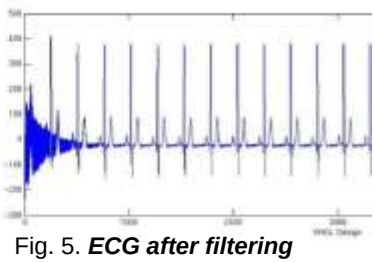


Fig. 5. ***ECG after filtering***

Using MATLAB Tools, the results are computed. The noisy ECG signal which is taken as input is filtered using adaptive filter algorithms LMS. The original ECG signal is passed through the LMS adaptive algorithms and hence improving the SNR ratio of the signal to a greater extent.

V. CONCLUSION

This paper shows the simplicity of LMS algorithm and ease of implementation, evident from above make this algorithm better in many real time systems to improve the SNR and to reduce the noise of signal. Information of fetal heart rate, derived from the fetal ECG, is valuable in assessing the condition of the baby before or during birth of a baby. Adaptive filter have been used to derive a noise free fetal electrocardiogram signal.

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DESIGN AND IMPLEMENTATION OF HEARTBEAT AND PULSE OXIMETER MONITORING SYSTEM ON GENERAL INTENSIVE CARE UNIT (ICU)

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Abstract : A novel approach which has potential to improve quality of patient care about Heart beat & pulse oximeter monitoring system on general Intensive Care unit is proposed. Patient care is a labour-intensive task that requires high input of human resources. A heart beat & pulse oximeter Monitoring system is proposed which can go some way towards improving patient monitoring on general Intensive Care unit. Sometimes it becomes necessary to monitor physiological events from a distance monitoring a patient in an ambulance and in other applications away from the hospital, collection of medical data from a home or office and use of telephone links for transmission of medical data. When the patient is in critical condition and is admitted in intensive care unit (ICU) or is being operated upon in the operation theatre (OT), it is crucial to monitor the patient for his physiological parameters such as heart beat, blood pressure, temperature, respiration rate, pulse oximeter rate etc. This monitoring is necessitated on account of the immediate response required for support of patients. The monitor provides the healthcare team with the information that is used to make decisions about the patient's treatment.

In this system vital signs i.e. signals are gathered from patients and sent to a control unit for centralized monitoring. The heart beat & pulse oxymeter monitoring system can complement the role of nurses in monitoring patients' vital signs. They will be able to focus on holistic needs of patients thereby providing better personal care. Wireless network technologies, ZigBee, Bluetooth, GSM and Wi-Fi, are utilized for transmission of vital signs in the proposed heart beat monitoring system. They provide flexibility and mobility to patients. The results illustrated the capability, suitability and limitation of the chosen technology.

Keywords: Embedded, Heartbeat, pulse oximeter, ICU, Remote patients Monitoring, Wireless etc.

I. Introduction

"Health is Wealth", is true not only for an individual, but is perhaps equally important for society in large. A Health care is one of the fast emerging fields today. With the average age of general population increasing each year the credit goes to cutting edge of medical research. New methods are developed almost every month to as a solution to numerous health problems for which accurate diagnosis is the need of the day. The Biomedical equipment providing accurate reproduction of body signals and automated diagnosis and patient monitoring systems. The field of biomedical instrumentation is an integral part of medical research. Although many types of illnesses currently can be managed in an outpatient setting, there are clearly medical conditions that require more intensive care and treatment in a hospital. Generally, patients are either brought to an emergency or urgent care department for accurate diagnosis and management or a ICU to receive non-urgent treatment. The diverse healthcare environments generate different requirements of heart beat monitoring. These requirements should be carefully considered for further development in the healthcare system. In this paper the basic requirements of heart beat monitoring on general ICU will be studied.

II. HEARTBEAT MONITORING ON GENERAL INTENSIVE CARE UNIT (ICU)

A general ICU is a non-specialist hospital unit offering a range of treatments to a variety of patients. Advances in medical technology have led to patients living with much more complex health issues, leading to an increase in the variety of patients being managed within the ICU setting. Therefore, patients may require different level of care and attention; some require frequent visits by medical personnel whilst others who are in stable condition require less.

Heartbeat monitoring is an essential part of management and care of patients on Intensive care Unit (ICU). The purpose is to identify and record changes that occur to vital signs, as this may be helpful in preventing deteriorations of patients' condition. The frequency of monitoring may also vary depending on the severity of the patient's condition. Varshney (2006) suggested some basic requirements that should be considered in heartbeat monitoring on general intensive care unit (ICU). The following vital signs should be recorded at the initial assessment and as part of routine monitoring. Out of these vital signs, we have studied only Heart rate monitoring.

1. Heart rate
2. Oxygen saturation

3. Systolic blood pressure
4. Respiratory rate
5. Body temperature

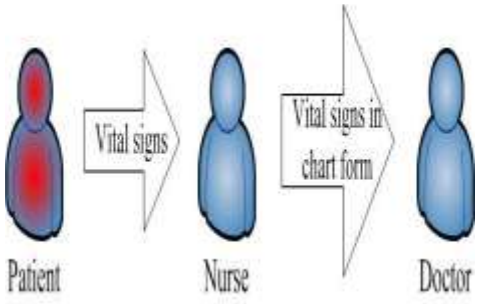

Figure 2.1 - Role of nurse in a Heartbeat Monitoring process

Vital sign measurement is the initial and the most important task in Heartbeat monitoring System. The existing instruments are commonly equipped with cable-based sensors, which make them bulky, intrusive and inconvenient. These sensors may not suit for long-term monitoring of vital sign in heartbeat monitoring on general intensive care unit(ICU). To improve comfort and mobility of patients, wireless biomedical sensors are considered. They are normally small in size and have wireless communication capability.

III. RELATED WORK

The functioning of this work is based on the fact that blood circulation occurs for every heart beat which can be sensed by using a circuit formed by the combination of an LDR and LED. Depending upon the rate of circulation of blood per second the heart beat rate per minute is calculated. This device consists of a microcontroller which takes the input from the heart beat sensor and calculates the heart rate of the patients.

A. SENSORS FOR HEART RATE MONITORING

Fig 3.1 Heart rate Sensor

Heart rate measurement indicates the soundness of the human cardiovascular system. The heartbeat sensor is based on the principle of photo phlethysmography. Heart rate is very important in patient monitoring. In traditional medicine, heart examination and monitoring was carried out by stethoscopes, through which medical personnel listened to a patient's heart sound and made decisions based on their knowledge and experience. The development of electronics and digital signals processing techniques have made it possible to use a small microphone to record cardiac sound and use a computer to analyze it. However noise cancellation is yet under research to ensure the accuracy of heart sound monitoring. 20 Budinger (2003) indicated that heart rate can also be measured by electrical waveform as well as pressure detection and electromagnetic flow. In this paper, some sensors that can be used to measure heart rate are evaluated; they are ECG, heart-rate chest strap and oximeter.

B. ELECTROCARDIOGRAPH (ECG) SENSOR

Figure 3.2 shows such a wireless 12-lead ECG. The hand-held device is for Wireless Transmission of ECG signals to a PC nearby or in remote location.

ECG is primarily a tool for examination of cardiac diseases. An ECG sensing device commonly consists of a group of electrodes to detect electrical events of a heart. It is used to indicate that the most prevalent ECG sensor involves the connection of 12 electrodes (also referred to as leads) to a patient's chest, arms and right leg via adhesive foam pads. The sensor records a short sampling (no more than thirty seconds) of the heart's electrical activity between different pairs of leads. Each pair of leads provides a unique and detailed picture of the cardiac rhythm by detect the change of electrical energy and referenced to a ground signal. It is indicated that computer-based applications and the development of wireless technology had allowed the transmission of 12-lead ECG waveforms from remote locations to a hand-held computer carried by a cardiologist.

C. HEART-RATE CHEST STRAP

Figure 3.3 - A heart-rate chest strap (adapted from (Techchee 2010))

Techchee (2010) stated that "current heart-rate chest strap is based on a tiny piezoelectric sensor to detect heart beat" (as shown in Figure 3.3). A microprocessor is integrated to transfer detected signal into heart rate. The heart rate is then sent by an integrated transmitter to a wrist-mounted device for display. The wrist-mounted device usually has local warning and wireless transmission capability. In the event that the wearer's heart rate goes beyond the threshold of a preset safe range, the wrist-mounted device will warn locally as well as sending an alert signal to a physician. In contrast to ECG sensors, the strap can be simply placed on a patient's chest for measuring heart rate without the assistance of skilled medical personnel. A heart-rate chest strap does not affect a patient's mobility; however the comfort needs consideration for long-term monitoring. Currently it is mainly used for patients with some degree of chronic disease who may require regular exercises and self-monitoring (Casio 2010).

D. PULSE OXIMETER

The pulse oximeter was invented for patient monitoring in the early 1970s (Tremper and Barker 1989). It can be used to examine two types of vital signs: heart rate and blood oxygen saturation. These parameters yield critical information, particularly in emergencies when sudden changes in the heart rate or reduction in blood oxygen saturation can indicate a need for urgent medical intervention. With advanced warning, patients could get treatments to avoid hypoxemia before they manifests physical symptoms (Shnayder *et al.* 2005).

Figure 3.4 - A wireless oximeter based monitoring system

A pulse oximeter typically incorporates a plastic housing, which contains an array of LEDs and an optoelectronic sensor opposite. By detecting the amount of light absorbed by haemoglobin in blood with two different wavelengths (typically 650nm and 805nm), the level of oxygen saturation can be measured. In addition, heart rate can be determined from the pattern of light absorption over time, since blood vessels contract and expand with the patient's pulse. Computation of heart rate and SpO2 from the light transmission waveforms can be performed using standard digital signal processing techniques. There are two types of oximeters, transmittance pulse oximeters

and reflectance oximeters. The applied position of transmittance pulse oximeters is limited to the peripheral tissue, such as the fingertip, ear lobe, or toe.

IV. EXPERIMENTAL WORK

For designing and Implementation of an embedded system for heart beat & pulse oximeter monitoring of patients using wireless technology, the microcontrollers are to be selected. This system consists of a microcontroller which takes the input from the heart beat sensor and calculates the Heartbeat for the patients. Also same controller takes the input from the body signals and provides the pulse oximeter rate. The system design with Microcontroller, power supply, heart beat sensor, LCD, touch screen sensor, crystal oscillator, LED and LDR etc. In addition to this, some more resources required like RF transceiver modules, crystal oscillator etc. which will provide additional capability use for the complete system design.

The software aspect requires controlling & observing the Heartbeat of the patients. The controllers used in the research are programmed using Embedded C language and some assembly language programming.

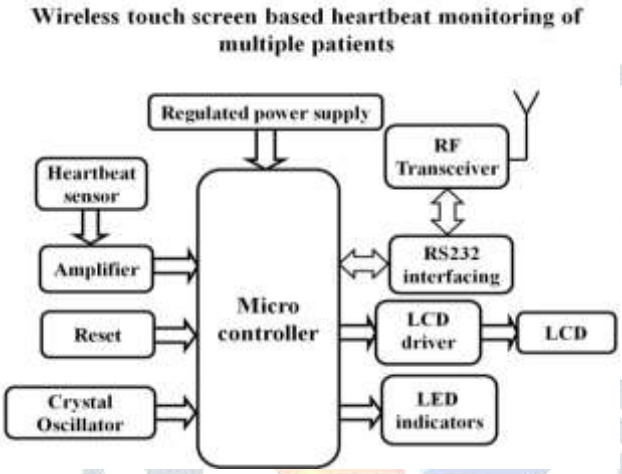

Fig 4.1 Block diagram of Heartbeat Monitoring of patients using wireless Technology

A. REGULATED POWER SUPPLY

Requirements of power supply is the main task, power supply of +5V and +12V is required for the circuit. The supply of +12 V needed for the relay connections and 7805 IC which has given +5V to the circuit.

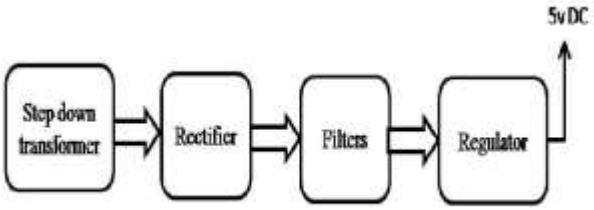

Fig 4.2 Power Supply

B. MICROCONTROLLER (PIC18F252)

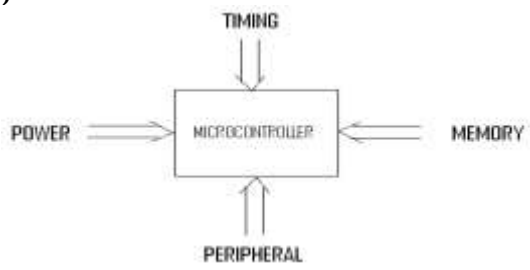

Fig 4.3 Essential block of microcontroller requirement

PIC18F252 is the 28 pin IC, having 10 bit inbuilt A/D converter with five input channels. Operating frequency is DC-40MHz, 32k bytes program memory and data memory is of 1536 bytes. In this work PortA is used for the analog inputs, port B is used as output port for the LCD Display and on PortC there are 4 pins used for push-button and other 4 pins are used for the LED indication.

C. LCD (LIQUID CRISTAL DISPLAY) WITH DRIVER

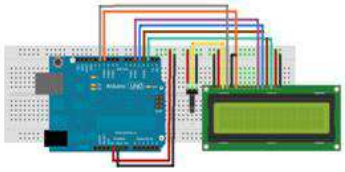

Fig 4.4 LCD (Liquid Crystal Display)

A liquid crystal display is a type of display used in digital watches and many portable computers. LCD displays utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light. Monochrome LCD images usually appear as blue or dark gray images on top of a grayish-white background. Color LCD displays use two basic techniques for producing color: Passive matrix is the less expensive of the two technologies.

D. RF TRANSCEIVER MODULES

Fig. 4.5 RF Module

An **RF module** (radio frequency module) is a (usually) small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through Radio Frequency (RF) communication. For many applications the medium of choice is RF since it does not require line of sight. RF communications incorporate a transmitter and/or receiver. RF modules are widely used in electronic design owing to the difficulty of designing radio circuitry. Good electronic radio design is notoriously complex because of the sensitivity of radio circuits and the accuracy of components and layouts required to achieve operation on a specific frequency. In addition, reliable RF communication circuit requires careful heart beat monitoring of the patients.

E. GLCD WITH DRIVER

Fig 4.6. GLCD with Driver

The graphical LCD used in this experiment is based on KS0108B controller, which is a 128×64 pixel monochromatic display. The KS0108B is a dot matrix LCD segment driver with 64 channel output. On the other hand, the KS0107B is a 64-channel common driver which generates the timing signal to control the two KS0108B segment drivers. The KS0108B and KS0107B are a very popular controllers and have made their way into many graphical LCDs. The internal block diagram of the GLCD module is shown below.

H. LED INDICATORS

A Light-Emitting-Diode (LED) is a P-N junction device (diode) that gives off light radiation when biased in the forward direction. LED chip materials are combinations of elements from the III and V columns of the periodic chart. The light emitting phenomenon makes

use of the recombination within the P-N junction instead of thermal radiation, therefore, LED's are free of waste and wear and can be expected to have a long life time. The photodiode and LED are used for the photoplethysmography unit. By controlling the forward current, the radiant flux of the LED can be easily controlled. The response time of an LED is very high (a few hundred nanoseconds) and can be pulsed at greater forward currents, to obtain high intensity radiant peaks. The resin packaging of LED's allow for superb mechanical integrity and can withstand dropping, vibration and shock. These semiconductor devices can be mounted in any position.

IV. CONCLUSION

An automated Heartbeat & pulse oximeter monitoring system by providing real-time monitoring could go some way towards improving patient care on general wards. Such a system gathers patients' vital signs and sends them to a control room for centralized monitoring. It can provide opportunity to improve the efficiency of patient monitoring and holistic care on general Intensive Care Unit (ICU). Sensors are important components in any Heartbeat monitoring system as well as pulse oximeter monitoring. Relevant sensors that can be used in Heartbeat were evaluated. The focus was on wireless sensors with the capability of measuring vital signs. A wireless sensor can offer enhanced mobility and comfort to patients during hospitalization. The capability and suitability of two wireless network technologies, Bluetooth and ZigBee were examined. Due to low-power consumption and security features, ZigBee-based wireless sensor networks were adopted. Two alternative approaches of using ZigBee-based sensor networks were discussed. They differed from the network topology deployed as well as the use of master nodes that control the communication progress within the network.

With this kind of approach and resource simple and very cost effective heart beat & pulse oximter monitoring patients using wireless technology on general Intensive Care Unit (ICU) can be designed which will be very useful in medical field, laboratories and industries where we can get better and more accurate result as compared to other devices.

V. FUTURE SCOPE

The Scope of research work intended to design and construct an Embedded System for heart beat & pulse oxymeter monitoring patients using Wireless Technology which has the low cost, reliable, and portable and it is used in many medical laboratories and industries where we can get better and more accurate result as compared to other devices.

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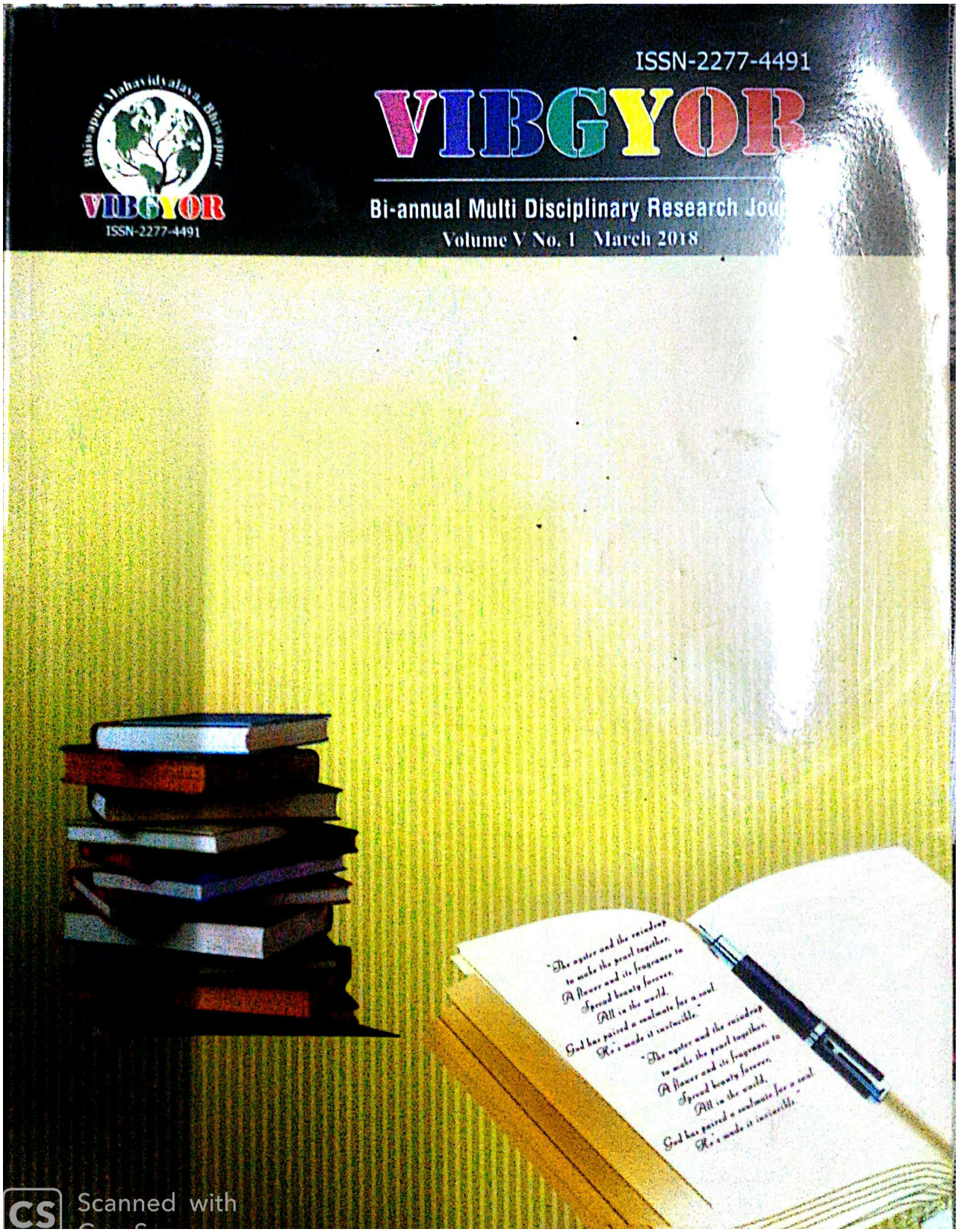
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An Embedded System For Motor Movement Controller Using Wireless Technology

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Abstract

Exchange of information and data is known as communication. In the real world of communication distance matter more and hence wireless communication makes a difference in cost & time. The name Embedded system for motor movement controller using wireless technology indicates that wireless technique for operating the motor with the help of remote controller.

Here we control the movement of motor using wireless communication system. In this system we give the code to various devices & these devices are control by the PWM of corresponding DTMF code. The switches will short different rows & column pins of DTMF generator IC. When these pins are shorted the DTMF code is generated by the IC. This DTMF code is given to the transmitter, which transmits code. The transmitter is used to obtain the range. The speed of motor is controlled by PWM. When the input is one the motor moves with particular speed when input changes which change the controller 89C51. The FM transmitter range of the transmitter is 10 feet. Range of transmitter can be increase doing modification. Modified range of the FM transmitter is 70 feet. Range of transmitter is depends on the FM transmitter. It is used in AM/FM transmitter, it require 30v & 30mA supply, it generate 260MHz frequency.

Keywords: Wireless Technology, motor, embedded System, DTMF.

I. INTRODUCTION

In industries and home appliances there are many devices in which motor used they can control by using this system. In the world of communication distance matters more & hence wireless communication makes a difference in cost & time. All the equipments of this world must be used. This paper describes the wireless technique for operating a motor with the help of micro controller. This circuit controls the movement of the motor with the help of Remote control.

The remote is designed in transmitter section. In this remote control switches are provided for controlling the movement of motor. The switches will short different rows & column pins of DTMF generator IC. When these pins are shorted the DTMF code is generated by the IC. This DTMF code is given to the transmitter, which transmits code. The transmitter is used to obtain the range. We use FM transmitter in the project. The transmitter is a carrier frequency transmitter.

In the receiver section the first block used is a FM receiver. This FM receiver rejects the carrier frequency. So the DTMF code converted into corresponding BCD output. The output of DTMF decoder IC which converts the code into corresponding BCD output. The output of switches is given to micro controller. The micro controller used is 89C51. When the microcontroller receives the BCD input. It reads the input & gives PWM output to the motor driver card & the speed of motor is controlled by PWM. When the input is one the motor moves with particular speed when the input changes which change the speed of motor in this way the speed of the motor is controlled by using micro controller 89C51.

BLOCK DIAGRAM

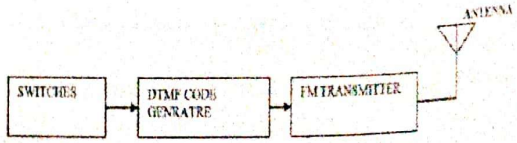

Fig.1.1 Block Digram of Transmiter

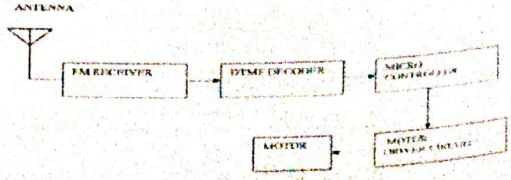

Fig. 1.2 Block Digram of Receiver

II. RELATED WORK

The remote control is designed in transmitter section. In this remote control switches are provided for controlling the speed of motor. The switches will short different rows & columns pins of DTMF generator IC. When these pins are shorted the IC generates the DTMF code. This DTMF code is given to the transmitter, which transmits code this transmitter is used to obtain the range. We use FM transmitter. The transmitter is a carrier frequency transmitter.

In the receiver section the first block used is a FM receiver. This FM receiver rejects the carrier frequency. So the DTMF codes appear as it is. These DTMF codes are given to DTMF decoder IC which converts the code into corresponding BCD output. The output of switches is given to the motor driver card & the movement of motor is controlled by PWM when the input changes which change the movement of motor in this way the movement of motor is controlled by using 89C51 micro controller because it is re-programmable.

We used main features of this IC are as under.

1. This IC is reprogrammable.
2. This IC has basic 8051 processor.
3. The RAM, EPROM, input/output etc are built-in.
4. Low power consumption & less peripheral components.
5. High frequency operation i.e. why faster operation.
6. Is has flash memory.

III. CONCLUSION

In this paper transmitter is used to obtain the range. In the transmitter circuit doing some modification the range can increase as per requirement. We can control the movement of advance type of motors, which is generally used in industries from distance place. In the previous FM transmitter range of this transmitter is 10 feet. Range of transmitter can be increase using 9018 transistor. Range of transmitter is depending on the FM transmitter. So for increase range of transmitter 9018 transistor is used. It is used in AM/FM transmitter, it require 30v & 30mA supply, it generate 260MHz frequency. Here we can control the direction of motor by using H-bridge.

IV. APPLICATIONS

1. This system is used to control industrial devices in which motor used.
2. Robotics can also control using this project.
3. It is also helpful for rotating radar.
4. It is used to control any types of motor such as stepper motor, dc motor ac motor etc.

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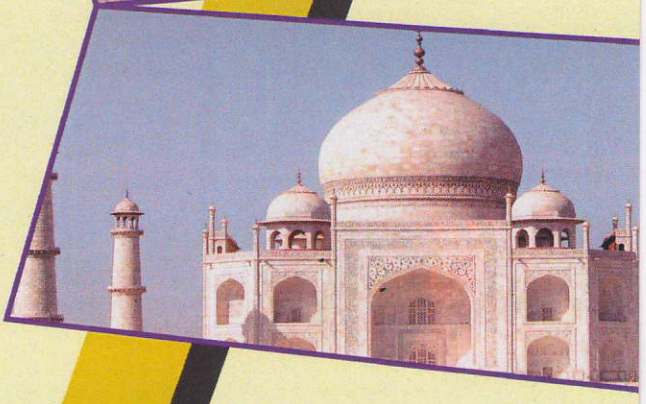

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Ajanta
Prakashan

31 Shashi Deshpande: Reading Feminism in Roots and Shadows

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Shashi Deshpande has confessed in some of her interviews that she was influenced by Jane Austen and liked reading Dickens, Tolstoy, Bronte sisters, Dorris Lessing. It is an incident but that her writings are influenced by Simone de Beauvoir.

While we go through her writings we come across several dialogues and statements that show a self trained and inspired writer behind. There is s genuine concern with the theme she picks up for bringing it to light. The Dark Holds No Terror is translated into German and Russian. Though she has achieved a better command over the subjects she treats in her novels and short stories, she is not fully satisfied. Her assertion is coloured with an unsatisfied and constant searching approach when she says, "None of any books has so far realized my dream of a good novel. I wish, I will one day be able to write one such book which will survive the text of time. My best book is yet to come:

Burdens of patriarchal society over woman folks have been a recurring theme. There are crises between the conventional and the unconventional. There are other aspects such as independent and financial stability; women can be seen achieving a balance between two different ends. Establishing 'identity' is a major aspect that retreats sometime but a motivating factor for the protagonists. The middle class women have always been at the centre of her writings and there is no doubt that only such women undergo various aspects of changing shifts in culture and traditions.

There are some possible reasons why she chooses such characters:

1) Her own background as she hails from a middle class family.
2) She is pre-occupied with the social forces at work in society. The class-clash between the old and the new; between idealism and pragmatism.
3) The middle class woman represents a larger part of the contemporary Indian Society.

The woman she portrays is quite unique i.e. she neither represents the old orthodox image her a modern westernized woman, she is the 'every woman' of the Indian middle class society who tires hart to rise above tradition but is involuntarily adopted into it."[1]

Roots and Shadows

Though the protagonists differ in appearance their plights of sorrow are similar n great extent. While we read her novels, we find a genuine concern Shashi Deshpande bears towards woman folk in Indian Society. Protest in her writings abounds and also a need for correction of ways.

'Roots and Shadows' figures Indu – the protagonist. She is prayed on by her patriarchal attitude right from her birth. Her father leaves her to fate as a baby fifteen days old. The dissatisfaction of father as a mal e towards birth of baby girl as female is clearly evident from this incident. It is no surprising because this has been a feature in Indian Society. A prejudiced male behavior is reflected clearly. These are fathers who are careful about a son who has a worthless appearance but a pride for the family. Madhav Kaka is character who prefers to be ignorant about his daughter's education but concerned about son. Another important aspect closely related with womenfolk's in India is marriage. Parents are prompted by other jubilantly and somewhat jokingly at the birth of a girl. A girl is born perhaps to lead the parents to misfortune and penury. A girl choosing her own partner for life is not a 'good girl' at all. A 'good girl' is the one who surrenders to choices made by male counterparts and sometimes even a younger brother. They have no choice to project but to confirm the voice of males in family. It is because of the social traditions and conventional bounds, that she is always burdened. The conversation between Mini and Indu is a testimonial of what impact the society bears. They are taking about 'marriage' and 'choice'.

"What choice do I have, Indu? She asked me. Millions of girls have asked this question millions of time in this country, surely it was time they stopped asking it. What choice do I have? Surely, it is this, this fact that I can choose, that differentiates me from animal. But years of blind folding can obscure your vision so that yo9u no more move out of your case of no choices. (R&S, p. 124-125).

There are difficulties on the side of the parents also. When a daughter is to be married, it is a kind of hunt for a suitable match. They need to run from pillar to past in order to make things happen. Demands by the grooms family is an additional bitter truth are revealed in course of time as Mini opens her heart to Indu. She says that, she does not have a choice except marrying him; whether she likes him is utterly insignificant. Mini is a perfect example to show the miserable plight of daughters and a sense of helplessness they bear with. By marrying daughters, parents feel their duty performed well and concluded. But this is mother beginning of a new story. These remain hundred incidents in stove that tests anything with daughters and her family. Mini recites her experience encountered several times while fixing her marriage. "You don't know what it has been like watching Kaka and Hemant and even Madhav Kaka recurring around after eligible Men. And then sending the horoscope and haring it come back with a message, it dosen't match?

And if the horoscope matched, there was the meeting to be arranged. And another and Atya shagging in the kitchen the whole day. And all those people coming and staring and asking all kind of questions. And if

we heard they were old fashioned people, I would dressed-up in an old fashioned manner and they would say, "She is not modern enough". And if I dressed up well, they would say, she is too fashionable of us. Or too short, or too tall, or too something". And kaka trying to laugh and talk to those people, while his eyes looked so anxious and I am feeling like as it I had committed a great crime by being born a girl. So we would have to go through with it all over again. And if everything was fine there was the dowry". (R&S135)

This seems to be a close summary of most of the girls experience at their marriageable age. The parents meek at fortune and facing society at the toughest for every move are just not a fantasy of mind. This is all for real. There are traditional characteristics or features of appearance and behavior of a girl. She must be obedient, surrendered to wills of the male' – the father, grandfather, brothers – sometimes younger, cousins everyone but male. Indu locates her memories of childhood "As a child, they had told me I must be obedient and unquestioning. As a girl, they had told me I must be meek and submissive. Why? I had asked. Because you are a female. You must accept everything, even defeat, with grace because you are a girl, they had said. It is the only way, they said, for a female to live and survive. And I had watched them and formed it to be true. There had to be, if not the substance, at least the shadow of submission. But still, I had laughed at them, and sworn I would never to be what I was not. (R&S158-159)

Incidents here cross the dreamland rooted with 'marriage'. We came across situations where we find that marriage is an instrument to suppress women. A girl when married loses her identity and gains a new. She tries to bit herself into the routines of a new house and people. Her childhood is marginalized with traditional sanctions and her youth remains unchanged. Narration of "Akka" and her marriage is very pathetic. The sorrow contained is common in case of Indian Boundaries.

"She (Akka) was just 12 when she was married. And he was well part 30, remember him still. He was tall, bulky man with large course features. And she …… she was small, dainty, really pretty, with her round face….

Now your punishment begins, Narmada. You have to pay for all those series and jewels" (R&S 77). Such marriages are no marriages at all because they do not carry sanctity of wedlock. Innocence is cheated in the best way possible in presence of all wise men and hundreds of them attest it happily. Girls in their innocent age are left to their fortune where they are sexually abused. They fall into various other domestic chores even before they have understood its actual cause. The supremacy of men is maintained for all time and women remain subtend.

Deshpande has portrayed a fine character in the form of Akka. Akka has suffered a lot after her marriage. She experienced countless situation where missing new no bounds. But when her husband suffered a stroke of Paralysis, she takes to rule everything. Her husband had a mistress whom Akka does not allow to meet. This appears as if she might be avenging her part, but even she weeps in lonely dark homes. When

asked, she tells that she has been inflicted tortures of every kind; she remembers those days and lightens her heart to herself only. Due to her husband's paralytic posture, the miseries too are halted but the youthful years were just hell-like.

This incident reflects that a man is free to behave according to his will and no traditional bound is maintained. He can satisfy his needs physically or emotionally before or after marriage with anyone and still remains right to his self and society. But a woman cannot. A man who becomes faithless in marriage is hardly scolded. But a woman is rejected at any end. Her parents, relatives, society, friends all blame her. There is no plane with in-laws. There is a truth revealed".

It cannot be forgotten that Indu's marriage too suffers. It appears that perhaps marriages settled by parents without taking into consideration what the daughter had to say and select, may go failure. Indu recalls her meeting and marriage with Jayant; "I had felt incomplete, not as a woman, but as a person. And in Jayant I had thought I had found the other part of my whole self. (R&S, 51) This romantic elevation of her thoughts and life within grants her short lived pleasure because very soon she had to face the other side of it. The hidden sorrows and tears of failure are related to:

"Then I had met Jayant. And I had found out that he too expected me to submit. No, not expected. He took it for granted that I would. And I did it, because, I told myself, I loved him. As if that justified everything. ..... And so I went on lying, even to myself, compromising, shedding bits of myself along the way" (R&S, 158-159)

Indu seems fighting at two different ends. She has to make compromise with identity and adjust against the notions of marriage. There could be slots of woes to her woes self but she retorts them all only to see that any failure be avoided. She pays a heavy cost for it. This time he undergoes a self suppression executed by her won. When we talk & 'individuality' and 'Identity' of a woman, we find here that most often it is brutally murdered or lost in whatever case.

Females may choose to remain single in such cases. But the Indian society does not allow this to be a free status. A girl who remains unmarried for a longer time or beyond 'Marriageable age as the traditionalists think' – then she is criticized and ——— at par. It is seen that criticism at parents becomes a nightmare for them. The social pressure is evident everywhere.

It cannot be exempted even the thought and acts of a traditionalists women. It is the women themselves who make others 'womanly'. Womanhood is an expensive affair for all women. From being born a girl to attaining puberty and setting married to stranger male is a wholesome route of pain and agony. A connection with what Mini retorts, Indu too recollects her experience. "My womanhood... I had ever thought of it until the knowledge had been ——— brutally, gracelessly on me the day, I had grown up. You are a woman

now, kaki had told me. " You can have babies yourself! I, a woman?..... you can't touch anyone or anything." And that I had been my introduction to the beautiful world of being a woman. I was unclean. (87)

In Indian society, there are various 'taboo' undertakings in addition to menstruation cycles. Sexual desires are never thought upon. It has been never touched anywhere. Women are the time sufferers of this all. It happens because women are only object of sexual gratification. Men are free to satisfy their physical needs to though any alternatives they find suitable for and they do not face nay criticism. But a woman missing even an inch of her 'good behaviour' or 'goodness', she becomes a topic of loose tlk and social criticism. These are natural expressions which need to be governed by socially thoughtful and noble bounds. But creating extra – social and strictly traditional constraints, no doubt, shall really be disastrous. As it happen in case of Indu when Jayant disregards her feelings and womanly concerns she decides, "I had found in myself an immense capacity for deception. I had least to reveal to Jayant nothing but what he wanted to see, to say to him nothing but what he wanted to hear. I hid any responses and emotions as if they were bits of garbage." (R&S, 04)

It is not that by submitting her wishes to Jayant and surrendering to his every wish, she is miserable. This actually brings double loss – loss of her own simple wishes and loss of self-esteem. This is where loss of identity begins.

The protagonists in Deshpande's novels are educated and possess free intellect but his way or the other, she has to surrender her voice to the male world.

Indu is a journalist and writes for a magazine. But she cannot write her will – she has to modify her views or modify her tone accordingly to what suits to her husband or the editor of the magazine. An incident reflects that Indu's opinion about the magazine she works with is not so well and it is frustrating to be with it. But Jayants' reaction is routine and practically based on needs. She wanted one to know what Jayant thinks about the whole affair. He says plainly, "That's life! What can one person do against the whole system! No point making yourself ridicules with futile gestures. We need the money, don't we? Don't forget we have a long way to go". (R&S, 19) Indu continues working but it is really loathsome in company of the magazine and the editors.

Deshpande has touched another traditional aspect of feministic concern. The evil practices to be followed by young widows. The custom of sharing heads is a patriarchal measure to disfigure women and look them like unwanted elements in social life. Make them lool low in appearance and self esteem is another aspect of it. This pathetic condition of young widows reflects the inhuman way Indian society holds women. Once Indu looks at a young widow and her heart aches with agony. She says, "The base skull, with its short hair, looked somehow not only indent, but observe when bared. And I understood why kaka had, when Atya was unidowed, so shortly resisted the idea of her becoming a shaven widow. He had won but at the cast of

Atya's status. She was now a second class citizen in the kingdom of widows. The orthodox would not eat food cooked by her. (R&S, 130)

Roots and Shadows is a noteworthy novel for yet another reason. This novel represents a 'transition' where the utterly dominated women are speaking up out their own position. They are moving beyond the traditional characteristics awarded to a woman and liberating themselves towards a new identity.

Simone de Beauvoir observes, "Few tanks are more like the torture of Sisyphus than housework, with its endless repetition; the clean become soiled, the soiled is made clean, over and over, day after day. The housewife wears herself out working time. She makes nothing, simply perpetuates the present." (Simone de Beauvoir, the second sex).

Society itself perpetuates such things an female. They are supposed and granted her obedience and meekness of behavior. They should not resist, reject or rebut anything. They are given orders by the males. And they have to follow without complaint. Inequality between male and female child is always maintained without fail. These inflame impact the growing mind. It can be certainly considered that the hatred towards being a female starts in the tender age only. Tradition set and faced by senior women in the family one imposed upon the growing fellows with strict adherence to what upcoming males want additionally. A girl is made disciplined and meek, surrendered and submissive, a coward and compromising right from her tender age. Whereas boys shall always be as they wish. As the roles change – a daughter next becoming a wife and daughter in-law adds more sacrifices at each stage she acquires further. Her puberty beings trauma of appearance, she is made to be afraid of many things around especially a 'male touch' she cannot play and roam as a child before 'that day'. Childhood disappears at once, snatched, criticized and thrown away. Indus' rejection of all these characteristics roped through traditions is reflected once while she takes to Naren. "How will you understand, Naren, you who have never had to fight, turn aggressive, to assert yourself? How easily it comes to you. Just became you are a man, for me, as a child they had told me, I must be obedient and unquestioning. As a girl they had told I must be meek and submissive. Why? I had asked. Because you are a female, you must accept everything, even defeat with grace because you are a girl, they said it is the only way, they said, for a female to live and survive."(R&S, 174)

Childless women are also address in a pertinent way by Shashi Deshpande. The challenge by Indu reflect the attitude of the writer too. A childless women is much inferior and rejected element in the society. A woman who bears children is ranked higher. It all shows that motherhood is a seriously required identity without which a woman my tend to lose her 'self'. Other achievement of any kind which world otherwise be highly distinctive are ever rated to their status. Indu expresses her anger and pain both…"Nothing about me, my academic distinctions, my career, my success, my money, name of these would impress her. To her, I was just a childless woman. To set married to bear children, to have sons and them grandchildren, they were still

for them the only success a woman could have. I had almost forgotten this bread of woman since I had left home. (R&S, 128). The inner voice is perhaps about independence of opting for motherhood. This can be seen as an attempt to free herself from the traditional tyranny of society.

There are some funny tradition Shashi Deshpande touches at. A belief that if a woman pronounces name of her husband – the husbands' life may be cut short by the providence. If this to be believed, then even the blame is put on women themselves. Women are the root of all evil occurrences in society. She puts forth angrily, indicating hopelessness of the thought, "what connection can be these between a man's longevity and his wife's calling him by name? It is as bad as praying to the Tulsi to increase his life-span." (R&S, 35)

Women cannot participate in decision making in a family. Their job is to listen what the males discuss and follow what they decide. If women demands participation or her opinions be included, then she is not modest woman. Indus' stands apart in this case two. After Akka's death when the money left behind by her was to be distributed. She makes a her presence felt loud by recording her story opinions. She faces opposition from the most but she has her own stature. Her talks and dialogue positively and without failing any of the true aspects of her profession as a journalist and her education reflect her sensibility and wisdom. She makes it very clear that she cannot be treated like any other women.

Even after strictly traditional comment from the revivers, the incident stands important for other reasons of feministic approach; her independence of choice is her own realization of being someone. This bold step and justification of adultery by Indu appears true and valid for sometime but the traditionalists have criticized it through. The adultery must not be seen as a response or answer to suppression of women's feelings toward sex or initiation in it. Whether it represents the modern Indian woman is still on issue to be discussed separately.

Indu, even after committing this act, does not keep her aside from the role of a traditional wife. She takes case that her husband remains pleased with her. She comes for likes and dislikes of her husband with ease. She says, "Always what he wants, what he would like, what would please him. And I can't blame him. It is not to be who has pressurized me into this. It is the way I want it to be? I become fluid with no shape, no form of my won." (54)

Indu is interested in creative writing and she finds it a means to articulate her feminine voice. But her husband does not want her to write what she genuinely feels, for it would not be sold in the market to fetch money. Jayant insists on the monitory aspect of her creative writing. Indu surrenders herself to the wishes of Jayant. This is where she finds that her story features of a creative writer are lost with this she loses her identity too. All this happens because she conforms to the dictates of marriage, that is to keep herself maintained with what Jayant thinks fit for them. She extends her efforts to become prefect wife, and makes s suitable appearance to her husband. This becoming a perfect wife in front of Jayant makes her pause to think, "Am I on my way to becoming an ideal woman? A woman who sheds her 'I' loses her identity in her husband's (49). This shows

that Indu has become now passive and submissive, the wife of a dominating disband. Jayants' expectations of a good wife are fulfilled well that pleases him too much. Indu has internalized the reality of society that man is superior to woman. The happiness of husband seems dependent on the degree of submissiveness of wife. A good and perfect wife is the one who takes care of everything that shall please her husband. She reciprocates with herself.

"Now I dress the way I want. As Jayant please ..... As I please? No, that's' not true. When I dress, I think of Jayant. When I undress, I think of him. Always what he wants what he could like. What would please him? And I I can't blame him. It's way of the want it to be (49).

This is perhaps making an undercurrent statement that marriage has reduced her identity. It's a kind of 'total surrender (52). She cannot think of her own as a separate being. It becomes critical when the warmth between them is lost. There is an observation." It is a trap that's what marriage is. A trap a cage ..... a cage with two trapped animals glaring hatred at each other isn't so wrong after all. And it's not a joke, but a tragedy. But what animal would cage itself?"(59). The symbols may not be fitting here with each other. The cage 'and the animals and the trap' are unsuitable in case of desorbing a marriage. These symbols reduce the noble colours and importance of the marital tie altogether. If seen through a different angles not all the marriages appear so. A case like this of Indu and Jayant cannot be taken for granted to validate all the marriages. It can be really validated that where such relationships occurs then the marriage is like a trap the husband wife like animals and the relationship like a 'cage'.

There are some other aspects of married life too which are not generally discussed openly sexual gratification on the part of both partners also plays a dominant role towards sustaining a good marital relationship. Here also the male stands important. There can be demands to this but if the female initiates this it is not a sign of goodness whereas males can openly demand this. This is a traditional outlook through the need is equal passions. It happens at times that Jayant tends to refuse Indus' demands. This rejection creates a disharmony between them. It is actual that Indu would remain unsatisfied for the basic aspect and need of human life and she develops a feeling to get rid of this.

When Akka calls her, this change is like a relief from this drab routine. The parental surroundings additionally provide her enough chances to liberate the tension and stay angry from the thoughts of rejection and dissatisfaction. An incident where she willingly surrenders to Naren, brings her relaxation. It appears that her mind is rejuvenated to teak an objection note of the whole affairs. The earlier mode of becoming a perfect wife with Jayant that has brought her nothing worthful is gradually lost. She fees able enough to think of freedom and independence. She realizes, "freedom lies in having the courage to do what one believes is the right thing to do. And the determination and the tenacity to adhere to it. That alone can being harmony in life. (P. Bhatanager).

She begins to compare her life with other women in the family and realizes that they were like bounded labours, enslaved to their husbands. In an effort to become a perfect wife she had moulded herself to the wishes of Jayant and had thought that it was a suitable move. But now she feels that it was fruitless. She feels now courageous to take a clear note of what her mind thinks independently she is able enough to take certain decisions towards a meaningful life with Jayant. It is surprising that the home she had left in fury now has become a place for solace. Her hopes are revitalized and bear a fresher outlook towards life. This is very positively reflected though her reflections when she says, "No, there is no such thing. To accept it will be to deny the miracle of life itself. If not this stump, there is another. If not this tree, there will be others. Other trees will grow, other flowers will bloom, other fragrances will —— other airs. .... I felt as if I was watching life itself.... Endless, limitless, formless and full of grace" (202). This shows that she has greatly relieved herself of unbearable tensions and dissatisfaction towards life.

Her relationship with Nasen is a catharsis of her feelings. The pent – up emotions and suppressions ins given away and now she has a clear vision of life. An insurmountable situation is won and she becomes a perfect 'self' rather than a perfect wife. She decides not to deceive Jayant and simultaneously not to suppress her own self too. She resolves everything and gets rid of many complexes. She during commitment with herself to talk everything to Jayant is in itself feministic starve.

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Myths and Realism in Amish Tripathi's The Shiva Trilogy

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Amish Tripathi is a illustrious Indian English novelist who describes legendary stories with coherent clarifications to the new generation readers. His books 'The Immortals of Meluha', 'The Secret of Nagas' and 'The Oath of Vayuputras' are the three books that make the Shiva Trilogy arrangement. It centers around looking at how the characters and episodes in the Indian Mythology, antiquated writings rework the legendary past, and how the particular writers use fantasy innovatively for dealing with the present situation. In Indian English writing, the utilization of Hindu folklore resembles scholarly convention. Indian legends have an all-inclusive history settling all sort of social, political, other worldly worries. Indian legends help in more profound comprehension of human kind just as teach and lecture about the ideal method of human existence. Indian writers utilize myths and fantasies emblematically and figuratively. This paper investigates the legendary world in Indian fictions. Myths have consistently given innovative force to the writers over the ages and it shapes the importance of a scholarly work with all profundity and expansiveness of its significance. Appropriate is to consider, "Amish amends Shiva Purana by redefining Lord Shiva as a man of flesh and blood who later transforms to godly stature because of his karma. Human centred approach revolves throughout the novel which empower the author to present Shiva Trilogy as a spiritual guide to upcoming generation as it equip them to discover Mahadev with in them to absorb evil and perspire goodness" (Chandran & Nair, 2017)

For as far back as couple of many years, the act of retelling of folklore in writing, particularly in Indian Writing in English has gone through wonderful changes taking into account the desires for new readers. Myths have been an unavoidable source and subject of study in writing down the ages. Notwithstanding the reactions and allegations coordinated towards legends scrutinizing its authority, writers have been rehearsing re-evaluation of legendary stories. This basic act of retelling legendary stories includes recreation of stories and characters suitable to the unique situation. As of late the new type of writers like the Amish Tripathi, Ashok Banker and Ashwin

Sanghi are using the myths and legends by mixing it with different methods of composing for example, Ashok Banker and Amish Tripathi. Amish's position among writers is in a bigger range and his commitment to Indian Writing in English is noteworthy. The novels, The Immortals of Meluha (2010), The Secret of the Nagas (2011) and The Oath of the Vayuputras (2013) are the best writings to fictionalize Shiva as a person.

The set of three is the festival of an epic saint 'Shiva' and his journey. Shiva has been portrayed as a man of fragile living who rises himself up to the degree of a divine being by his deeds. It is examined how the ordinary treatment of the fantasies have been reshaped through spotlight on the balanced portrayal of innovation, the enlightened way of life, persuading relations and the excursion of a man from a Tibetan clan towards turning out to be Lord Shiva.

Amish through his novel 'The Immortals of Meluha', has moreover attempted to justify that Lord Shiva was not a nonexistent character from mythology but rather an individual from the world of experiences. He has likewise taken Vedic ideas from the sacred text and introduced in this novel as science. We should take into consideration that "Shiva Trilogy contains various aspects of magical realism such as use of myth, dreams, telepathy and telekinesis, mind-reading and parables. The writings of Amish Tripathi penetrate our Indian mythology deeper than other writers (Pragadeeshwaran, 2018). Amish has utilized this freedom in remaking the mythic stories and characters the manner in which he proposed, and needed his readers to start to lead the pack. He recognizes this view in the interview in the Culture magazine as, "These books are absolutely fiction. I compose the story the manner in which it comes to me… . This is my translation. That is the excellence of India. Aside from the most recent 200 years; the convention of modernizing and changing has been there for long" (enter reference).

The portrayal of different occasions and places and scenes in Shiva Trilogy stylishly bid the feelings of the readers via conveying them into another universe of creative mind. The wonderful depiction of the city of Meluha, Devagiri and Ayodhya loans another appeal. His remarkable mix of snapping narrating, strict imagery and significant ways of thinking elegantly appeal to one's brain. Amish has put forth a decent attempt in depicting a horde of feelings and dispersing them proportionately among characters. The work of different Greek war techniques, the sign of military workmanship by Ganesha as a champion and the enthusiastic passionate obligation of Shiva and Sati are the a few methodologies utilized by Tripathi to draw in the readers of the novel.

In this period of demythologization and re-mythologization, Amish has solidly settled a fictionalized verifiable record in Indian anecdotal composition by delivering the entertainment of the customary legends through the methods for the dream mode in Shiva Trilogy. In a manner Amish has broken the traditional treatment of the fantasies by the early Indian writers. The contemporary authors have reformed the Indian Writing in English to familiarize the Indian crowds with the legacy of India.

Amish Tripathi is a banker educated from Indian Institute of Management, Calcutta. He is energetic about history, folklore and hypothesis. He is a vivacious reader of history and his motivations for the story went from writers like Graham Hancock and Gregory Possehl to the Amar Chitra Katha plan of Indian stories. For fanciful parts in the novel, Tripathi depended on the stories and tales that he had got from his family. He accepts that there is a sensation and significance in all social orders and religions of the world. Eventually, while seeing a serial program, Tripathi and his family got into a conversation about mindfulness and the evil inside man. In the program, they found that in old Persia, Demons were known as 'Daeva' and heavenly attendants were called 'Asuras'.

Tripathi felt the longing to make regarding this matter and found that no subject is better than Shiva, one of the significant Hindu divine beings and the ‘destroyer of evils’. Shiva's experience and story would pass on the writing Amish expected to pass on to his readers. He saw that Hindu splendid characters were presumably not "legendary animals or a fantasy of a rich inventive capacity", yet rather they were once people like the rest. It was their deeds in the human existence that put them on the map as heavenly beings.

Inside the novel, Tripathi centers around the social issues through legendary framework. The issues of natural contamination have been brought up in the substance.

The Indian writers in English have considered over their old past in feeding the abstract craftsmanship. To catch the ethos and sensibilities of India they got back to the rich tradition of India. Indian writing in English has shaped into a lot of interconnecting characterizations which pass on with them the straightforwardness of Indian lifestyle and the multifaceted idea of Indian feelings in a got language, English. The introduction of English language in the Indian scholarly scene has changed the substance of basically every sort, going from sensation, sentiment, misfortune to consistent with life and fiction. Writers today are endeavoring to decode and update old stories so they can end up being progressively conceivable and important for the current readers. Gone are the days when Indian English works were named subordinate and activity: it has achieved a free character today.

Because of colonization, followed by the English education at schools and colleges, English fiction is on the climb both with respect to readers and writers.

The paper figures out the essentialness of the present in association with their antiquated past. This common act of retelling legendary stories incorporates proliferation of narratives and characters according to the extraordinary situation. Starting late, the new type of writers like Amish Tripathi, Ashok Banker and Ashwin Sanghi are using the folklore sort by mixing it with various strategies for composing. For instance, Ashok Banker and Amish Tripathi have blended folklore in with dream mode. With such a utilization these writers are modernizing the Indian folklore. It has been tried to explore Amish's situation in this profound established practice in a greater reach and his commitment to Indian Writing in English. The novels, for instance, The Immortals of Meluha (2010), The Secret of the Nagas (2011) and The Oath of the Vayuputras

(2013) would be investigated in order to fictionalize Shiva as a person. Further, it includes close examination of Shiva Trilogy concerning the act of retelling of Indian folklore.

The writers like Amish Tripathi and Ashwin Sanghi with energy for innovativeness augmented the extent of this sort in the Indian publishing industry. Fictions by these writers have recuperated folklore from disposal. Epic stories can be considered as the transcendent factor behind the resurgence of this profound practice recorded as narratives. Amish Tripathi has taken a lead in Indian mythology-based composing by deconstructing the status of Shiva and giving it another viewpoint in Shiva Trilogy.

The arrangement of the trilogy is the celebration of an epic legend 'Shiva' and his life story. Shiva has been depicted as a man of fragile living who rises himself up to the component of a perfect being by his deeds. It is examined how the standard treatment of the dreams has been reshaped through focus on the reasonable depiction of advancement, the illuminated lifestyle, convincing relations and the journey of a man from a Tibetan faction towards having the chance to be Lord Shiva. The writer has endeavored to keep the saint as human as possible to where Shiva introspects about the stumbles that he made in his previous birth and his outright aversion to be known as Neelkanth, the Destroyer of Evil. The novels show how Shiva as a person goes probably as a rescuer and helpers people through his intelligence. Amish through his novel 'The Immortals of Meluha', has moreover endeavored to vindicate that Lord Shiva was not a nonexistent character from folklore yet rather a person from the set of experiences. He has besides taken Vedic thoughts from the holy content and showed in this novel as science. Amish has used this opportunity in imitating the mythic stories and characters the way where he expected, and required his readers to stand out. He perceives this view in the gathering circulated in the Culture magazine as, "These books are totally fiction. I form the story the way where it comes to me. This is my agreement. That is the magnificence of India. Beside the latest 200 years; the show of modernizing and changing has been there for long" (10).

The depiction of various events and scenes in Shiva Trilogy elegantly advances the resources of the readers by means of passing on them into another universe of innovative capacity. The great portrayal of the city of Meluha, Devagiri and Ayodhya credits another attraction. His unique mix of description, strict symbolism and critical techniques for understanding gracefully guarantees to one's mind. Amish has tried in portraying a swarm of emotions and appropriating them proportionately among characters. Crafted by various Greek war methodology, the indication of military craftsmanship by Ganesha as a champion and the energetic excited commitment of Shiva and Sati are the a couple of strategies used by Tripathi to attract the readers.

In Shiva Trilogy, Tripathi carefully spreads out territories that are picture-flawless as in literature for kids. Modifying dream additionally works out as expected of a plan novel that re-scrutinizes past set of course of action of codes, opening it with another cryptographic-authentic key, revealing reality from an interlinking deceptions. Despite revisionist history, the novel raises a substitute structure of captivating codes and customs. For example, Tripathi attempt to re-present Shiva as representative holy person is a revisionist one with explicit features of a novel. Shiva's blue throat, Sati's downfall by fire or Ganesh' elephant-head is another rubric of legends. Old

dreams have been replaced by new mixes. The depiction of the thoughts like ‘somras’ and ‘blue throat’ offers a unique combination to the readers. Sentiments are the standard subjects and there is unlimited use of action, pressure, humor, betraying, misfortune and pain. The writer has used ordinary, customary English to make the writing more comfortable interesting.

Another concept which is found in this novel is innovation. A couple of perspectives, happenings and styles in current novel are used in the novel. The battle among incredible and evil is originally a happening in Mahabharata.

In the third book 'The Oath of the Vayuputras' there is equal and convincing portrayal of mythological characters.

Amish accepts that, 'Legends are just mixed memories of a legitimate past. A past covered under hills of earth and deadness'. As given in the Oxford Dictionary, “Legend is a customary story, particularly one concerning the early history of the historical backdrop of individuals or clarifying a characteristic or social marvel and normally including otherworldly being or wonder." Nirmala expresses, “Myths are the reflections of a profound reality. They are said to be the greatest falsehoods, which tells us the greatest truths. In the novels, The Immortals of Meluha and The secret of the Nagas we could find the concept of karma. According to that, a person life is based on his own thoughts and actions. If our thoughts and actions are good then they will lead a good life. On the other hand, those persons who are suffering in their present life are due to their past life sins”(Rani 2019).

The talented authors have found source materials from dreams and have utilized them imaginatively. Reality is genuinely not another idea for books yet using legends has added to another taste. Amish's usage of imagination outlines the rule subject of his books, these can't be neglected. In a manner these legends are the vital bit of the books. In a legend a bit of the essential characters are Gods, a couple of characters are super individuals. In Shiva's Trilogy ruler Ram is God, notwithstanding the way that he is definitely not a working character, anyway ordinarily his quality and force is reminded to the reader in the most punctual reference purpose of the novel. At various spots there is a conversation on the standards laid by Lord Ram, and besides the way in which people are following them overwhelmingly for example, during the conversation among Daksha and Shiva on Somras, Daksha is telling Shiva, that Somras was planned by Lord Brahma and was given to everyone but to a particular social occasion. Anyway now it is given to all of the four places according to the guidelines made by Lord Ram.

Shiva, in the novel is an average man whom legends change into God. He is appreciated so much, that he is apparently a lot over the mankind when everything is said in deeds. He is an obvious man whose *Karma* recasts him as Neelkanth, the Mahadeva, the celestial power of awesome beings. Exactly when Ayurvati sees Shiva’s throat turning blue, tears roll down her eyes. She kept repeating, 'Om Brahmaye namah, Om Brahmaye namah'. 'My lord you have come! The Neelkanth has come!'

These characters similarly accept a basic utility in the novel. These are shown as shrewd characters anyway are later found to be incredible. Kali, Sati's sister and Ganesh, Sati and Shiva's kids are likewise Nagas. The author now and again uses the legendary and puranic segment with a purpose to show their readers something great. Various writers have utilized such methodology in their works.

In the Shiva's Trilogy the essential concern is discussed about Somras which is cruel. In making of Somras massive amount of water of Saraswati river is used and wasted. Shiva is fighting to save this river. May be the writer, through his novel, requires to make people aware of sparing a couple of rivers, which will be drained out.

Shiva, in these novels, is indeed the God that is one of the man of just character of early period of divine beings – Bramha, Vishnu and Mahesh – who have been adored since ages by Indian people. Shiva plays with snakes, smokes a *chillum* and has a blue throat – something that, as shown by the book, are the signs of the friend in need. Here he is showed up as the natural head of Gunas, who live at the foot of Mount Kailash in Tibet. Nandi isn't the bull on which Shiva rides; rather it is the captain of the Suryavanshi family who invites Shiva and his intrinsic Gunas to get comfy Meluha (Kashmir) which is viewed as the most excessive and most predominant area on earth. Having come to there, Shiva is declared a guardian angel who has come to help the Suryavanshi clan of Meluha against the tainted Chandravanshi clan of Ayodhya, who regardless of the way that adoration Lord Ram, have wandered from his message of libertarianism. They have joined hands with the Nagas and been doing attacks with respect to the Suryavanshis.

Tripathi's Shiva is a neglectful and humble character. He doesn't consider Lord Ram, nor does he know the significance of the sacred word 'Aum' or Om. Nandi in like manner goes probably as a Guru to Shiva at times, as when Shiva is to be illuminated about the significance of Aum. Says Nandi: "My Lord, Aum is the holiest word in our religion. It is viewed as crude sound of nature. Tripathi maintains to create philosophy when he declares that the Shiva Trilogy was worked around the philosophical request of "What is Evil?"

Amish's Shiva Trilogy deals with the rich fanciful tradition of old India. A section lost in the profundities of time and obliviousness by individuals. In Ancient India, various sacrosanct writings had elucidated the condition of the women, where she appreciated equivalent status indistinguishable from that of men. Women were given equivalent open door in the area of scholarship just as in the field of law or property, social support, political or organizational. The role of women in arranging life and family were clarified in Rig Vedic age which is incredibly portrayed by Amish Tripathi in his 'The Immortals of Meluha'. The height of Vedic women is reflected in the female characters of Amish's 'The Immortals of Meluha' where women are given self-sufficiency and freedom. The young age of India, eventually is significantly enthused about considering its hidden establishments, and another age of writers is riding the wave, producing one book of legendary fiction after another.

This exploration will help researchers with different estimations to look at folklore. This will defeat any issues of old and contemporary references of folklore. Amish Tripathi through these novels addresses the social reality of the contemporary society. He re-evaluates the Shiva myth to address the evil plans of people in modern times and how their silly craving prompts devastation and destruction. In this age of demythologization and re-mythologization, Amish has firmly established a fictionalized historical account in Indian fictional writing by rendering the recreation of the traditional myths through the means of the fantasy mode in Shiva Trilogy. (Rani, 2012) He prescribes a normal angle to deal with these issues. The magnificent components of the Shiva mythology are intertwined with the contemporary reality. Thus, we can say that Amish has a winning concern setting up socio-political and geographical solidarity, authentic and austere (especially from Puranas) convictions. The Trilogy is fascinating to examine. The authentic facts, rationalities and legendary components are used in present day structures.

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THE VOICE OF THE DEPRIVED IN ARUNDHATI ROY'S *'THE GOD OF SMALL THING'*

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ABSTRACT

India is a country of vast inequalities. There is a dividing line of inequality which is drawn between caste, class and gender. Due to these inequalities, deprived class has to suffer a lot. The social status of people in India is determined by power and privilege. The upper class communities govern and exercise power on the lower strata of the society in most parts of the country. After the independence, India adopted democracy. But it is only on papers but still the underprivileged are marginalized and deprived of their freedom and rights. In this connection, many Indian Writers like Sulman Rushdie, Amitav Ghosh, Anita Desai, Shashi Tharoor, etc have tried to raise their voice through their writings on issues like social inequalities, stratified hierarchy ,women's position and also on the injustice done to the dalit and underprivileged people. These writers have taken initiatives in making tremendous changes in the society thereby spreading awareness and also challenging the assumptions and belief which acts as a barrier in the progress of the world. Among these India English Writers, one such writer is Arundhati Roy, one of the most controversial novelists in India. She has touched the most sensitive part of Indian society and depicted it so deeply in her novel "The God of small things" that touch the hearts of readers. The present Research paper is divided into four parts. In the first Part, forms of caste system in India is described. In the second part, the main aspect in the novel is discussed. The Third part deals with women sufferings through different female characters in the novel. The last part mentions the overall conclusion.

Key Words: Class, Caste, Discrimination, Exploitation, Gender, Untouchable, Injustice, Identity Crisis Etc.

Introduction

In Indian English literature, many writers have tried to depict the reality of Indian culture through their writing about Class, Caste, Race, Religion, Class Exploitation etc. Among them a well renowned Indian Writer, booker Prize winner (1997) is Arundhati Roy. She is much interested in contemporary social issues which can be seen in many of her articles, interviews, books .She has written internationally acclaimed and thought provoking works like "the Algebra of infinite Justice" appealing the world to stop violence against innocent people in Afghanistan. She tries to expose the social realities of the contemporary Indian

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Society through her novel 'The God of Small Things'. She has thrown light on a very critical issue which is related to those people of our society who have been totally neglected and was not even given the power to speak and are marginalized by the old age traditional system .This traditional system led to create caste division and low status of women in the society.

Caste System in India

About Caste, the word is derived from Portuguese word 'casta' which means 'pure'. In India caste system plays an important role from the beginning i.e Ancient Hindus tradition and it begins form 1200 BC. In Ancient time, India developed a social system in which people were divided into separate class. This class system is a division of society in which there are four castes arranged in hierarchical order. But the caste system were made more difficult by including more castes and sub castes. There were several religious theories related to caste system like different Varnas were created from different parts of his body. The Brahmas from the head; the Kshatrias from the hands; the Vaishias from his thighs and the Sudras from his feet. Other religious theories suggest that the varnas were based on the body organs of Brahmas, the founder of the Universe. But no religious theory is able to explain how each varnas and the untouchables were formed.

About the novel

The novel "The God of Small Things" is set in Kerala in a village called Ayemenem and the period is about 1960.The main protagonists of the novel are Ammu and Velutha. Ammu a daughter of upper class man Pappachi and Velutha a son of a Paravan Or an untouchable .Both are in love with each other , but due to caste differences, they are separated and in the end both die in a very critical condition .The novel highlights the rigid caste system and violation of these system led to serious consequences. Even conversion to Christianity does not free them from casteism and low status. It throws light on the political issues whose aim is to bring a Marxist revolution to stop exploitation and form a society on the based on equality. This is represented by the character Comrade Pillai, a follower of EMS Namboodripad, a local Marxist leader and a great political manipulator. He joins hands with the oppressors of Velutha. The author holds a ridiculous attitude towards police, whose duty is to protect the innocent and traps the criminals. But here we see the police inspector Thomas Mathew from Kottayam Police station bullies the common people and keep a bad eye on women and join hands with politicians to exploit the untouchable Velutha.

Arundhati Roy in the novel 'The God of Small Things' put a question before us about the caste system leading to the degradation of our society. She wants to expose the inhuman done to the untouchables or the low caste. Due to these social barriers such as casteism, untouchability, patriarchy, some specific low caste groups are facing problems of their individuality. They have been marginalized and identifies as SC, ST, OBC, NT, or the other minority groups. She put a question before us that in the world when God created a human beings as equal, why such divisions occur? By dividing people into different groups, we are not only differentiating human beings but also insulting God (The divine power). We are going against God creation.

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Miserable conditions of untouchables

In India, untouchability is a heinous crime. People are given importance on the basic of their castes. Untouchables are looked down as an inferiors as if they have no identity of their own. Arundhati Roy in her novel 'The God of Small Things' depicts a very miserable condition of untouchable through the character Velutha who is a Paravan or a low caste converted to Christianity. The story is of a South Indian state of Kerala along the Malabar Coast. The people residing there are Syrian Christians. Along with them are the paravan or low caste people who have converted themselves to Christianity. These paravan are treated very badly as an outsiders and downtrodden .They are not allow in the Syrian Christian community and had their own churches. They speak Malayalam and are resided in the Neyyattikere taluka of Trivandrum district. These paravan are very laborious and expertise just like other beings. Roy presents untouchability in the way Amitav Ghosh has portrayed in his novel '**The Sea of Poppies'**. The difference between the two characters Velutha (The God of Small Things) and kalua ('The Sea of Poppies') the former is simple and innocent and the later is active and decision making. In Sea of poppies, kalua a low caste chamar is an ox cart driver and is in love with Deeti, a widow from high caste. Kalua saves her life and marries her. Velutha, an untouchable having a love affair with a woman Ammu from the high caste Christian community, a divorce woman with two twin children Rahel and Estha go against society by breaking the traditional system and this leads to their death at the end.

Velutha an untouchable is shown as a very talented youth, a talented carpenter, who has built a dining table of rose wood with twelve chairs for Mammachi. He can repair radio, water pipes, he has knowledge of plumbing and electrical gadgets in the house. For his talent, he is greatly admired. But in spite of all these qualities, he is oppressed because he is an untouchable.

Status of women in Novel

In the novel 'The God of Small things, author portrays the struggle of a woman to secure herself in a patriarchal society. In this novel, the sufferings of Indian women are studied to highlight their deplorable condition. The author has used different women characters like Ammu, Mammachi, Baby Kochamma and Rahel. These women act openly against social institution as outside the boundaries of the institution of marriage. Arundhati Roy shows a way for the Indian women for resisting local as well as global inequities. She has tried to give them the power to speak and to fight against the injustice done to them. The protagonist Ammu is depicted in such a way to show the reality of condition of women in India under the patriarchal system.

Ammu

Ammu is the Protagonist of the novel. Her father Pappachi is of the opinion that the girl's education was an unnecessary expense. On the other hand Ammu's brother Chako is given higher education even though he is not capable for such education. This is Indian mentality that girls should be married and no use of education and boys are income source of the family given a higher education. Such discrimination hampers the growth of every capable woman, the growth of society and the growth of our nation. So Ammu is left with only one thing to leave Delhi and accompany her father to Ayemenem house in Kerala. Ammu now waits in

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Ayemenem House for a marriage proposal. Ammu goes to Calcutta and meet a man who is Assistant Manager of Tea Estate. After spending time with him, she decides to gets married. After marriage, she comes to know the real character of her husband. Her husband is alcoholic and self centred. He forced Ammu to push in the arms of Mr. Hollick, his boss for promotion. Being very angry, Ammu decides to break the marriage. It shows her strongest protest against the violence. She takes divorce and returns to her father's house along with her children Rahel and Estha but unwelcome by her parents. This shows a divorce woman has no respect not only in the society but also at her parents' house . Ammu's father knowing the fact that her husband wants to prostitute her in order to please his boss not stand in favor of her. Arundhati Roy here presents the picture of powerlessness in women .Our constitution guarantee equal power to women, but still women are facing the problems of patriarchal tradition. Women are still powerless in deciding their career, marriage, and job. They even have no power towards their inheritance rights. These human rights of women are normally violated by high caste and powerful community to practice and exhibit patriarchy and casteism. After divorce, she feels very lonely and meets her childhood friend Velutha , an untouchable who has now grown as a handsome man .She feels attracted to him. Both of them neglect the orthodox society. But their union led the whole Syrian Community to act against their love. On the other hand, her brother Chako who is already divorce is having several affairs with the women labours working in his pickle factory. In a patriarchal system, a divorce woman is led to live a miserable life and a divorce man is not objected for having several love affairs. Why such a system where men and women are discriminated on the basis of gender? Ammu rebels against the social norm of the Syrian Christian Community in Kerala. She stands for those women who are striving for freedom and equality. Although she is not successful in bringing a specific change but she acts bravely for fulfilling her dreams.

Mammachi

On the other hand, Ammu's Mother Mammachi is marginalized by the oppressive patriarchal system. She undergoes trauma and torcher under the hands of her husband Pappachi and speaks nothing against him. She is very active woman and talented one handling a Pickle Factory but never receives support from her husband who is of the opinion that it is not a suitable job for high ranked ex-government officer. Mammachi is a woman who adores her son and contempt her daughter Ammu. Her son Chacko takes the pickle factory from her. Chacko replaces his mother and takes the role of a patriarch showing as it's belong to men in the family.

Baby Kochamma

Another woman character is Baby Kochamma, who is sister of Pappachi. In her past life, she dreamt to marry an Irish priest father Mulligan but he rejected her proposal and so she was heartbroken. She starts to lead an isolated life in Ayemenem house. This creates a worst impact on her mind. As she herself is not happy, she starts creating problems in the life of others. When Baby Kochamma comes to know about the love affair between untouchable Velutha and Ammu a high class. She conspires with the police Inspector Matthew. Velutha is charged of kidnapping Estha and Rahel. Police inspector forcibly confirms from Estha and she being much feared keeps mum showing the sign of confirmation and the innocent Velutha is proved to be guilty. He is mercilessly beaten and dies in the police station. Ammu

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also dies in a lodge. After Ammu's death she is not buried in church for her illicit relationship with Velutha and is given electronic crematorium. Her daughter Rahel commits the same mistakes and suffers a lot in her life.

Conclusion

Arundhati Roy is really successful in depicting the aspects of loss on the basis of caste and gender in the novel 'The God of Small Thing'. This novel is a brilliant Indian novel which shows the pains and sufferings of mute and downtrodden. Arundhati Roy deliberately stresses on rigid system of society that are deliberately working against women's interest and low caste people. In this, all are involved the so called police, the family, the society etc. These traditional system in Indian Societies grows and finds encouragement in maintaining their hold over the weaker people. The novel portrays the sufferings of women and also depicts how the downtrodden voice ultimately stopped. But it does not show any revolution done against these systems to change the society and ultimately the world .

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CONTENTS

Displacement and Identity Crisis in Khaled Hosseini's *The Kite Runner*

Priti Singh

Abstract

Postcolonial literature is prominently characterised by place and displacement. It is here that the special post colonial crisis of identity comes into being, and is essentially integrated with the two major concepts of home and identity. One of the most enduring legacies of modernity is the homelessness – the sense of alienation and identity crisis it creates. According to postcolonial theory place does not simply mean landscape. Rather place in postcolonial discourse is a complex interaction of languages, history, and environment. Similarly identity is also complex and fluid and inevitably hybrid caused by the collision of cultures, ethnicities, and language among other factors. In Khaled Hosseini's The Kite Runner, displacement constitutes a complex pattern of not only physical displacement but also psychological and cultural displacement.

Keywords: Postcolonial, Displacement, Home, Identity, Culture.

Khaled Hosseini's widely received debut novel is a poignant tale of love and growing up, set against a very tumultuous and disturbing period of Afghan history. "The novel has, at its core a sense of loss, of displacement, of the ineluctable distance between the present and the past."(Hosseini, 2003) The events of the story happen between the years 1970 and 2002. Afghanistan is a very

heterogenous country, its ethnic population includes the Pashtuns, the Tajiks, the Hazaras, the Baluchis and the Turkoman people. Kabul has a slightly cosmopolitan population. Afghanistan has 22 languages of which the Dari and Pashtun are recognized. Out of the six ethnic groups the Hazaras are Shias while the others are Sunni. Afghanistan came into political attention following the coup of 1973, when king Zahir Shah, who was at the helm since 1933 was overthrown by his own cousin and former Prime minister Muhammed Daod Khan, in a bloodless coup. Soon after assuming power Muhammed Daod's government started removing all the officials who had inclination towards Marxist ideologies. In April 1978, he was also overthrown by the PDPA (People's Democratic Party of Afghanistan) with the help of the Army. The PDPA was sympathetic to the left and tried to bring about social and political reforms, which included the abolition of religious and traditional customs. This resulted in the alienation of the tribals, and religious institutions incited them to challenge the government thus declaring a Jihad against the Afghan state.

The Soviet Army finally withdrew in 1989, but Afghanistan remained under the PDPA for three more years. In 1992 in the aftermath of the collapse of the USSR the Mujahidin finally won and Afghanistan was converted into an Islamic state. After the Russian withdrawal, there was fierce infighting among rival militant groups which rendered Afghanistan into an unsafe place to live in. Thereafter, in 1996, some Pashtun supremacists came together and took control of Afghanistan. They were the Taliban. The Taliban suppressed the infighting but being hardcore Sunni fundamentalists, they soon became very unpopular, because they massacred Shias and Hazaras. Their fundamentalist laws not only prohibited music and dance, but also put a restriction on women's rights.

The *Kite Runner* written by Khaled Hosseini, is a famous novel

for its devastating and painful, honest depiction of identity, betrayal, displacement, deception and atonement. The narrative portrays the journey of a boy escaping from his haunted childhood while torturing himself with his own contrition. In The *Kite Runner*, both the personal as well as the political history seem to merge together. The story begins with Amir, the protagonist recollecting his childhood days in Kabul, prior to the soviet occupation of Afghanistan. The narrator and his father, Baba flee Kabul in 1981, two years after the Russian troops rolled in, in 1979. The journey out of Kabul describes the pain, shock and fear of dislocation and displacement. Hosseini's vivid description recreates the intense disorientation and terror of the experience. They had left their beautiful house without telling even the servants, for one never knew who was an informer. Their journey is fraught with danger and uncertainty. From Jalalabad, the truck that is to take them to Pakistan does not arrive and they have to escape in a fuel tanker, it is so cramped that some like Kamal don't survive the journey. The last thing that Baba does before leaving Afghanistan is significant.

> Baba fished the snuff-box from his pocket. He emptied the box and picked up a handful of dirt from the middle of the road. He kissed the dirt. Poured it into a box. Stowed the box in his breast pocket, next to his heart. (TKR 105)

For Baba leaving Kabul must have been especially hard. Here was his home and it defined who he was. "Everyone agreed that my father, my Baba, had built the most beautiful house in the Wazir Akbar Khan district, a new and affluent neighbourhood in the northern part of Kabul. Some said it was the prettiest house in all Kabul". (4) When they finally reach Pakistan, the magnitude of their loss is even felt by Amir who is now eighteen: "My eyes returned to our suitcases. They made me sad for Baba. After everything he'd built, planned, fought for, fretted over, dreamed of, this was the summation of his life: one disappointing son and two suitcases". (108) This loss of personal belongings indicate a loss of identity and

erasure of status. Immigration particularly is accompanied by loss of physical and psychological moorings. Indeed when markers of identity like home or family are lost, it is little wonder that the immigrant is eager to claim his identity in the land to which he has migrated.

They settle in Freemont, California, in an area called Little Kabul. "A prominent feature of diaspora is that a strong sense of connection to a homeland is maintained through cultural practices and ways of life. Among these, culinary culture has an important role to play in diasporic identification". (Encyclopaedia of Food and Culture) Here they find a thriving Afghan diaspora comprising of former Generals, doctors and professors. Their Afghan presence is in every pore of their being. Even though the original Afghanistan from which they had migrated no longer exists yet in the words of Said, "it lingers on their memories as an imaginative geography and history". (173) They try to recreate their homeland in their new space. Thus Afghan music is played in the aisles of the used goods section of the flea market every Sunday, potato bolani or qabuli was cooked, they had their own traditional clothes and stuck to their traditional social customs. Their Afghanistan had become a part of their Afghan imaginary to which they could never return. However, their craving for plenitude and fulfilment that such an image signifies creates an endless desire in them to return to their roots. The story line shifts between Afghanistan and California as Amir with rare honesty tries to go over the past twenty- six years of his life.

Amir experiences physical as well as psychological displacement. According to Homi Bhabha, "a new cultural identity is gained by changing and absorbing the influences of other culture. It means an individual needs to absorb the new culture in order to adapt and form a new identity". (88) Physical displacement compels Amir to adapt to his new environment in America, and psychologically, it is a consequence of a single event in the past. The

event had been so traumatic that he says, "I became what I am at the age of twelve". (TKR,1) Immediately we are transported to the peaceful streets of Kabul prior to the Russian invasion. Amir the son of a rich Pashtun and Hassan, a Hazara, the son of his father's servant are inseparable, roaming the streets and flying kites. Amir, the narrator and protagonist, grows up as a child who is uncertain about his own identity and struggles to discover his "real" self. At first, Amir's goal is to gain the acceptance of Baba, and through that, he may be able to find his true self. But in reality, Amir's dedication to gaining Baba's acceptance leads him astray from finding his true self and creates even more confusion for the young boy. Amir's friend and servant, Hassan, helps Amir actually discover Amir's real identity, both in adulthood and childhood. Amir even claims that Hassan is his guide to his identity when he says, "I thought of the life I had lived until the winter of 1975 came along and changed everything. And made me what I am today" (TKR,2). In an interview, Hosseini admits "I have very fond memories (of a pre Soviet era Afghanistan) of my childhood in Afghanistan". (1) But this idyllic childhood is shattered when Aseef the local bully brutally rapes Hassan. Amir comes looking for him but stops short when he sees the scene:

> I stopped watching, turned away from the alley. Something warm was running down my wrist. I blinked, saw I was biting down on my fist, hard enough to draw blood from the knuckles. I realized something else. I was weeping. From just round the corner, I could hear Aseef's quick rhythmic grunts.
>
> I had one last chance to make a decision. One final opportunity to decide who I was going to be. I could step into the alley, stand up for Hassan - the way he had stood up for me all those times in the past – and accept whatever would happen to me. Or I could run. In the end I ran. (TKR,68)

This incident scars Amir for life. He falls in his own estimation. What makes it worse is that Hassan does not hold him responsible, doesn't even mention it to Amir. One probable reason could be that Hassan is not conscious of being a Hazara, and his sense of duty and loyalty is so ingrained in his identity of who he is and what is expected of him that it never occurs to him that Amir has let him down. Haunted by guilt and shame at his cowardice, Amir cannot face Hassan. Another thing that disturbs Amir is the feeling that his father loves Hassan more than him, and he feels that if his father were to know that he had failed to stand up for Hassan he would fall further in his father's eyes. Amir's escape to the U.S.A was therefore a relief, Kabul for him had become a city of ghosts "a city of hare lipped ghosts". (TKR,144) Hall differentiates between two kinds of entities. One he calls an identity of being which is eternally fixed in some essentialised past, the second one is an identity of becoming, where ones identity changes in accordance with the changing position of a person in history. (225) So while it is quite clear that Amir's second identity is dynamic, evolving as he grows, his essentialised identity is fragmented, fraught as it is with memories of his cowardice, coupled with the knowledge that in his father's eyes he is second best. He can never get Hassan out of his mind. Just how visceral the trauma is can be gauged from his reaction to the following words his father says on his graduation day. "Then Baba rolled his head toward me. 'I wish Hassan had been with us today' he said. A pair of steel hands closed around my windpipe at the sound of Hassan's name. I rolled down the window. Waited for the steel hands to loosen their grip". (TKR,141). The words reveal that neither Amir nor Baba can forget their past just by relocating. Angelika Bammer states that cultural displacement refers to the experience of millions of people who have been separated from their native culture through physical dislocation... or the colonizing imposition of a foreign culture. (xi) And the experience of cultural displacement may result in unhomeliness

and a fragmented identity. Therefore, when Rahim Khan, his father's friend asks for his help to rescue Hassan's son Sohrab, Amir hesitates, unwilling at first to risk the identity he has carefully constructed in his new place. "I had a good life in California, pretty Victorian home with a peaked roof, a good marriage, a promising writing career, in-laws who loved me. I didn't need any of this shit" (TKR,195) Ultimately however, he cannot refuse the chance to redeem himself.

He returns to a war torn Afghanistan. Amir's visit is not only a temporal and spatial displacement from his carefully constructed self, but when Rahim khan tells him that Hassan was actually his half-brother, Baba's illegitimate son, his very identity is problematised. The self that he had carefully constructed threatens to disintegrate. He tells Rahim Khan, "What can you possibly say to me? I'm Thirty- eight years old and I've just found out my whole life is one big fucking lie!" (TKR,195). In Kabul he had never called Hassan his 'friend' but after he brings Sohrab to the U.S.A he adopts Sohrab who is now his half nephew. When his father in law expresses concern over what people might say about a Hazara boy living in his daughter's house, Amir protests. "And one more thing, General Sahib, I said, 'You will never again refer to him as Hazara boy in my presence. He has a name and his name is Shorab'. (TKR 315) Amir is slowly beginning to reclaim his past. Amir's fragmented identity slowly begins to heal when Sohrab gradually learns to trust him.

A brief reading and analysis of the text shows that displacement, be it a consequence of armed conflict, cultural hegemony, or economic and social inequality, gives rise to a feeling of inadequacy in the displaced persons, which manifests itself in inappropriate social behaviour.

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संयुक्त महाराष्ट्राची चळवळ आणि दादासाहेब गायकवाड

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सारांश :

महाराष्ट्र राज्याने पुरोगामी राज्याचा नाव लौकिक मिळविला आहे. अशा या महारा ट्राच्या उभारणीला अनेक व्यक्तींचा, संघटनेचा व पक्षांचा भक्कम पाठींबा मिळाला. दादासाहेब गायकवाड व त्यांच्या पक्ष संघटनेने महाराष्ट्राच्या उभारणीत मोठे योगदान दिले आहे. त्यामुळे महाराष्ट्र राज्याच्या जडणघडणीच्या इतिहासाचे सिंहावलोकन करणे आज गरजेचे आहे. या महान कार्यात स्वत:ला झोकून दिलेल्या व्यक्तींचा, संघटनेचा व पक्षाचा सर्वसामान्यांना विसर पडला आहे. त्यामुळे त्यांच्या कार्यांना आज उजाळा देऊन त्यांच्याबाबत कृतज्ञता व्यक्त करुन व त्यांनी केलेल्या कार्याचा गौरव करुन नव्या पिढीसमोर आपल्या पूर्वजांच्या कार्याचा तपशील पुढे ठेवणे गरजेचे आहे. या प्रामाणिक हेतूनेच सदर शोधनिबंध तयार केला आहे.

कि वर्डस् : अस्पृश्य, संयुक्त महाराष्ट्र, भाष्यावार राज्य

प्रस्तावना :

भारताला स्वातंत्र्य मिळाल्यानंतर भाषिक तत्वावर प्रत्येक राज्याची पुनर्रचना करण्यात यावी अशी मागणी जोर धरु लागली असे असले तरी १९१७ साली जयपूरच्या प्रा. वि. वि. ताम्हणकर यांनी 'लोकशिक्षण' मासिकात हैद्राबाद संस्थान व वऱ्हाड मध्यप्रांत येथील मराठी भाषिकांचा प्रदेश मुंबई राज्यातील मराठी भा ाक जिल्हयांना जोडावा अशी कल्पना प्रथम मांडली होती.[१] पुढे मराठी भा ाक असलेल्या विदर्भातून स्वतंत्र विदर्भाची मागणी होऊ लागली. त्यासाठी ऑगस्ट १९४० मध्ये विदर्भातील कॉग्रेसच्या कार्यकर्त्यांनी 'महाविदर्भ सभा' स्थापन करुन स्वतंत्र विदर्भासाठी चळवळ सुरु केली.[२] बेळगाव येथे १९४६ साली भरलेल्या मराठी साहित्य संमेलनाचे अध्यक्ष श्री. ग. न्यं. माडखोलकर यांनी महाराष्ट्राची मागणी करणारा ठराव पारित केला. या ठरावानुसार दत्तो वामन पोतदार, शंकरराव देव, केशवराज जेधे, श्री श. नवरे, ग. न्यं. माडखोलकर यांची समिती स्थापन करण्यात

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आली.[३] पुढे २८ जुलै १९४६ मध्ये विदर्भ, मराठवाडा आणि मुंबईसह संयुक्त महारा ट्राच्या उभारणीसाठी महारा ट्रातील कॉग्रेसच्या कार्यकर्त्यांनी संयुक्त महाराष्ट्र परि ादेची स्थापना करुन चळवळ सुरु केली.[४] याच काळात नागपूरचे मराठा समाजाचे विद्वान पुढारी श्री गोपाळराव दळवी यांनी २३/६/४६ च्या तरुण भारतात ''महाराष्ट्रातील कुणबी, माळी, तेली, को टी, अस्पृश्य, कलार, भंडारी यांनी आपण सर्व मराठे आहोत असे समजून मराठा या सदराखाली संघटित व्हावे.''[५] असे आवाहन केले.

संशोधन पद्धती :

ऐतिहासिक संशोधन पद्धतीचा अवलंब करून उपलब्ध साहित्याचा शास्त्रीय दृष्टीने परिक्षण करून मुल्यमापन केले गेले.

गृहीत तत्त्वे : दादासाहेब गायकवादांचा संयुक्त महाराष्ट्राच्या निर्मितीत मोलाचा वाटा होता.

दादासाहेबांचा संयुक्त महाराष्ट्र चळवळींतील सहभाग :

मुंबई प्रांतात शेडयुल्ड कास्ट फेडरेशन ही महत्वाची संघटना तळागाळातील लोकांचे प्रश्न हाती घेऊन लढत होती. डॉ. आंबेडकर आणि दादासाहेब गायकवाडांनी या संघटनेच्या मार्फत महारा ट्रात अनेक लहान—मोठे लढे उभारुन दलितांच्या संघटित शक्तीचा परिचय दिला होता. त्यामुळे संयुक्त महाराष्ट्राच्या प्रश्नावर हया संघटनेला डावलून आंदोलन उभे करणे शक्य नाही याची जाणीव संयुक्त महाराष्ट्र समितीच्या नेत्यांना झाली होती. म्हणूनच १९४६ च्या ऑगस्टमध्ये डॉ. आंबेडकरांना भेटण्यासाठी श्री. माडखोलकर आणि मुंबईतील मुख्य कार्यकर्ते श्री. श्रीपादराव नवरे, सिध्दार्थ कॉलेजमध्ये गेले होते. तेव्हा ''माझ्या कानावर जशी ही गोष्ट घातली तशी नाशिकला जाऊन दादासाहेब गायकवाडांच्या कानावरही गोष्ट घाला.''[६] असे समितीच्या लोकांना डॉ. आंबेडकरांनी सुचविले.

सन १९५२ च्या सार्वजनिक निवडणुकीत **शे. का. फे** पक्षाला पराभवाचा सामना करावा लागला. त्यामुळे त्यातून समविचारी पक्षाशी सहकार्य करण्याचा विचार पुढे येऊ लागला. विदर्भ राज्याची निर्मिती ही संयुक्त महारा ट्राच्या मागणीतील मोठा अडथळा होता. त्यामुळे संयुक्त महाराष्ट्रवाद्यांनी विदर्भवाद्यांना काही सवलती देण्याचे मान्य करुन त्याप्रमाणे त्यांच्याशी २८ सप्टेंबर १९५३ रोजी 'नागपूर करार' केला.[७] त्यामुळे संयुक्त महारा ट्राच्या निर्मितीचा मार्ग प्रशस्त झाला. याच कालावधीत **शे. का. फे** या पक्षाने संयुक्त महारा ट्र समितीत सहभागी होण्याच्या हालचाली सुरु केल्या असल्याची जाणीव तत्कालीन पत्रव्यवहारातून होते.[८] १०

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ऑक्टोबर १९५५ ला राज्यपुनर्रचना आयोगाचा अहवाल प्रसिध्द झाला. त्यात मुंबईसह महाराष्ट्राची मागणी आयोगाने फेटाळली होती. त्यामुळे १० ऑक्टोबर १९५५ ला दादासाहेबांनी 'काळा दिवस' म्हणून त्यांची गणना केली.[९] पुढे केन्द्र सरकारने मुंबई शहराला केन्द्रशासित प्रदेशाचा दर्जा देऊन बाकीच्या प्रदेशाचा संयुक्त महाराष्ट्र होईल असा आपला निर्णय १६ जानेवारी १९५६ रोजी जाहीर केला. या निर्णयाचा कडाडून विरोध करताना डॉ. आंबेडकर म्हणाले होते की, ''मला हे सांगा मुंबईच्या लोकापेक्षा राजकीयदृ टया श्रे ठ असे लोक उभ्या हिंदुस्थानात कुठे आहेत ? आणि त्यांना म्हणे तुम्ही मध्यवर्ती नियंत्रणाखाली आणणार ? कोणता महारा ट्रीय आणि कोणता मुंबईतील स्वाभिमान असलेला माणूस हा अपमान सहन करील. मुंबईतील लोकांची दिल्लीतील किंवा मणिपूरमधील लोकांची तुम्ही तुलना तरी करु शकला काय ?''[१०] तेव्हा अशा बिकटप्रसंगी शे. का. फे. पक्षाने कोणती भूमिका घ्यावी यासंबंधी दादासाहेबांनी डॉ. आंबेडकरांकडे विचारणा केली. त्यावर डॉ. आंबेडकरांनी दादासाहेबांना कळविले की, ''...स्थानिक स्वराज्य संस्थांचा कारभारच बंद पाडण्यास सरकारला भाग पाडावे...''[११] त्यानुसार दादसाहेबांनी हालचाली करुन शे.का.फे. पक्षाने एक ठराव पारित करुन आपल्या मुंबई महापालिकेच्या सर्व सभासदांना मुंबईला केन्द्रशासित प्रदेशाचा दर्जा दिल्याच्या निषेधार्थ राजीनामे देण्याचा आदेश दिला.[१२] केन्द्र सरकारने घेतलेल्या निर्णयाचा विरोध करतांना डॉ. आंबेडकर राज्यसभेत म्हणाले की, ''देशाच्या ऐक्यासाठी उत्तरप्रदेशाचे तीन, बिहारची तीन व मध्यप्रदेशाची दोन राज्ये करावी. मुंबई ाहराचेही स्वतंत्र राज्य करावे आणि मराठवाडयाचे सुध्दा वेगळे राज्य करावे. पण सरकार मुंबईला निकोबारचा दर्जा देऊ पाहत आहे. म्हणून मी माझा पवित्रा बदलवून इतर महाराष्ट्रीयांबरोबर या प्रश्नावर झुंज देईल...''[१३] या डॉ. आंबेडकरांच्या वक्तव्यावरुन ते समितीत सहभागी होणार असे संयुक्त महाराष्ट्र समितीच्या लोकांना वाटू लागले. याच काळात नाशिक — इगतपूरी विधानसभेची पोटनिवडणुक झाली. या पोटनिवडणुकीत संयुक्त महारा ट्रवादी स्वतंत्र उमेदवार श्री. पांडुरंग महादेव मुर्कुटेनी दादासाहेबांचा पराभव केला.[१४] त्यामुळे संयुक्त महाराष्ट्र समितीची खरी ताकद दादासाहेबांनाही अनुभवता आली. याच सुमारास प्रबोधनकार के. सी. ठाकरे यांनी, 'जय महाराष्ट्र' या मराठी साप्ताहिकाच्या दिनांक २५/७/५६ च्या अंकात डॉ. आंबेडकरांना उद्देशून महाराष्ट्राचे नेतृत्व स्वीकारण्याचे आवाहन करणारे विनंतीपत्र जाहीर केले.[१५] संयुक्त महाराष्ट्र समितीने १९५७ ची सार्वत्रिक निवडणूक

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लढविण्याचा निर्णय घेतल्याने समितीच्या कार्याला अधिकच जोर चढला. यानिमित्याने सर्व घटक पक्षांचा यात सहभाग असावा यावर चर्चा करण्यासाठी संयुक्त आघाडीच्या कार्यकर्त्यांची एक सभा मुंबई येथे घेण्यात आली. या सभेकरिता श्री. एस. एम.जोशी यांनी दादासाहेबांना तार करुन फेडरेशनचे प्रतिनिधी म्हणून बोलविले होते.[१६] या बैठकीत दादासाहेबांनी **शे. का. फे**. या पक्षाला राखीव जागेव्यतिरिक्त प्रत्येक जिल्हयात एक जनरल जागा द्यावी अशी समितीच्या लोकांकडे मागणी केली. आगामी निवडणुकीच्या सहकार्याबाबत विस्तृत चर्चा समितीच्या लोकांसोबत करण्यासाठी नोव्हेंबर १९५६ मध्येच दिल्ली येथील डॉ. आंबेडकराच्या निवासस्थानी एक बैठक घ्यावी असे डॉ. आबेडकरांनी दादासाहेबांना कळविले.[१७] त्याप्रमाणे दिल्ली येथे बैठक होऊन संयुक्त महाराष्ट्र समितीने **शे. का. फे.** चे उमेदवार जनरल जागेवर उभे करुन निवडूण आणावेत, सर्व राखीव जागा **शे. का. फे.** द्याव्यात, समितीने खेडयापाडयात अस्पृश्यांवर होणाऱ्या अन्यायाचे निवारण करावे. या **शे. का. फे.** पक्षाच्या सर्व अटी समितीच्या नेत्यांनी मान्य केल्या.[१८] पुढे डॉ. आंबेडरांनी संयुक्त महारा ट्र समितीच्या आंदोलनावि ायी वेळोवेळी कोणती भूमिका घ्यावी याचे सर्व अधिकार दादसाहेबांकडे सोपविले.[१९] त्यानंतर ३० नोव्हेंबर १९५६ रोजी **शे**. का. फे. पक्ष रीतसर सयुंक्त महाराष्ट्र समितीत दाखल झाला.[२०] त्या वेळी सयुंक्त महाराष्ट्र समितीचे नेतृत्व कॉ. डांगे, एस. एम. जोशी, प्र. के. अत्रे, केशवराव जेधे, ना. ग. गोरे, दत्ता देशमुख इत्यादी नामवंत मंडळी करीत होती. यातील कम्युनिस्ट पक्षाची कामगारांच्या संघटनेवर मजबूत पकड होती. त्यामुळे संबंध कामगार वर्गाने या लढयाला मोठा हातभार लावला; पण दादासाहेबांच्या नेतृत्वाखाली जेव्हा आंबेडकरी समाज या लढयात उतरला तेव्हा दादासाहेबांनी ठिकठिकाणी दौरे काढून दलितांची ताकद संयुक्त महारा ट्र समितीच्या बाजुने उभी केली.

संयुक्त महारा ट्रासाठी उभारलेल्या लढयाचे व आगामी निवडणुकीत एकजुटीने घ्यावयाच्या निर्णयासाठी श्री. एस. एम. डांगे हयांच्या अध्यक्षतेखाली ११ सभासदांचे एक चिटणीस मंडळ निवडले गेले. त्यात दादासाहेबांचा सभासद म्हणून सहभाग होता.[२१] मुंबईसह संयुक्त महारा ट्र उभा राहावा यासाठी प्रत्येक मराठी माणूस पेटून उठला होता. त्यामुळे स्थानिक स्वराज्य संस्थेपासून लोकसभा, विधानसभेच्या १९५७ मधील निवडणुकीत कॉग्रेस पक्षाला मोठा पराभव पत्करावा लागला. तोपर्यंत कॉग्रेस पक्षाला निवडणुकीत पराभव माहीत नव्हता; पण संयुक्त महाराष्ट्र समितीच्या

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निमित्ताने कॉग्रेसला विरोध करणारा एक प्रभावी विरोधी गट निर्माण झाला. सन १९५७ च्या निवडणुकीत **शे. का. फे.** पक्षाच्यावतीने सर्वसाधारण जागेवरुन दादासाहेब गायकवाड आणि ॲड. बी. सी. कांबळे हे कॉग्रेस उमेदवारांचा पराभव करुन निवडून आले[२२] आणि आपले समितीतील अस्तित्वही सिध्द केले. पुढे **शे. का. फे.** पक्ष बरखास्त करुन विशाल ध्येय असलेल्या रिपब्लिकन पक्षाची स्थापना करण्यात आली. संयुक्त महारा ट्राची चळवळ ही संकुचित प्रांतवादी चळवळ नसल्याची जाणीव रिपब्लिकन पक्षाला असल्याने हा नवा पक्षही संयुक्त महारा ट्राच्या चळवळीत सामील झाला. [२३] आणि दादासाहेबांच्या नेतृत्वात समितीच्या पाठीमागे भक्कमपणे उभा राहिला.

संयुक्त महारा ट्राच्या लढयाच्या निमित्याने छोटे छोटे पक्ष समितीत सामील झाले होते. हे सर्व पक्ष वेगवेगळया जाती, गटांचे नेतृत्व करणारे होते. तेव्हा या संधीचा दादासाहेबांनी फायदा घेवुन जातीयवादाची पाळेमुळे न ट करुन नवा महाराष्ट्र उभा करता यावा आणि मराठी माणूस एकजीवी होवुन परस्परांशी बंधुभावाने वागावा यासाठी 'एक गाव एक पाणवठा' असा कार्यक्रम क्रांतीसिंह नाना पाटलांच्या सहकार्याने दादासाहेबांनी हाती घेतला. [२४] पुढे रिपब्लिकन पक्षात फूट पडून दुरुस्त व नादुरुस्त असे दोन गट निर्माण झाले. दुरुस्त गटाने समितीच्या कामकाजातून आपले अंग काढून घेतले. समाजवादी महारा ट्र निर्माण करणे हा संयुक्त महारा ट्र समितीचा उद्देश होता.[२५] या उद्देशपूर्तीसाठी दादासाहेबांच्या नेतृत्वाखालील नादुरुस्त गटाने समितीच्या कार्याला सहकार्य देण्याचे धोरण पुढे चालूच ठेवले. तेव्हा दुरुस्त पक्षाने दादासाहेब गायकवाडांवर कम्युनिस्ट धार्जिणे असल्याचा आरोप लावला. त्यावर दादासाहेब म्हणाले की, ''....मी एक वेळ कम्युनिस्टांना पचवीन पण कम्युनिस्ट मला पचवू शकणार नाहीत...''[२६] अशाप्रकारे सर्व आरोपांचे खंडन करुन त्यांनी समितीच्या कार्याला आपले पूर्ण सहकार्य सुरुच ठेवले.

संयुक्त महारा ट्र समितीच्या कार्याला पुढे यश येऊन १ मे १९६० रोजी मुंबईसह महारा ट्राची निर्मिती करण्यात आली. त्या वेळी यशवंतराव चव्हाण यांनी संयुक्त महारा ट्र मिळविण्यासाठी स्वत: 'दाई' ची भूमिका वठविण्याचे बोलून दाखविले होते. तेव्हा यावर दादासाहेबांनी ''तुम्ही जर संयुक्त महारा ट्राचे दाईपन केलेत तर संयुक्त महारा ट्राचा बाप कोण ?''[२७] असा रोखठोक प्रश्न विचारला होता. मुंबईसह महारा ट्राची निर्मिती झाली असली तरी मराठी भाि ाक बेळगाव, कारवार, डांग हा भाग महारा ट्रात सामील केला नव्हता. तेव्हा मुंबई राज्य पुनर्रचना बिलावर लोकसभेत

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बोलतांना दादासाहेब म्हणाले होते की, ''... भा ाावार प्रांतरचनेच्या मुळाशी त्या त्या प्रांतभाषेचे अधि ठान असते. असे जर असेल तर महारा ट्राची निर्मिती करतांना हे तत्व तंतोतंत पाळण्यात आलेले आहे असे वाटत नाही. महारा ट्राचा बराच भूभाग नवमहारा ट्रातून वगळण्यात आला. १९५६ साली भा ाावार प्रांतरचनेच्या मसुद्याने व सल्लागार समितीच्या सूचनेनुसार 'डांग' जिल्हा महारा ट्राला जोडण्यात आला. डांग हे महारा ट्राचे उपअंग आहे हे सत्य असतांना देखील महारा ट्राच्या कोंदणात बसलेला म्हणजेच डांग जिल्हा महारा ट्रापासून हिरावून घेऊन गुजरात राज्याला जोडण्यात येतो ही किती विक्षिप्त गो ट आहे...''[२८] अशाप्रकारे दादासाहेबांनी संयुक्त महारा ट्रबद्दलची आपली भूमिका विशद करुन संपूर्ण मराठी भाषिक प्रदेश महारा ट्रात सामील करुन घेण्याविषयी हालचाल करावी अशी सदनाला विंनती केली.

महाराष्ट्र राज्यनिर्मितीनंतर बराच मराठी भाषिक प्रदेश महारा ट्रात सामील झाला नव्हता. असे असताना देखील आता समितीचे विसर्जन करण्यात यावे असा विचार समितीतील काही घटक पक्षाने पुढे मांडला. तेव्हा त्यावर दादासाहेब म्हणाले होते की, ''...महाराष्ट्र मिळावावा हाच एकमेव उद्देश कुणी समजोत पण समितीचा हा उद्देश आम्ही दुय्यम समजतो. राष्ट्रकल्याण साधणारा व साधवून घेणारा मजबूत असा विरोधी पक्ष आमच्या नजरेत समितीचा उद्देश आहे. या उद्देशाने वागलो तर राज्य घेऊ नाही तर सत्ताधाऱ्यांवर धाक ठेवून लोककल्याण व राष्ट्रकल्याण करवून घेवू...''[२९] असे विशाल ध्येय समितीबद्दल दादासाहेबांचे असल्याने त्यांनी समितीच्या विसर्जनाला कसून विरोध केला. पण समितीच्या घटक पक्षांत या मुद्दयावर जास्त मतभेद निर्माण झाल्याने शेवटी दादासाहेबांनी समितीतून बाहेर पडण्याचा निर्णय घेतला. समितीच्या संपूर्ण कार्यकाळात दादासाहेबांनी दलित, कष्टकऱ्यांना या आंदोलनात सहभागी करुन घेतले. त्यांच्या प्रश्नांना वाचा फोडून त्यांच्या प्रगतीचा मार्ग प्रशस्त केला. हा त्यांच्या समितीच्या कार्यातील महत्वपूर्ण सहभाग होता.

मुल्यांकन:

आज संयुक्त महाराष्ट्राची ५० वर्षाच्या वर वाटचाल झाली आहे. या समग्र कालखंडाचा बारकाईने अभ्यास केला तर आपल्या असे लक्षात येईल की डॉ. आंबेडकर व दादासाहेब गायकवाड यांना अभिप्रेत असलेला समन्यायी विकासाचा टप्पा महाराष्ट्र गाठू ाकला नाही. दिवसेंदिवस प्रादेशिक असमतोल वाढतच आहे. ज्या विकासाच्या कारणासाठी विदर्भवाद्यांनी स्वतंत्र विदर्भाचा मुद्दा सोडून 'एक भाषिक' राज्यासाठी

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आपली भूमिका बदलविली; परंतु विकासाचा महामेरु त्यांच्यापर्यंत अजूनपर्यंत पोहचलाच नाही. तेव्हा अशा परिस्थितीत दादासाहेब गायकवाड हयात असते तर त्यांनी निश्चितच आपला पवित्रा बदलवून मागासलेल्या प्रदेशाचे प्रश्न हाती घेऊन लढा उभारला असता. तेव्हा त्यांना आपला आदर्श मानून नवे नेतृत्व विदर्भ राज्यासाठी उभे करणे निकडीचे झाले आहे आणि त्यासाठी 'एक भाषिकत्वा' चे जू विदर्भातील लोकांनी फेकून देऊन डॉ. आंबेडकर व दादासाहेबांना अभिप्रेत असलेल्या विकास मार्गाने वाटचाल करणेच आवश्यक आहे. यासाठी आज तरी स्वतंत्र विदर्भाशिवाय दुसरा पर्याय दिसत नाही.

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Editor
Dr.Bapu G. Gholap

यासाठी शासनाने वेगळे पर्यत करण्याची गरज आहे. तसेच यु.जी.सी.च्या विविध योजनेअंतर्गत लाभ घेणे गरजेचे आहे.

मुख्य निष्कर्ष:—

महाराष्ट्रातील शारीरिक शिक्षण महाविद्यालयात एन.सी.टी.ई. च्या मापदंड व मानकाप्रमाणे महाविद्यालयातील मुलभुत सोयी सुविधांचा अभ्यास केला असता. मानका प्रमाणे आवश्यक मुलभुत सोयी सुविधा कमी प्रमाणात उपलब्ध आहे. या घटकात नकारात्मक प्रभाव दिसून आला.

संदर्भ:—

१. कुलकर्णी विश्वभंर, डॉ. भिंताडे विनायक रामचंद्र, भारतीय आधुनिक शिक्षण : समस्या आणि उपाय, विद्या प्रकाशन, पुणे., २६ जाने २००७.

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५. मनोज कुमार (२०१५)'कंट्रक्शन ऑफ नॉर्म फॉर हेल्थ रिलेटेड फिजीकल फिटनेस फॉर १६ टू १८ इअर कॉलेज मेन स्टूडंट.' युरोपीयन ॲंकॅडेमिक रिसर्च.' खंड ३, आवृत्ती ५

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७. Government Educational policy of india

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नाशिक येथील श्री काळाराम मंदिर प्रवेश सत्याग्रह व समता सैनिक दलाच्या कार्याची वाटचाल

प्रा. डॉ. अविनाश फुलझेले
मार्गदर्शक, डॉ. आंबेडकर महाविद्यालय, दीक्षाभूमी, नागपूर

श्री. प्रेमराज बारीकराव खोब्रागडे
शोधनिबंध लेखक, जि. प. हायस्कूल, गुंजेवाही, जि.प. चंद्रपूर.

प्रस्तावना :—

कोणतेही मानवीय अधिकार नसलेल्या अस्पृश्य समाजाला ते मिळवून देण्यासाठी डॉ. बाबासाहेब आंबेडकरांनी इ. स. १९१९ पासून सामाजिक, शैक्षणिक, धार्मिक व राजकीय आंदोलने उभी करून समतेचा लढा सुरू केला. त्यावेळी संपूर्ण हिंदू समाजव्यवस्थेला एक प्रचंड हादरा बसला. कारण यामुळे चातुर्वर्ण्य नावाची बिना शिडीची चार मजली इमारत हलायला लागलेली होती. अमरावती येथील अंबाबाई, महाड येथील चवदार तळे व मनुस्मृती दहन आणि पुणे येथील पार्वती सत्याग्रह. या अस्पृश्यांनी केलेल्या सत्याग्रहांनी महाराष्ट्रातील अस्पृश्यांमध्ये नवचैतन्याची ज्योत पेटवली आणि नाशिकच्या सत्याग्रहाने ती दिव्य ज्योत अखिल भारताच्या अस्पृश्यांमध्ये फिरविली व तेवत ठेवली. १९२६—२७ पासून 'डॉ. आंबेडकर सेवा दल' वा 'स्वयंसेवक दल' म्हणून कार्य करीत असणारे स्वयंसेवक हे तत्कालीन कालखंडात मोठ्या स्वरूपात 'समता सैनिक दल' या नावाने ओळखले जात नसले तरी हे 'समता सैनिक दलाचे' पूर्वरूपच होते. नाशिकचा सत्याग्रह हा सुरूवातीला डॉ. बाबासाहेब आंबेडकरांच्या नेतृत्व आणि मार्गदर्शनाखाली चालला. परंतु काही

अपवादात्मक कालखंड सोडला तर डॉ. बाबासाहेब आंबेडकर गोलमेज परिषदांसाठी इंग्लंडमध्ये तसेच इतर कार्यात व्यस्त होते. असे असतांनाही त्यांच्या अनुपस्थितित प्रदीर्घ काळ चाललेला हा संघर्ष आणि सत्याग्रह म्हणजे आंबेडकरी चळवळ आणि समता सैनिक दलाच्या इतिहासातील सोनेरी पान आहे.

प्रस्तुत शोधनिबंधाचा उद्देश :—

सामाजिक समता प्रस्थापित करण्यासाठी नाशिक येथे सुरू करण्यात आलेल्या श्री काळाराम मंदिर प्रवेश सत्याग्रहात समता सैनिक दलाने केलेल्या कार्याचा अभ्यास करणे.

समता सैनिक दलाचे श्री काळाराम मंदिर प्रवेश सत्याग्रहातील कार्य :— नाशिक येथील श्री काळाराम मंदिर प्रवेश सत्याग्रहास प्रत्यक्षात २ मार्च १९३० ला सुरुवात झालेली दिसत असली तरी त्याची पूर्वतयारी पुणे येथील पार्वती सत्याग्रहाचे दरम्यानच्या काळातच सुरू केलेली दिसून येते. या सत्याग्रहासाठी एक हजार स्वयंसेवकांनी नावे नोंदविली असल्याचे नाशिकच्या जिल्हा पोलीस अधिक्षकाने १ फेब्रुवारी १९३० ला सरकारला कळविलेल्या अहवालातून स्पष्ट दिसून येते.[1] या सत्याग्रहासाठी हजारो लोकांचे थवेच्या थवे नाशिक येथे येत होते. सभेसाठी उभारलेला मंडप वेगवेगळ्या साधू—संतांच्या उक्तींनी व म्हणींनी सजलेला होता. सत्याग्रहाच्या पूर्वतयारीसाठी ता. २ मार्च १९३० ला सभा घेण्यात आली. या सभेत डॉ. आंबेडकरांनी सत्याग्रह कसा करावा, सत्याग्रहात शांततापूर्वक वर्तन ठेवणे किती जरुर आहे, इत्यादी गोष्टींची समज सर्वांना दिली होती. दुपारी तीन वाजता प्रत्येक रांगेत चार—चार प्रमाणे मिरवणूक निघाली. मिरवणुकीच्या अग्रभागी नाशिक रोडच्या 'बहिष्कृत हितचिंतक सेवा संघाचा' मिलिटरी पद्धतीचा बँड, त्यांचेमागे २५ स्कॉउटची तुकडी, त्यांचेमागे ५०० सत्याग्रही स्त्रिया व मागे सर्व सत्याग्रही मंडळी होती. मिरवणुकीत एकंदर सुमारे १६००० लोकांनी भाग घेतला होता.[2] त्यात प्रामुख्याने समता सैनिक दलाचे स्वयंसेवक अग्रभागी होते, हे यावरून दिसून येते. दुसरे दिवशी ता. ३ मार्च १९३० सोमवारी सकाळी ९ वाजता डॉ. आंबेडकरांच्या अध्यक्षतेखाली एक सभा झाली. या सभेत मंदिराच्या दारात धरणे धरून बसणाऱ्या स्वयंसेवकांना काही महत्त्वपूर्ण सूचना देण्यात आल्या. त्यात स्वयंसेवकांनी कोणावरही कोणत्याही प्रकारचा अत्याचार करायचा नाही ही स्पष्ट सूचना होती. हा सत्याग्रह पूर्ण यशस्वी होईपर्यंत लढा टिकविण्याविषयी फारच कळकळीने सांगितल्यानंतर काही स्वयंसेवकांना खादी टोप्या व शर्ट वाटण्यात आले. दोन—दोन स्वयंसेवकांची एक—एक रांग, याप्रमाणे मिरवणुकीची रचना केली. चार दरवाजांवर चार तुकड्यांची नेतृत्वांसह जबाबदारी निश्चित करण्यात आली व मिरवणूक निघाली. उत्तर दरवाजावर श्री. पतितपावनदास, पूर्व दरवाजावर श्री. कचर मथुजी साळवे, दक्षिण दरवाजावर श्री. पांडुरंग नाथूजी राजभोज, पश्चिम दरवाजावर श्री. शंकरदास नारायणदास यांचे नेतृत्वाखाली स्वयंसेवकांनी धरणे धरली.[3] नाशिक सत्याग्रहाबाबतचा अहवाल आयुक्त श्री. घोषाळ यांनी गृहमंत्री मि. अर्नेस्ट यांना पाठविला त्यात ते लिहितात की, "खाकी पोषाख केलेले आणि हातात काठ्या घेतलेले लोक पहारा देत होते. सत्याग्रहींचा वेष खादीचा होता."[4] सत्याग्रहाचे स्वरूप पूर्णपणे शांतता व शिस्तीवर आधारलेले असले तरी 'शक्य असेल तोवर अहिंसा, जरुर पडेल तर हिंसा, असे धोरण सत्याग्रही माणसांनी ठेवणे हे सिद्धीच्या दृष्टिने रास्त आहे. इतकेच नव्हें तर नीतीच्या दृष्टिनेही ते प्रशस्त आहे.' असे डॉ. बाबासाहेब आंबेडकर नेहमी सांगत असत. रामनवमीच्या दिवशी ता. ९ एप्रिलला रामनवमीला निघणाऱ्या रथयात्रेसाठी एक तडजोड करण्यात आली होती. परंतु सनातन्यांनी ही तडजोड वा वचन न पाळल्याने अस्पृश्यांनी विमान व रथ अडवला आणि मिरवणुकीत भाग घेण्याचा हक्क प्रस्थापित केला. त्याचे पर्यवसान मारामारीत झाले. रथाची मिरवणूक बाजूस राहून ठोकाठोकी आणि दगडफेक होऊ लागली. दगडांचा वर्षाव सुरू असतांना डॉ. आंबेडकरांचे दगडांच्या वर्षावापासून संरक्षण करण्यासाठी स्वयंसेवक दलाचे कार्यकर्ते डॉ. आंबेडकरांवर छत्री धरून त्यांचे दगडांपासून संरक्षण करीत होते. या दंगलीत अनेक स्पृश्य—अस्पृश्य, स्त्रिया तथा डॉ. बाबासाहेब आंबेडकरही जखमी झालेत[5] या भयंकर परिस्थितीत समता सैनिक दलाच्या स्वयंसेवकांनी डॉ. बाबासाहेब आंबेडकरांना सुरक्षित स्थळी हलविले. पुढे दादासाहेब गायकवाड आणि

डॉ. आंबेडकरांनी सत्याग्रह थांबवावा म्हणून इंग्रजांनी जी बोलणी सुरू केली होती, त्यास प्रतिसाद देत हा सत्याग्रह २५ मे १९३० रोजी तात्पुरता स्थगीत केला. परंतु सवर्ण हिंदुंचे कोणतेही हृदयपरिवर्तन होत नाही, हे पाहून १५ मार्च १९३१ ला पुन्हा सत्याग्रह सुरू करण्याचे ठरले. १५ मार्च १९३१ ला सत्याग्रहास अनुकूल असलेल्या ५००० लोकांची मिरवणूक तुपारी निघाली. अस्पृश्यांतील निरनिराळ्या पथकाचे स्वयंसेवकांनी या मिरवणुकीची व्यवस्था ठेवली होती.[९] गंगेच्या काठावरील पटांगणात मिरवणुकीतील मंडळी जेवण करायला बसलेली असतांना स्पृश्यांनी जोरदार दगडफेक सुरू केली. त्यानंतर पुन्हा गंगेवरून मिरवणूक परत जात असतांना त्यांनी पुन्हा शिव्यांचा व दगडांचा भडिमार सुरू केला. तेव्हा अस्पृश्य तरुण सत्याग्रह्यांनी व स्वयंसेवकांनी शिस्त व शांतता कायम ठेवत सर्वांना संरक्षण दिले. यावरून समता सैनिक दलाची वाटचाल किती खडतर मार्गातून होत होती, हे निदर्शनास येते.

पूर्वी जाहीर केल्याप्रमाणे ५ नोव्हेंबर १९३१ ला सत्याग्रहाची मोहीम सुरू करण्यात आली. तेव्हा प्रचंड संख्येनी लोक आले. एवढ्या प्रचंड संख्येत आलेल्या लोकांची शिस्त बिघडली तर फारच अनर्थ ओढवेल, ही भीती होती. त्यामुळे मुंबई किंवा इतर भागातून आलेल्या समता सैनिक दलाची जबाबदारी अधिकच वाढली. सत्याग्रहासाठी चौघा सत्याग्रही स्वयंसेवकांची निवड करण्यात आली. मिरवणुकीच्या पुढे समता सैनिक दलाचे बँड, मागे चौघे सत्याग्रही वीर, त्यांच्या मागे निवडक लढवैया शिवा, मध्यंतरी पुढारी मंडळी, त्यांच्यामागून स्वयंसेवक व इतर जनसमुदाय चालत होता. एवढ्यात चौथा दरवाजाही बंद करण्यात आल्याचे समजले. दुसऱ्या दिवसापासून फिरत्या स्वयंसेवकांच्या पथकांचा सत्याग्रह सायंकाळपर्यंत सुरूच होता. सायंकाळी ५ वा. सनातनी मंडळींनी उत्तर दरवाजा उघडला. त्याबरोबर या पथकातील साध्या पोषाखातील एक सत्याग्रही श्री. सीताराम काळू हाटे यांनी मंदिरात प्रवेश केला. आत गेल्याबरोबर "डॉ. आंबेडकर की जय" असा जयघोष केला. त्यानंतर त्यास अटक केली. नंतर याच दरवाजावर सत्याग्रह करणाऱ्या इतर आठ सत्याग्रहींना अटक करण्यात आली. तिसऱ्या दिवशीही सत्याग्रह सुरूच ठेवला. सायंकाळी साडेपाच वाजता मंदिराचा उत्तर दरवाजा उघडताच त्यांनी प्रवेश करण्याचा प्रयत्न तेव्हा २३ स्वयंसेवक सत्याग्रहींना अटक करण्यात आली. पण लवकरच त्यांना सोडून देण्यात आले. १४४ कलम मोडल्याबद्दल ४१ स्वयंसेवकांना पोलीसांनी अटक केली. त्यांच्यावर दुसऱ्या दिवशी रितसर खटला भरला. त्यांना पोलीस स्टेशनवर नेत असता बऱ्याच पोलीसांनी त्यांना बुटांनी मारले. यात बऱ्याच जनांना जखमा झाल्या. तरीही स्वयंसेवकांचा निर्धार डळमळीत झाला नाही. दुसऱ्या दिवशी स्वयंसेवकांच्या इतर तुकडीने सत्याग्रह चालूच ठेवण्याचा निर्धार केला. त्या ४१ जनांवर ता. १२/११/१९३१ ला सिटी मॅजिस्ट्रेट कोर्टात खटला दाखल करण्यात आला. यापैकी १२ सत्याग्रहींना कायदेभंगाबद्दल एक—एक महिन्याची सक्त मजुरीची शिक्षा ठोठावली. सिटी मॅजिस्ट्रेटने शिक्षा जाहीर करताच कोर्टातच 'डॉ. आंबेडकर की जय' असा जयघोष सुरू केला. डॉ. आंबेडकरांनीही तारेने त्यांचे अभिनंदन करीत त्यांना स्फुर्तीदायक संदेश पाठविला. तो असा— "सरकारी अटकेत असलेल्या धैर्यशाली सत्याग्रहींचे मी अंत:करणपूर्वक अभिनंदन करतो. सत्याग्रहाचा रणसंग्राम असाच धैर्याने लढा. आपल्या अलौकिक स्वार्थत्यागानेच आपणाला यश मिळणार आहे, ही गोष्ट सर्वांनीच लक्षात ठेवावी."[१०] एवढे झाले तरीही स्वयंसेवकांनी आपला फिरता सत्याग्रह सुरूच ठेवला. ता. २०/११/१९३१ ला या सर्व ४१ आरोपींवर ठेवण्यात आलेल्या दोषारोपांवर पुन्हा शिक्षा ठोठावण्यात आली. 'नाशिक जिल्हा युवक संघाचे स्वयंसेवक' कार्यकर्त्यांनी गावोगांव फिरुन चार मण धान्य जमविले. तुरुंगवास झालेल्या व्यक्तिंच्या अभिनंदनार्थ ठिकठिकाणी सभाही घेतल्या. फिरता सत्याग्रहही सुरुच होता. स्वाभिमानाची लढाई लढत असतांना अनेक गावी अस्पृश्यांवर मारहाणीचे प्रसंग आले. सोबतच अन्न—पाण्याचा बहिष्कार इत्यादी प्रसंग येतच होते. परंतु आता स्वसन्मानाची पेटलेली ही ज्योत अधिकच तीव्र होत होती.

ठरल्याप्रमाणे १३ डिसेंबर १९३१ ला अस्पृश्यांच्या नऊ सत्याग्रह्यांची एक तुकडी पुष्पहारांनी मंडित होऊन सत्याग्रह छावणीतून बाहेर पडली. हे सर्व

सत्याग्रही तरुण वीर आणि मनाने खंबीर होते. त्यांच्यासोबत फक्त नेतृत्व करणारी पुढारी मंडळी होती. वरून कोसळणारा मुसळधार पाऊस व अंगाला झोंबणारा थंडगार वारा यातही सत्याग्रही कुंडाकडे पोहचण्याचा प्रयत्न करीत होते. परंतु शेकडो स्पृश्यांनी हाताची साखळी करून त्यांचा मार्ग रोखून धरला होता. त्यामुळे पहिल्या दिवशी अंगावर पातळ कुडत्याखेरीज काहीही नसतांना सतत ५ तास स्वयंसेवक सत्याग्रही थंड वारा आणि पावसात उभे होते.[८] पहिल्या दिवशीचा हा सत्याग्रह पुढारी मंडळींनी सायंकाळी थांबविला नसता तर पुढे याही स्थितीत ते रात्रभर उभे राहिले असते. परंतु सनातन्यांच्या या आडमुठी धोरणाला एक अस्पृश्य तरूण कंटाळला व प्रसंग पाहून स्पृश्यात मिसळला व धावत जात 'डॉ. आंबेडकर की जय' अशी गर्जना करीत रामकुंडात उडी टाकली. हे पाहून सनातनी मंडळी फार क्रोधित झाली व त्याला मारहाण करू लागली. तरीही तो कुंडातच उभा होता. त्याच्या सर्वांगातून रक्ताच्या धारा वाहत होत्या. या तरुणाचे नाव शंकर श्रावण गायकवाड होते. तो मुंबईचा असून डॉ. आंबेडकरांचा अनुयायी होता. पुढे या कुंडाला 'शंकर कुंड' असे अस्पृश्य म्हणू लागले.[९] मुंबईवरून नाशिकच्या मंदिर प्रवेश सत्याग्रहासाठी तो आलेला होता.

दुसरे दिवशीही ता. १४/१२/१९३१ रोजी सत्याग्रही स्वयंसेवक व पुढारी मंडळींचा निर्धार कायम होता. दररोज सकाळपासून सायंकाळपर्यंत ५० स्वयंसेवक सत्याग्रहासाठी पाठविण्याचे ठरले. ही व्यवस्था पाहण्याचे काम श्री. तुळशीरामजी काळे यांचेकडे सोपविण्यात आले. ता. ३१/१२/१९३१ रोजी काळाराम मंदिर प्रवेशास बंदी असलेले १४४ व्या कलमाची मुदत संपत असल्याने पोलीस बंदोबस्त काढण्यात येऊ लागला. मंदिराचे सर्व दरवाजे बंद असल्याने फिरते सत्याग्रही मधून-मधून उत्तर व पश्चिम दरवाजावर बसत असत. त्यावेळी आसपासच्या घरांमधून व मंदिरामधून सत्याग्रहींवर दगडांचा वर्षाव होत असे. ता. १ ते ४ जानेवारी १९३२ च्या दरम्यान दगडफेकीमुळे सत्याग्रहींना जखमा झाल्या. सत्याग्रहींना जमिनीवर पाडून मन मानेल तसे लाथा-बुक्क्यांनी, वहाना-बुटांनी व लाठ्या-काठ्यांनी बेदम मारहाण केली. हे सर्व करण्यामागे त्यांचा उद्देश, सत्याग्रही चवताळून कायदा हातात घेतील व मारहाणीस प्रवृत्त होतील हा होता. परंतु सत्याग्रही स्वयंसेवकांनी आपली शिस्त व शांतता ढळू दिली नाही.[१०]

ता. १८ नोव्हेंबर १९३१ रोजी तुरुंगवासाची शिक्षा झालेल्या ४१ सत्याग्रहींपैकी ३५ जनांची मुदत १८ जानेवारी १९३२ रोजी संपल्याने धुळे येथील तुरुंगातून सुटका होणार होती. ज्या वीर सत्याग्रहींनी तुरुंगवास पत्करला त्यांची तुरुंगातून सुटका होताच ठिकठिकाणी समता सैनिक दलाच्या विद्यमाने समता सैनिक दलाच्या पथकांनी गार्ड ऑफ ऑनर (लष्करी धर्तीची सलामी) देऊन त्यांच्या कार्याचा गौरव केला.[११] रामनवमीच्या दिवशी ता. १५ एप्रिल १९३२ ला पुजाऱ्याचे घरातून सनातनी मंडळी काळाराम मंदिरात जाण्याचा प्रयत्न करीत होते. शिवाय सकाळी ७ वा. उत्तर दरवाजा उघडला. त्यातून स्पृश्यांना आत जाऊ देणे व दक्षिण दरवाजातून बाहेर पडणे, असा प्रकार सुरू झाला. सत्याग्रहीवीरांनी आपली शिस्त, धैर्य व वर्तणूक शांत ठेवण्याचा प्रयत्न केला. सकाळी सुरू झालेल्या या सत्याग्रहासाठी स्त्री-पुरुष सैनिकांची चुरस सुरू झालेली होती. सनातन्यांना ज्या दरवाजातून जाऊ देऊ लागले, त्याच दरवाजातून सत्याग्रही स्वयंसेवक जाऊ लागले, तेव्हा एकामागून एक अशा वीस स्त्री-पुरुष स्वयंसेवकांना अटक केली.[१२] काही महिलांना एक-एक महिन्याची व सर्व पुरुष सत्याग्रहीवीरांना प्रत्येकी दोन महिन्यांची शिक्षा देण्यात आली.

समता सैनिक दलाचे जाळे आता सगळीकडे पसरलेले होते. ते आता कोणत्याही कठीण प्रसंगांना तोंड देण्यास समर्थ होते. नाशिक येथील श्री काळाराम मंदिर प्रवेश सत्याग्रहासंबंधी विचार करता १९२९ पासून सुरू झालेला हा सत्याग्रह विशेष पद्धतीने लढला गेला असे दिसून येते. तुरुंगवास झाल्यानंतरही माफीनामा न सादर करता स्व-खुशीने व स्व-सहमतीने तुरुंगवास पत्करला. या सर्व गोष्टिंचा विचार करता, नाशिक येथील श्री काळाराम मंदिर प्रवेश सत्याग्रह इतर कोणत्याही सत्याग्रहापेक्षा श्रेष्ठ व कौतुकास्पद आहे, हे निःसंशय खरे आहे. या सर्वांचे श्रेय जसे पुढारी मंडळींना जाते, तसेच व तेवढेच श्रेय समता सैनिक दलाच्या

स्वयंसेवकांनाही जाते. याबाबत डॉ. बाबासाहेब आंबेडकर म्हणतात की, "नाशिक जिल्ह्यातील माझ्या अस्पृश्य बांधवांबद्दल मला मोठा अभिमान वाटतो. अस्पृश्यांची सर्वतोपरी असलेली विपरीत व बिकट परिस्थिती लक्षात घेता, त्यांनी गेल्या तीन–चार वर्षांत जे स्वावलंबन व जे संघटन प्रत्यक्ष व्यवहारात प्रकट करून दाखविले व ज्या सोशिक व धैर्यवृत्तीचा माझ्या या बंधू–भगिनींनी परिचय करून दिला. ती ही सारी घटना खरोखरच अपूर्व अशी आहे... नाशिक सत्याग्रहासारखी चळवळ सतत तीन–चार वर्षे एवढ्या मोठ्या प्रमाणांत, एवढ्या उत्साहाने व इतक्या संघटीतपणाने चालविलेली ही एकट्या हिंदूस्थानातीलच नव्हे तर जगांतील सर्व पददलित जनतेने अभिमान बाळगण्याजोगी घटना आहे..."[१३] असे असले तरी यातून स्पृश्य जनतेचे हृदयपरिवर्तन मात्र घडून आलेले दिसून येत नाही. तेव्हा हा सत्याग्रह पुन्हा सुरू करावा काय, अशी विचारणा दादासाहेब गायकवाडांनी डॉ. बाबासाहेब आंबेडकरांना केली. तेव्हा ३ मार्च १९३४ ला पाठविलेल्या पत्रात डॉ. आंबेडकर म्हणतात की, "मंदिर प्रवेशाची चळवळ मी सुरू केली, ती नंतर त्यांनी देवपूजा करून मोक्ष मिळविण्यासाठी नाही... तर त्यांच्यात स्वाभिमानाची जाणीव निर्माण व्हावी, हेच माझे मत होते... मला विश्वास आहे, मी तो उद्देश साध्य केला... आता त्यांनी त्यांची शक्ती आणि साधने राजकारण आणि शिक्षणावर खर्च करावी..."[१४] असा संदेश त्यांनी दिला. त्यानंतर मंदिरप्रवेशाची चळवळ थांबविण्यात आली. या सत्याग्रहात समता सैनिक दलाच्या स्वयंसेवकांनी अभूतपूर्व अशी कामगिरी करून डॉ. बाबासाहेब आंबेडकरांचा या सत्याग्रहामागील मूळ उद्देश सफल होईल अशी वाटचाल करून हा सत्याग्रह यशस्वी करून दाखविला. कारण या सत्याग्रहामागचा डॉ. बाबासाहेब आंबेडकरांचा मूळ उद्देश होता की, अस्पृश्यांमध्ये हजारो वर्षांपासूनचा मेलेला स्वाभिमान जागृत करणे आणि त्यासाठी लढा द्यावयास शिकविणे. या लढ्यातूनच भविष्यातील क्रांतिची बीजे पेरल्या गेलीत. या सत्याग्रहात भाग घेतलेल्या स्वयंसेवकांनी, पुढाऱ्यांनी, समता सैनिक दलाच्या कार्यकर्त्यांनी दगडफेक, लाठीमार, वगैरेंना तोंड दिले. काहींनी कारावास सोसला. अस्पृश्यांच्या चळवळीत तुरुंगवास भोगण्याची ही पहिलीच वेळ. या चळवळीत स्त्रियांनी भाग घेतला. तुरुंगवास पत्करला. हेही पहिल्यांदाच घडले. हे सर्व डॉ. अंबिडकरांनी उभे केलेल्या समता सैनिक दलाच्या स्वयंसेवकांमुळे होऊ शकले, असे आपण निश्चितपणे म्हणू शकतो. यातूनच नवे नेतृत्व उदयास आले. या लढ्यापासून समता सैनिक दलाची संरक्षण फळी अधिकच सतर्क राहू लागली. समाजातील सर्व स्तरातून लोक नाशिक येथील सत्याग्रहासाठी समता सैनिक दलात सहभागी होऊ लागले.

समारोप :–

अशाप्रकारे 'समता सैनिक दल' ही समाजाची गरज वाटायला लागली. कायदा, न्यायव्यवस्था, पोलीसयंत्रणा ही सर्व आपल्यासाठी नसून आपल्या अस्तित्वाची लढाई आपल्यालाच लढायची आहे, ही जाणीव अस्पृश्यांमध्ये निर्माण झाली. समता सैनिक दलाचे संघटन अधिकच बळकट झाले. या सत्याग्रहानंतर पुन्हा संघटन नव्या जोमाने उभे केले. त्यातूनच समता सैनिक दलाचे संघटन, एकी व लढाऊ वृत्तीचे दर्शन घडून आले. एकंदरित, सामाजिक समता प्रस्थापित करण्यासाठी समता सैनिक दलाने नाशिक येथील श्री काळाराम मंदिर प्रवेश सत्याग्रहातील आंदोलनात अत्यंत मौलिक भूमिका बजावत आपली वाटचाल सुरू केली आणि त्यात ते मोठ्या प्रमाणात यशस्वी झालेले दिसून येते. भविष्यातील येणाऱ्या आव्हानांना तोंड देत समाजाला संरक्षण पुरविणाऱ्या या नि:स्वार्थी संघटनेत तरुणांनी मोठ्या स्वरुपात सामील होऊन संघटन मजबूत करून यानंतरही हे लढे असेच सुरू ठेवून डॉ. बाबासाहेब आंबेडकरांना अभिप्रेत असलेले संघटन पुन्हा नव्या जोमाने उभे करावे.

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भारत देशातील वाढणारी तरूणांची आत्महत्या प्रवृत्ती

प्रा. श्री. कोल्हे तुकाराम ज्यंबकराव
समाजशास्त्र विभागप्रमुख, वि.पा.शी.प्र.मं.सं.कला, विज्ञान व वाणिज्य महाविलय, कन्नड
ता. कन्नड जि. औरंगाबाद

प्रस्तावणा

वर्तमान काळात भारतीय तरूणांमध्ये दिवसेन दिवस आत्महत्या करण्याच्या प्रमाणात तीव्र गतीने वाढ होताना दिसत आहे. पश्चिमी देशात मादक पदार्थ, दारू आणि वेगवेगळया हत्याऱ्यांच्या सहाय्याने आत्महत्या होताना दिसतात. मात्र भारतात परिक्षेचा दबाव व संकट निराशा न पचवण्याची मानसिकता यासारखी कारणे दिसून येतात. सर्वेक्षणानुसार सिध्द होत आहे. की, दर ९० मिनिटात एक तरूण आत्महत्या करयाचा प्रयत्न करतो (जवळ जवळ) यामध्ये आकर्षित करण्यासाठी प्रेम, मिळविण्यासाठी, प्रेमात अपयश येत असल्यास आत्महत्या करण्याचा प्रयत्न होताना दिसत आहे. यामध्ये दर सहा तासाला एक तरूण आत्महत्या करताना यशस्वी होताना दिसत आहे. नॅशनल क्राइम रिकार्ड ब्यूरो ने २००६-०७ च्या सर्वेशणात असे म्हटले आहे की, भारतात त्या वर्षी १४८ मुली व ५० मुलांनी आत्महत्या केल्या होत्या. तसेच २००८ मध्ये भारतात जवळ जवळ १५० विद्यार्थ्यांनी आत्महत्या करून जीवन संपविले आहे.

Suicide is the third leading caves of death among youth aged 15-24 suicide is the sixth Leading Caves of death among youth aged 5-14

यामध्ये तनाव सहन करण्याची क्षमता कमी दिसून येते. परिक्षेची तयारी व्यवस्थीत न करणे, त्याचा ताण तणाव येणे. राग सहन न होणे यासारख्या कारणांचा समावेश दिसून येतो. २००४ च्या सर्वेक्षणानुसार एका भारतीय अभ्यासात असे दिसून आले आहे की, आजचा तरूण वर्ग असा आहे की, त्याला असे वाटते की, मी काहीपण इच्छा, आकांक्षा प्राप्त करू शकतो व ताबोडतोब

AN ANALYSIS OF HEALTH CONCERNIN INDIA AS ONE OF THE TARGET OF SUSTAINABLE DEVELOPMENT GOALS

—Mrs. Vaishali A. Sukhdeve[1]

Abstract:

Sustainable development is a guide of natural resource utilisation which targets to meet human needs while preserving and protecting the environment so that these needs can be met not only in the present, but also for future generations. The Millennium Development Goals which were launched in the year 2000 had set 2015 as the target year. The United Nations recognizing the success of the Goals and the fact that a new development agenda was needed beyond 2015,urged to establish an open working group to develop a set of sustainable development goals. After more than a year of negotiations, the Open Working Group presented its recommendation for the 17 sustainable development goals. In August 2015, the 193 member states of the United Nations unanimously adopted the new agenda "Transforming our World: The 2030 Agenda for Sustainable Development".Accordingly, the countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years.For the goals to be reached, everyone needs to do their part i.e. the respective governments, the private sector, civil society and people like us.But the question arises that whether our countrylike India has successfully adopted the Millennium Development Goals and are we really in a position to adopt and implement the Sustainable Development goals of 2030.In this article, I would like to lay emphasis on the present environmental scenario of our country and how it is severely affecting the health and lives of numerous people.

Introduction:

The Sustainable Development Goals are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity.The United Nations Sustainable Development Goals 2030 comprises of the 17 Goals including new areas such as

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respiratory irritation to chronic respiratory and heart disease, lung cancer, acute respiratory infections in children and chronic bronchitis in adults, aggravating pre-existing heart and lung disease, or asthmatic attacks. In addition, short and long term exposures have also been linked with premature mortality and reduced life expectancy.

Impact of Thermal pollution:

Thermal pollution is defined as sudden increase or decrease in temperature of a natural body of water which may be ocean, lake, river or pond by human influence. With the constant flow of high temperature discharge from industries, there is a huge increase in toxins that are being released into the natural body of water. These toxins may contain chemicals or radiation that may have harsh impact on the local ecology and make them susceptible to various diseases.

On 4thNovember 2016, the Paris Agreement on climate change entered into force, addressing the need to limit the rise of global temperatures. The historic Paris Agreement provides an opportunity for countries to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius. Even India is party to this agreement, and it is really a great challenge for our country to maintain this constant rise in temperature in our eco system.

Occupational health diseases:

India being a developing nation is faced with traditional public health problems like communicable diseases, malnutrition, poor environmental sanitation and inadequate medical care. However, globalization and rapid industrial growth in the last few years has resulted in emergence of occupational health related issues. The major occupational diseases which are ofsevere concern in India are silicosis, musculoskeletal injuries, coal workers' pneumoconiosis, chronic obstructive lung diseases, asbestosis, byssinosis, pesticide poisoning and noise induced hearing loss.

There are many agencies like National Institute of Occupational Health, Industrial Toxicology Research Centre, Central Labour Institute, etc. are working on researchable issues like Asbestos and asbestos related diseases, Pesticide poisoning and Musculoskeletal disorders. Still much more is to be done for improving the occupational health research. The measures such as creation of advanced research facilities, human resources development,

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A SHIFT FROM ANTHROPOCENTRIC TO ECO-CENTRIC APPROACH FOR MANAGEMENT & PROTECTION OF SPECIFIC SPECIES: A CASE STUDY

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ABSTRACT

We are living on the verge of imbalanced ecology. The human endeavour to restore that balance is evidenced by an 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 basis for international environmental regulatory efforts. However, all these efforts were surrounded towards the interest of human being i.e. anthropocentric approach was prevalent. However, recently the Supreme Court of India in *Centre for Environmental Law, WWF-I Vs. Union of India,* on 15th April 2013 shifted its focus from Anthropocentric to Eco-Centric approach. In this case the Court has clearly stated that, human interest does not take automatic precedence and humans have obligations to non-humans independently of human interest. Eco-centrism is, therefore, life as well as nature-centred where nature includes both humans and non-humans. So, this paper focus upon a shift From Anthropocentric to Eco-centric approach for management and protection of specific species, through the case study method.

Key Words: Wildlife, management, protection, anthropocentric, eco-centric

INTRODUCTION

We live in an era of momentous changes and global environmental challenges. It is no doubt great testing period for the human species on this small planet. History shows that humans, as one of nature's finest creatures, have time and again shown a remarkable ability to survive within the means dictated by the finite resources of the Earth. But as Gandhi underscored "Earth provides enough to satisfy everyone's need but not anybody's greed". In fact defining and respecting the threshold of need is the principle source of humankind's dilemma. The problem is, we are upsetting the delicate balance which the nature defines for us.

All countries of the globe are very much concerned with the serious threat being caused to the earth's deteriorating environment. Scientists and engineers usually take years to find a solution, often only part of the solution to a given environmental problem and sometimes decades for its development, implementation and utilization, while the society continues to create new environmental problems at an alarming rate.

World is facing adverse consequences of the gradual degradation of its natural resources in the form of draughts, floods and heavy rains. Quality of human life is being seriously damaged by air, water and noise pollution, combined with mismanagement of solid waste, changes in mortality, fertility, loss of competitiveness, reduced output in resource based sectors, ecological imbalance, bio-diversity, acid rains are other disasters.

Besides, urbanisation and industrialisation, availability of natural resources and the life style of the people also affect the environment. The most important cause, however, is growth of population and resultant rise of poverty. The World's population is increasing relentlessly and so are peoples perceived needs and especially wants and this is putting all sectors of the global economy, power generation, transportation, agriculture production etc. under increasing pressure. The problem is exaggerated by the fact that people in the developing countries are now persuaded by all manners of consumerism of what is paraded as Western life style- the good life. Growth of unchecked population, increase of human wants and desire have direct impact on natural surroundings i.e. land, water and air in various ways.

The human endeavour to restore that balance is evidenced by an array of measures to prevent the frightening prospect

of ecocide. The efforts have warranted international environmental cooperation cutting across nation-states. International Environmental Institutions have been employed as tools for the protection of the environment and natural resources. A set of principles and rules of international law have evolved in the process to provide a basis for international environmental regulatory efforts. However, all these efforts were surrounded towards the interest of human being i.e. anthropocentric approach was prevalent. However, recently the Supreme Court of India in *Centre for Environmental Law, WWF-I Vs. Union of India,* on 15th April 2013 shifted its focus from Anthropocentric to Eco-Centric approach. In this case the Court has clearly stated that, human interest does not take automatic precedence and humans have obligations to non-humans independently of human interest. Eco-centrism is, therefore, both life and nature-centred where nature includes both humans and non-humans. So, this paper attempts to focus upon a shift From Anthropocentric to Eco-centric approach for management and protection of specific species, through the case study method.

ROLE OF JUDICIARY

Our judiciary especially the Supreme Court of India has adopted a new role, what we may call 'the precipitant role' involving different kinds of judicial strategies. Realising the serious damage to the quality of life that was being continually caused by the environmental pollution, the apex Court stepped into the arena that patently and potentially belongs to the executive government. It is indeed true that the problem of environmental protection is extremely complex. It is so because it has many loose ends and trying them together is not an easy task. May be it is for this reason, coupled with the kind of technical assistance that came to be provided to the court at various phases of development, the progress in the desired direction had been extremely tardy. Notwithstanding all sorts of limitations, attempt made by the judiciary spell out the gains made by the Supreme Court, howsoever feeble they may sound at first blush, in this rather elusive area of environmental protection. The gains here are being seen as a part of the precipitant role of the Supreme Court in the form of continual creation of successive strategies by way of judicial intervention. The recent judgement of the Apex Court, because of its prospective approach has once again proved that, our Supreme Court has become truly an 'environmental court' monitoring the progress of the environmental project as its chief concern or preoccupation.

LEGAL FRAME WORK

Let us first understand the constitutional and the legal framework on which the various issues which have come up for consideration in this case.

The subject "Protection of wild animals and birds" falls under List III, Entry 17B of Seventh Schedule. The Parliament passed The Wild Life (Protection) Act 53 of 1972 to provide protection for wild animals and birds to ensure the ecological and environmental security of the country. The Parliament vide Constitution (42nd Amendment) Act, 1976 inserted Article 48A w.e.f. 03.01.1977 in Part IV of the Constitution placing responsibility on the State "to endeavour to protect and improve the environment and to safeguard the forests and wild life of the country." Article 51A was also introduced in Part IVA by the above-mentioned amendment state that "it shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures".

By Act 23 of 1982, Section 12(bb) was inserted in the Wild Life (Protection) Act w.e.f. 21.05.1982 which authorised the Chief Wild Life Warden to grant a special permit for the purpose of scientific management which would include translocation of any wild animal to an alternative suitable habitat or population management of wild life without killing or poisoning or destroying any wild animals.

The Parliament later vide Act 16 of 2003 inserted Section 5A w.e.f. 22.09.2003 authorizing the Central Government to constitute the National Board for Wild Life (NBWL). By the same Amendment Act, Section 5C was also introduced eliciting functions of the National Board. Section 5B was also introduced by the aforesaid amendment authorizing the National Board to constitute a Standing Committee for the purpose of exercising such powers and performing such duties as may be delegated to the Committee by the National Board. NBWL is, therefore, the top most scientific body established to frame policies and advise the Central and State Governments on the ways and means of promoting wild life conservation and to review the progress in the field of wild life conservation in the country and suggesting measures for improvement thereto. The Central and the State Governments cannot brush aside its opinion without any cogent or acceptable reasons. Legislation in its wisdom has conferred a duty on NBWL to provide conservation and development of wild life and forests.

MANAGEMENT & PROTECTION OF WILD LIFE

The Hon'ble Supreme Court of India in *Sansar Chand vs. State of Rajasthan,* held that all efforts must be made to implement the spirit and provisions of the Wild Life (Protection) Act, 1972; the provisions of which are statutory and are necessary to be implemented to maintain ecological chain and balance. The Stockholm Declaration, the Declaration of United Nations, Conventions on Human Environment signed in the year 1972, to which India is the signatory, have laid down the foundation of sustainable development and urged the nations to work together for the protection of the environment. Conventions on Biological Diversity, signed in the year 1992 at Rio Summit, recognized for the first time in International Law that the conservation of biological diversity is "a common concern of human kind" and is an integral part of the development process.

The Parliament enacted the Biological Diversity Act in the year 2002 followed by the National Biodiversity Rules in the year 2004. The main objective of the Act is the conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Biodiversity includes all the organisms found on our planet i.e. plants, animals and micro-organisms, the genes they contain and the different ecosystems of which they form a part. The rapid deterioration of the ecology due to human interference is aiding the fast disappearance of several wild animal species. Poaching and the wildlife trade, habitat loss, human-animal conflict, epidemic etc. are also some of the reasons which threaten and endanger some of the species.

BRIEF FACTS OF THE CASE

The Wildlife Institute of India (WII), an autonomous institution under the Ministry of Environment and Forests (MoEF), Government of India, through its Wildlife Biologists had done considerable research at the Gir Forest in the State of Gujarat since 1986. All those studies were geared to provide data which would help for the better management of the Gir forest and enhance the prospects for the long term conservation of lions at Gir, a single habitat of Asiatic lion in the world. The data collected by the Wildlife Biologists highlighted the necessity of a second natural habitat for its long term conservation.

The court were supposed to decide the necessity of a second home for Asiatic Lion (*Panthera leo persica*), an endangered species, for its long term survival and to protect the species from extinction as issue rooted on eco-centrism, which supports the protection of all wildlife forms, not just those which are of instrumental value to humans but those which have intrinsic worth.

JUDGEMENT

The Court observed that, "India is known for its rich heritage of biological diversity and has so far documented over 91,200 species of animals. In India's bio-graphic regions, 45,500 species of plants are documented endangered as per IUCN Red List 2008. India has many critically threatened animal species. IUCN has noticed today the only living representative of lions once found throughout much of south-west Asia occurred in India's Gir forest which has been noticed as a critically endangered species in IUCN Red List. The IUCN adopted a resolution of 1963 by which a multi-lateral treaty was drafted as the Washington Convention also known as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973. CITES entered into force on 1st July, 1975, which aims to ensure that international trade in specimens of wild animals and plants does not threaten the survival of the species in the wild, and it accords varying degrees of protection to more than 33,000 species of animals and plants. Appendix 1 of CITES refers to 1200 species which are threatened with extinction. Asiatic lion is listed in Appendix 1 recognizing that species is threatened with extinction."

The Hon'ble Court noticed, for achieving the objectives of various conventions including Convention on Biological Diversity (CBD) and also for proper implementation of IUCN, CITES etc., and the provisions of the Wild Life (Protection) Act, Bio-diversity Act, Forest Conservation Act etc. in the light of Articles 48A and 51A(g), the Government of India has laid down various policies and action plans such as the National Forest Policy (NFP) 1988, National Environment Policy (NEP) 2006, National Bio-diversity Action Plan (NBAP) 2008, National Action Plan on Climate Change (NAPCC) 2008 and the Integrated development of wild life habitats and centrally sponsored scheme framed in the year 2009 and integrated development of National Wild- life Action Plan (NWAP) 2002-2016. Further observed that, the integrated Development of Wild Life habitat under the Centrally Sponsored Scheme of 2009 and the NWAP (2002-2016) have to be read along with the provisions of the Wile Life (Conservation) Act.

The Court further observed that, "the Prime Minister of India on 1.1.2002, in the XXI Meeting of the Indian Board for Wildlife, released the 'National Wildlife Action Plan (2002-2016)' (NWAP 2002-2016). NWAP has highlighted that the wildlife encompasses all uncultivated flora and undomesticated fauna and every species has the right to live and every threatened species must be protected to prevent its extinction. It was noticed with the mounting agricultural, industrial and demographic pressures; wilderness areas, which are the richest repositories of wildlife and biodiversity, have either shrunk or disappeared and their continued existence is crucial for the long term survival of the biodiversity and the ecosystems supporting them. NWAP, inter alia, highlighted the necessity to protect the long term ecological security of India and to identify and protect natural ecosystems from over-exploitation, contamination and degradation. NWAP has also urged the necessity to give primacy to *In Situ* conservation which is a sheet anchor of wildlife conservation. *Ex Situ* measures in zoological parks and gene banks may supplement this objective, without depleting scarce wild resources. NWAP also highlighted the ecological requirements for the survival of threatened, rare and endangered species together with their community associations of flora and fauna. It also highlighted the imperative necessity to have alternative homes for highly endangered species like the Great Indian Bustard, Bengal Florican, Asiatic Lion, Wild Buffalo, Dugong, the Manipur Brow Antlered Deer and the like. It was also noticed that where *In Situ* conservation efforts are unlikely to succeed, *Ex Situ*captive breeding and rehabilitation measures may be necessary, in tandem with the preparation of their wild habitats to receive back captive populations, especially in respect of lesser-known species where status and distribution of wild animals are not fully known." NWAP also highlighted the necessity of taking the following actions:

1. To identify all endangered species of flora and fauna, study their needs and survey their environs and habitats to establish the current level of security and the nature of threats. Conduct periodic reviews of flora and fauna species status, and correlate the same with the IUCN Red Data List every three years.
2. Invest special care and resources to protect habitats that harbour highly endangered species especially those having single population and a high degree of endemism.
3. Initiate action to prevent the "genetic swamping" of wild species.
4. To undertake a programme of *Ex Situ* captive breeding and rehabilitation in the wild for critically endangered species in accordance with IUCN guidelines, after developing requisite techniques and capabilities in this regard.
5. To publish flora, fauna and species status papers periodically, which should be translated into local languages.
6. To declare identified areas around Protected Areas and corridors as ecologically fragile under the Environment (Protection) Act, 1986, wherever necessary.

NWAP also highlighted the priority projects and to initiate a time-bound plan to identify and conduct status surveys of all endangered species covering all groups of rare and threatened species of flora and fauna and to provide protection to the environs and habitats of all rare and threatened species of flora and fauna under the priority projects. 2.2 of Para 3 of NWAP read as follows:

"Identify suitable alternative homes for single isolated populations of species such as Jerdon's Courser, Asiatic Lion, Manipur Deer, Wroughton's Free Tailed Bat and the like, and manage the same as Protected Areas effectively."

NWAP also states that the same is the responsibility of MoEF, State Governments, Scientific Institutions and NGOs. The necessity to take immediate steps for preventing the entry of domestic and feral species that may lead to genetic swamping, has also been highlighted. The importance to safeguard genetically pure populations from future genetic contamination and where genetic swamping has occurred, to phase out such swamping, was also highlighted. NWAP, in chapter IV, has highlighted the necessity to the restoration and management of degraded habitats outside the protected areas.

MoEF noticed that the fragmented nature of wildlife rich areas, increased human pressure, habitat degradation, proliferation of invasive species, man-animal conflicts, poaching and impacts of changing climate etc. are some of the challenges that has to be addressed at a war footing. The necessity for ensuring better protection of wildlife outside the protected areas and initiating recovery programmes for saving critically endangered species and habitats has also been high-lighted. Keeping that in view, a comprehensive Centrally Sponsored Scheme titled 'Integrated Development of Wildlife Habitats' has been made operational on 30.7.2009 which was in addition to the erstwhile Centrally Sponsored Scheme – 'Assistance for the Development of

National Parks and Sanctuaries'. The scheme incorporated additional components and activities for implementing the provisions of the Wildlife (Protection) Act (1972), the National Wildlife Action Plan (2002-2016), recommendations of the Tiger Task Force (2005) and the National Forest Commission (2006) and the necessities felt from time to time for the conservation of wildlife and biodiversity in the country. The scheme was formulated during the 11th year plan.

ANTHROPOCENTRIC Vs ECO-CENTRIC

The court observed that, there has been wide ranging discussions and deliberations on the international platforms and conferences for re- building of certain principles laid down in the earlier conventions on the Principles of Sustainable Development. The United Nations Commission on Environment and Development defined the 'sustainable development' as follows:

"Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Sustainable development, it has been argued by various eminent environmentalists, clearly postulates an anthropocentric bias, least concerned with the rights of other species which live on this earth. Anthropocentrism is always human interest focussed thinking that non-human has only instrumental value to humans, in other words, humans take precedence and human responsibilities to non-human are based benefits to humans. Eco-centrism is nature-centred, where humans are part of nature and non-humans have intrinsic value. In other words, human interest does not take automatic precedence and humans have obligations to non-humans independently of human interest. Eco-centrism is, therefore, life-centred, nature-centred where nature includes both humans and non-humans.

The Court re-iterated that while examining the necessity of a second home for the Asiatic lions, our approach should be eco-centric and not anthropocentric and we must apply the "species best interest standard", that is the best interest of the Asiatic lions. We must focus our attention to safeguard the interest of species, as species has equal rights to exist on this earth. Asiatic Lion has become critically endangered because of human intervention. The specie originally existed in North Africa and South-West Asia formerly stretched across the coastal forests of northern Africa and from northern Greece across south-west Asia to eastern India. Today the only living representatives of the lions once found throughout much of South-West Asia occur in India's Gir Forest. Asiatic lion currently exists as a single sub-population and is thus vulnerable to extinction from unpredictable events, such as an epidemic or large forest fire etc. and we are committed to safeguard this endangered species because this species has a right to live on this earth, just like human beings.

The court further said that article 21 of the Constitution of India protects not only the human rights but also casts an obligation on human beings to protect and preserve a specie becoming extinct, conservation and protection of environment is an inseparable part of right to life. In *M. C. Mehta vs. Kamal Nath and Others* , the Hon'ble Supreme Court enunciated the doctrine of "Public Trust", the thrust of that theory is that certain common properties such as rivers, seashores, forests and the air are held by the Government in trusteeship for the free and unimpeded use of the general public. The resources like air, sea, waters and the forests have such a great importance to the people as a whole, that it would be totally unjustified to make them a subject of private ownership. The State, as a custodian of the natural resources, has a duty to maintain them not merely for the benefit of the public, but for the best interest of flora and fauna, wildlife and so on. The doctrine of 'Public Trust' has to be addressed in that perspective.

The court further said that, we, as human beings, have a duty to prevent the species from going extinct and have to advocate for an effective species protection regimes. NWAP 2002-2016 and the Centrally Sponsored Scheme 2009 indicate that there are many animal species which are close enough to extinction and some of the other species have already disappeared from this earth. No species can survive on the brink of extinction indefinitely and that the continued existence of any species depends upon various factors like human-animal conflict, epidemics, forest fire and other natural calamities etc.

The Wildlife Biologists of WII, after conducting a research on Gir Forests, noticed the necessity for long term conservation of Asiatic lion in Gir and also highlighted the necessity of a second natural habitat for its long term conservation. Population and Habitat Analysis Workshop held at Baroda in October, 1993 also highlighted that fact. NBWL, as already indicted, has taken a consistent view in all its meetings about the necessity of a second habitat for Asiatic lion, an endangered species. Asiatic lion, it has been

noticed, has been restricted to only one single habitat, i.e. the Gir National Forest and its surrounding areas and an outbreak of possible epidemic or natural calamity might wipe off the entire species. A smaller population with limited genetic strength are more vulnerable to diseases and other catastrophes in comparison to large and widespread population. Threat, therefore, is real and has been proved by the outbreak of canine distemper in the lions of Serengeti NP, Tanzania in 1994. 85% of the Serengeti lion population, it was noticed, had Canine Distemper Virus antibodies and at least 30% of the Serengeti and Mara lions died due to the infection. Compared with Gir, the lion population in the 40,000 sq. km. Serengeti-Mara ecosystem is large with about 2500 lions. It was felt that if an epidemic of this scale were to affect the lions in Gir, it would be very difficult to save them from extinction, given the much smaller area of the Gir forests and the smaller lion population. The possibility of the disease spreading to the pockets of habitat such as Girnar, Mityala, Rajula, Kodinar and the surrounding areas, cannot be ruled out.

The Court found that there is uniformity in the views expressed by the Bio-Scientists of WII, NBWL, MoEF and other experts that to have a second home for the endangered species like Asiatic lion is of vital importance. A detailed study has been conducted to find out the most suitable habitat for its re-introduction and Kuno Wildlife Sanctuary (for short 'Kuno') in Madhya Pradaesh, as already indicted, has been found to be the most ideal habitat.

The Court further observed that, approach made by SWBL and the State of Gujarat is an anthropocentric approach, not eco-centric though the State of Gujarat can be justifiably proud of the fact that it has preserved an endangered species becoming extinct. The Court, however, showed its concern with a fundamental issue whether the Asiatic lions should have a second home and observed that, the cardinal issue is not whether the Asiatic lion is a "family member" or is part of the "Indian culture and civilization", or the pride of a State but the preservation of an endangered species for which we have to apply the "species best interest standard". "Our approach should not be human-centric or family-centric but eco-centric. "Scientific reasoning" for its re-location has to supersede the family bond or pride of the people and we have to look at the species best interest especially in a situation where the **species** is found to be a critically endangered one and the necessity of a second home has been keenly felt. We, therefore, find it difficult to agree with the reasoning of SBWL, Gujarat and the State of Gujarat that the Asiatic lion is a family member and hence be not parted with."

The Court highlighted the necessity of an exclusive parliamentary legislation for the preservation and protection of endangered species so as to carry out the recovery programmes before many of the species become extinct and to give the following directions:

(a) NWAP (2002-2016) has already identified species like the Great Indian Bustard, Bengal Florican, Dugong, the Manipur Brow Antlered Deer, over and above Asiatic Lion and Wild Buffalo as endangered species and hence we are, therefore, inclined to give a direction to the Government of India and the MoEF to take urgent steps for the preservation of those endangered species as well as to initiate recovery programmes.

(b) The Government of India and the MoEF are directed to identify, as already highlighted by NWAP, all endangered species of flora and fauna, study their needs and survey their environs and habitats to establish the current level of security and the nature of threats. They should also conduct periodic reviews of flora and fauna, species status, and correlate the same with the IUCN Red Data List every three years.

(c) Courts and environmentalists should pay more attention for implementing the recovery programmes and the same be carried out with imagination and commitment.

CONCLUSION

The doctrine of sustainable development was developed by the judiciary for the protection and management of environmental degradation. No doubt sustainable development is a good concept; nonetheless this postulates an anthropocentric bias, where human interest is always focussed. Therefore what is good or in the interest of a human being is always protected. However, Centre for Environmental Law, WWF-I is a unique case, where we find the shift from Anthropocentric bias to Eco-centric approach, where the importance of non-human species has been emphasised. Though there is theoretical underpinning in all legislative schemes, for the first time it has expressly been held that 'humans' have legal obligations to 'non-humans', independently of human interest. The Court's observations that both humans and non-humans are part of nature, and therefore, humans are legally obliged to take care of them irrespective of human interest is really a welcoming step.

Suggested Readings

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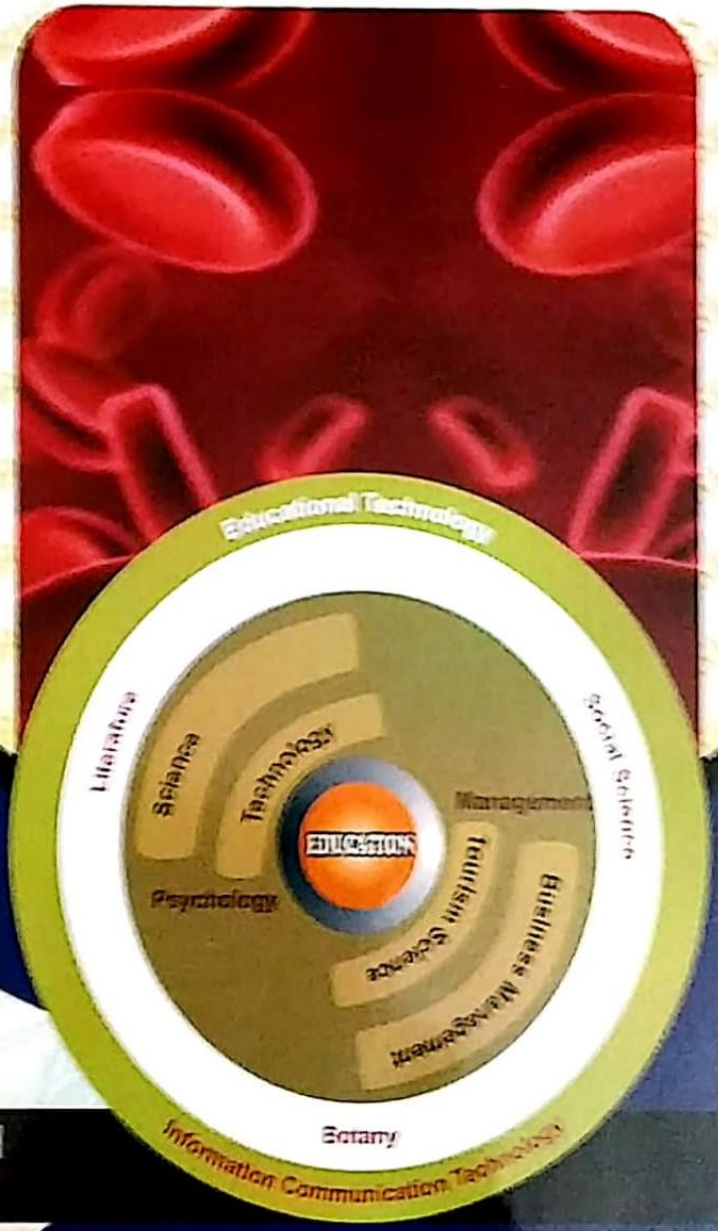

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EMPOWERMENT OF WOMEN IN INDIA: A LONG ROAD AHEAD

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Abstract
From time immemorial, women in this country have been socially and economically exploited. They have been deprived of equal participation in the socio economic activities of the country and atrocities against them continued unabated. The Constitution of India has taken a very strong stand for eradication of derogatory and discriminatory practices against women in India. It recognises women as a class by itself and permits enactment of laws and reservation favouring them. Several articles in our Constitution and other special laws, makes express provisions for affirmative action in favour of women. Not only this, Art. 51 of the Constitution obligates the state to honour International Law and Treaty obligations. Our natural obligation to renounce practices derogatory to the dignity of women has been elevated to the status of fundamental duty by Art. 51-A. Despite of all these developments the truth remains that widespread violations of women's rights continue to persists. Nevertheless, these legislative and unparalleled judicial efforts to uplift the women with dignity has been achieved to a great extent, especially in the last 3 decades. On priority, the agenda of women empowerment was addressed by the government and their attempt to reassert her strength and to redefine the patriarchal laws is really admirable. However, the author found that the pro-active role by judiciary is contributing more to reassert the strength and dignity of women, as this is the judiciary who acts as a custodian & guardian of the rights, which are otherwise merely on paper. Therefore, the author attempted to study few leading and recent judgments, which speaks about the sensitivity of judiciary towards women empowerment. These judgements also shows as how a woman succeeded in being the voice of thousands of other women, how they stepped up as women and took the lead. How these women's are responsible for women empowerment. However, author finds that, still, more concrete and conscious efforts are required to achieve women empowerment.This can be set as a vision for 2050, but author doubts about the fulfilment of this dream till 2050.

Keywords *– Women empowerment, gender equality and gender justice, dignity of women, change in attitude and mind-sets, judiciary as custodian & guardian of women's rights.*

INTRODUCTION: "One is compelled to think and constrained to deliberate why the women in India Cannot be allowed to live in peace and lead a life that is empowered with a dignity and freedom. It has to be kept in mind that she has a right to life and entitled to love according to her choice. She has an individual choice which has been legally recognised. It has to be socially respected. No one compel a woman to love. She has the absolute right to reject."

-Dipak Mishra, J.[11]

Since long women's are denied their basic rights, right even to choose her life partner and to live with self-respect & human dignity. In our society, either in domestic sphere or in the outer world, women from all walks of life have been criminally exploited. Women, who constitute one- half of the society and without whose presence the survival of the world would have been impossible, have ironically been made a subject of sexual exploitation and are going through

[11]Pawan Kumar V. State of H.P. (2017) 7 SCC 780 Para 47.

hell in this male dominated world.[12] Crime against women are as old as civilization and equally ancient are the efforts to combat and arrest them. These efforts have not succeeded and crime against women are continuously increasing. Women in India through the ages have been victimised, humiliated, tortured and exploited. Throughout the world, millions of women live in conditions of abject deprivation of, and attacks against their fundamental human rights for no reason other than that they are women. Human rights are those irreducible minima which belong to every member of the human race when pitted against the state or other oppressive communities.[13] Being a member of the human family, she has the right to be treated as human once she takes birth or is alive in the womb with a potential title to personhood.[14] Offences against women are not a women's issue alone but, human rights issue. Increased rate of crime against women in an area of concern for the law makers and it points out an emergent need to study in depth the root of the problem and remedy the same through a strict law and order regime. There are number of legislations and numerous penal provisions to punish the offenders of violence against women. However, it becomes important to ensure that gender justice does not remain only on paper."[15] Undoubtedly, there is a sea change in the status of women due to National and International efforts. Today, "In a civilised society male chauvinism has no room. The Constitution of India confers the affirmative rights on women and the said rights are perceptible from Art.15 of the Constitution. When the right is conferred under the constitution, it has to be understood that there is no condescendation. A man should not put his ego, for that matter, masculinity on a pedestal and abandon the concept of civility. Egoism must succumb to law. Equality has to be regarded as the summumbonum of constitutional principle in such context."[16] Gender equality means empowering women and girls. Gender equality is the precondition for ending poverty. This is all about achieving sustainable development and building a peaceful society. The author in this paper tried to analyse the concept of women empowerment and particularly the role of judiciary to empower the women in recent years. Through this study it was found that, though enough legislative and judicial efforts are taken to achieve the gender equality and empower the women folk, increasing number of crimes and discrimination shows that there is lot of time ahead to achieve equality in real spirit. This can be set as a vision for 2050, but author doubts about the fulfilment of this dream till 2050.

WOMEN EMPOWERMENT: Empowerment can be defined as a, "multidimensional social process that helps people gain control over their own lives. It is a process that fosters power in people, for use in their communities, & in their society, by acting on issues that they define as important." In the same way, Women's empowerment refers to, "women's ability to make

[12] Dr.SurendraMediratta, 'Crime Against Women and the Law', 2010, Delhi Law House.
[13] K. Vijaya Lakshmi, 'Women's Rights and Human Rights', (2000) 6 SCC 168 at 176.
[14] Supra Note 3.
[15] R. Banumathi, J. in Mukesh V. State (NCT of Delhi), (2017) 6 SCC 1, para 520.
[16] Supra Note 3, Para 48.

strategic life choices where that ability had been previously denied them". Accordingly, empowerment is central to the process of maintaining the benefits of women at individual, household, community and broader levels. It involves the action of boosting the status of women through literacy, education, training and raising awareness. Hence, women empowerment is all about allowing and equipping women to make life determining choices across different issues in the country. There are various means through which women will be empowered. The most important amongst them is female education. This is indeed sine qua non for women empowerment. Education is the first and foremost thing to seek women empowerment. Women are entitled to get the same kind of education which is made available formen. Equality guaranteed under the Constitution of India shall not be a mere paper right. It has to be transformed into action and made a reality. Today a woman is an equal match to her male counterpart in intellectual activities and physical pleasures. Gone are the days when she was confined to the household.[17] It provides social as well as economic gains and paves the way for political gains. It helps to improve the quality of life at home and outside. It reduces fertility and infant mortality rate. It helps to increase family health and nutritional level. It helps for art of living with efficient management. On the other hand female education helps to get economic benefits. It helps for efficiency, productivity and employment including standard of living. It brings about economic freedom.[18] Equally important is Health Care sector for women. In India, discrimination is particularly rampant in the health care sector. Women's are often refused treatment for want of money or care taker. They do not have access to health care due to their socio economic status. Therefore discrimination in health care is critical to address for a variety of reasons. Most important, the right tohealth is enshrined in most Constitutions as an aspect of the right to life.[19] Thus any barrier to equal access to health care will be a big hurdle in achieving empowerment. Therefore this must be overcome immediately. This issue must be dealt with urgency by the State. The author wish to refer here the dialogue from a Doll's House, a famous play from 1879, written by Henrik Ibsen. In this play Henry tells Nora, "First and foremost you are a wife and mother". Nora replied, "That I don't believe any more. I believe that first and foremost I am an individual, just as much as you are." This dialogue carries a forceful message. A woman today expects herself and rightly so… to be treated as an individual, a living human being, entitled to the same dignity and status, as her male

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[17] Dr. Justice A R Lakshmanan, 'Voice of Justice', Chapter 43, 'Today's Woamn- An Equal Match To Her Male Counter Part', Vol 2, 2007, ALT Publications p. 178.

[18] Sathyanarayana, "Empowerment of Women is the Key Towards Gender Equality", Ed. Asha Bhandari, Rekha Mehta, 'Women, Justice And The Rule of Law ', 2009, Serials Publications, New Delhi (India) p. 167.

[19] Indian Judiciary also read right to health as a fundamental right under Art. 21 of the Constitution of India in plethora of cases like, BandhuaMuktiMorchaetc V. Union of India &Ors. AIR 1984 SC 802, ParmanandKatra V. Union of India, (1989)4 SCC 286, Consumer Education & Research Centre V. Union of India (1995)3 SCC 42, PaschimBangaKhetMazdoorSamity and Ors. V. State of West Bengal 1996 (4) SCC 37 etc.

counterpart. This is indeed a perfect condition for women empowerment. This is the woman who has to be assertive about her rights. She should claim her share, as this society will never offer her the treatment which she deserves, at least for next few years. Perhaps that is the reason why do we have so many legislations favouring her. Law is one of the best instrument for bring social change, the only thing is we must use this weapon for our good and not to exploit our counterpart i.e. male fraternity.

LEGISLATIVE INITIATIVES: The Constitution of India has taken a very strong stand for eradication of derogatory and discriminatory practices against women in India. It recognises women as a class by itself and permits enactment of laws and reservation favouring them. Several articles in our Constitution and other special laws, makes express provisions for affirmative action in favour of women. Not only this, Art. 51 of the Constitution obligates the state to honour International Law and Treaty obligations. Our natural obligation to renounce practices derogatory to the dignity of women has been elevated to the status of fundamental duty by Art. 51-A. Despite of all these developments the truth remains that widespread violations of women's rights continue to persists. There are plethora of laws for the protection of women in India like, Dowry Prohibition Act, 1961,n Commission of Sati (Prevention) Act, 1987, Indecent Representation of women (Prohibition) Act, 1986, National Commission for Women Act, 1990, Protection of Women from Domestic Violence Act, 2005, Protection of Women against Sexual Harassment Act, 2013, Immoral Traffic (Prevention) Act, 1956, Pre-natal Diagnostic Techniques (Regulation & Prevention of Misuse) Act, 2001, Equal Remuneration Act, 1976, Maternity Benefit Act, 2002 etc. These legislative and unparalleled judicial efforts (Judicial efforts are discussed below) to uplift the women with dignity has been achieved to a great extent, especially in the last 3 decades.

SOME RECENT IMPORTANT JUDICIAL VERDICTS ON WOMEN EMPOWERMENT: Indian judiciary has always shown sensitivity to the needs of justice. It is one of the judiciaries in the world which enjoys a high reputation of being justice sensitive. During last three decades there has been a sea change in the concept of women empowerment, more so because of judicial activism. Here are the few recent cases where court acted unprecedently bold enough to uphold the dignity of women in a male dominated society.... India.

Affirming the Right to Maintenance to Muslim Women: In Shan Bano,[20] the SC held that a divorced Muslim woman is entitled to maintenance a in the case of women belonging to other sects. The Court also held that Talaq does not ipso facto or ipso jure take away the women's right to maintenance. Shah Bano'sjudgement was delivered in the context of Sec.125 of the Cr.P.C. which is a general provision for maintenance, irrespective of religion or personal laws.

The subsequent decision of the SC on the Constitutional validity of the Muslim Women (Protection of Rights on Divorce) Act, 1986 is significant in several ways. In Danial

[20] Mohd. Ahmad Khan V. Shah Bano Begum, 1985 AIR 945.

Latifi V. Union of India,[21] the apex court held that the entitlement to maintenance under the Act is not confined to the Iddat period. On the one hand, the judgement removes the doubts, if any, regarding the true meaning and intent of Sec.3 of the Act concerning the divorced women's entitlement to maintenance. On the other hand, more importantly, the judgement shattered the misconception that the legislation of 1986 was an attempt to sabotage the "revolutionary" verdict in Shah Bano Begum.[22] The apex court has analysed even the intention of the Parliament and laid down the law by way of an interpretive process in Danial Latifi. Later on as well the Hon'ble S C in ShabanaBano,[23]KhatoonNisa,[24]ShamimaFarooqui[25] and ShamimBano[26], reiterated the principle of Daniel latiffi, that Muslim women's are entitled for maintenance even after iddat period.

Affirming the right to dignity of women -No mercy to Rapist, Deterrent Punishments for Crime Against Women: In Mukesh V. State (NCT of Delhi)[27], is known as Nirbhaya's Case, is the brutal, barbaric and diabolic nature of crime. This is a case where the brutal, barbaric gang rape, unnatural sex and assault in a bus in Delhi leading to the death of victim. Holding the criminal liable and not allowing any kind of mercy in such heinous crime the Hon'ble SC once again showed their sensitivity and genuine efforts to act as a strict guardian of the women's right, reinsuring their faith on Indian legal system. The Court observed that:

"Imposition of appropriate punishment is the manner in which the Courts respond to the society's cry for justice against the crime. Justice demands that the Court should impose punishments befitting the crime so that it reflects public abhorrenceof the crime. Crimes like the one before us cannot be looked with magnanimity. Factors like young age of the accused and poor background cannot be said to be mitigating circumstances. Likewise, post- crime remorse and post-crime good conduct of the accused, the statement of the accused as to their background and family circumstances, age, absence of criminal antecedents and their good conduct in prison, in my view, cannot be taken as mitigating circumstances to take the case out of the category of "rarest of rare cases". The circumstances stated by the accused in their affidavits are too slender to be treated as mitigating circumstances."[28] The Court further observed that, "We have the responsibility to set good values and guidance for posterity. In the word of great scholar, Swami Vivekananda, "the best thermometer to the progress of a nation is its treatment of its women." Crime against women not only affects women's self-esteem and

[21] AIR 2001 SC 3958.
[22]Kaleeswaram Raj, "Rethinking Judicial Reforms- Reflections on Indian Legal System', Chapter 15, 'Shah Bano's Case in Retrospect', Universal Law Publication, 2017 p. 85.
[23]ShabanaBano V. Imran Khan, (2010) 1 SCC 666.
[24]Khantoon Nis V. State of Uttar Pradesh, (2014) 12 SCC 646.
[25]ShamimaFarooqui V. Shahid Khan, (20150 5 SCC 705.
[26]Shamim Bana V. Asraf Khan, (2014) 12 SCC 636.
[27](2017) 6 SCC p 1-208.
[28]Mukesh V. State of NCT, (2013) 2 SCC 587, Para 517.

dignity but also degrades the pace of societal development. I hope that this gruesome incident in the capital and death of this young woman will be an eye opener for a mass movement "to end violence against women" and "respect for women and her dignity" and sensitizing public at large. On gender justice. Every individual irrespective of his/her gender must be willing to assume the responsibility in fight for gender justice and also awaken public opinion on gender justice. Public at large, in particular men, are to be sensitized on gender justice. The battel of gender justice can be won only with strict implementation of legislative provisions, sensitization of public, taking other proactive steps at all levels for combating violence against women and ensuring widespread attitudinal changes and comprehensive change in the existing mindset. We hope that this incident will pave the way for the same."[29]

Affirming the right of a girl child over her body and reproductive rights: Independent Thought V. Union of India,[30] the question came before the Hon'ble Court, whether sexual intercourse between a man and his wife being a girl between 15 & 18 years of age is rape? Exception 2 to Sec.375 of the IPC, 1860 answers this in the negative, but the Court in this case held that, sexual intercourse with a girl below 18 years of age is rape regardless of whether she is married or not. The exception carved out in the IPC creates an unnecessary and artificial distinction between a married girl child and an unmarried girl child and has no rational nexus with any unclear objective sought to be achieved. The artificial distinction is arbitrary and discriminatory and is definitely not in the best interest of the girl child. The artificial distinction is contrary to the philosophy and ethos of Art. 15 (3) of the Constitution as well as contrary to Art. 21 of the Constitution and our commitments in International Conventions. It is also contrary to the philosophy behind some statutes, the bodily integrity of the girl child and her reproductive choice. What is equally dreadful, the artificial distinction turns a blind eye to trafficking of the girl child and surely each one of us must discourage trafficking which is such a horrible social evil.

Affirming Female Sexual Autonomy: Recently Delhi High Court in 2013, held that consensual sex with minor not a crime. The Court made these observations while acquitting a 22 year old boy who was charged for kidnapping and raping a girl of 15 year old, whom he later married. The Court said, the provisions of POCSO Act suggest that when a physical relation, which is not in the nature of an assault takes place with the minor girls consent and where the consent has not been obtained unlawfully, no offence can be said to have been committed. Rejecting the plea of the Police and Delhi Women's Commission that POCSO Act prohibits minors from having any kind of sexual relations Judge observed that, "I am afraid if that interpretation is allowed, it would mean that the human body of every individual under 18 years of age is the property of the state and no individual below 18 years can be allowed to have pleasures associated with one's body." The youth, a native of West Bengal, was

[29] Ibid para 521.
[30] W.P. (C) 382/ 2013.

acquitted of the charges as the Court held that the minor, on her own will, accompanied him and obstacles should not be put in their happy married life. However the Court urged state authorities to spread awareness related to unsafe sex or early marriage.

Upholding the Dignity of Muslim Women – Ban on Triple Talaq: In a landmark judgement[31], a Constitutional bench of SC, on 22 August 2017, declared the practice of triple talaq as unconstitutional. The Court observed that, there are schools of thought which say that ripple talaq is legal, but it is the worst and not a desirable form of dissolution of marriage amongst Muslims.This is really a very welcoming move on the part of judiciary who uplifted the status of Muslim women granting gender equality. Immediately after this the government introduced a bill[32] and this bill is considered to be a further step to concretize the historical verdict of Hon'ble S.C. by making it a punishable offence. It makes the pronouncement of talaq-e-biddat "void and illegal". According to clause 3 of the Bill, "Any pronouncement of talaq by a person upon his wife, by words, either spoken or written or in electronic form or in any other manner whatsoever, shall be void and illegal". A man who pronounces talaq to his wife shall be punishable with an imprisonment of three years and this bill also makes the pronouncement of talaq-e-biddat a non-bailable offence. Also, the woman upon whom talaq is pronounced will have to receive an allowance from her husband, and she can retain the custody of her children.

CONCLUSION: "Stringent legislation and punishments alone may not be sufficient for fighting increasing crimes against women. In our tradition bound society, certain attitudinal change and change in the mindset is needed to respect women and to ensure gender justice. Right from childhood years children ought to be sensitized to respect women. A child should be taught to respect women in the society in the same way as he is taught to respect men. Gender equality should be made a part of the school curriculum. The school teachers and parents should be trained, not only to conduct regular personality building and skill enhancing exercise. But also to keep watch on the actual behavioural pattern of the children so as to make them gender sensitized. The educational institutions, government institutions, the employers and all concerned must take steps to create awareness with regard to gender sensitization and to respect women. Sensitization of the public on gender justice through TV, media and press should be welcomed. On the practical side, few of the suggestions are worthwhile to be considered. Banners and placards in the public transport vehicles like autos, taxis and buses, etc. must be ensured. Use of streetlights, illuminated bus-stops and extra police patrol during odd hours must be ensured. Police/security guard must be posted at dark and lonely places like parks, streets, etc. Mobile apps for immediate assistance of women should be introduced and effectively maintained. Apart from effective implementation of the various legislation protecting women, change in the mindset of the society at large and creating awareness in the

[31] ShayraBano V. Union of India and Others WP (C) No.118 of 2016.
[32] The Muslim Women (Protection of Rights on Marriage) Bill, 2017.

...ards on gender justice, would go a long way to combat violence against women.[33] The ...ences like Nirbhaya in present day society only suggests that, despite of all the National ...al International efforts, the crime and atrocities against women are on increase. The ...ifying and gruesome conduct on the part of criminals is shocking in the 20th century. ...refore, there is a complete agreement and support to the findings of the Hon'ble Judge and ...ect that if these things are taken on priority with the change in attitude, definitely there will ...e fulfillment of our dream, to bring gender justice, ultimately for the developed and peaceful ...ety. The journey towards equality of women is thus long and arduous.[34] There are many ...men who passionately and steadfastly joined the campaign for women empowerment. We ...ust acknowledge the efforts on the part of government. Judiciary undoubtedly proved to be ...e strongest guardian for the protection of rights and bringing gender justice. No doubt there ...s a sea change into the status of women, yet a lot is to be done and achieve in near future to ...ring complete equality. The author doubts whether this journey's end will be till 2050 but ...eartheless hope that the wait will not be long after, and certainly there will be a change.

...Supra Note 19, para 373.

...ra Bhanda, Archana Parashar, "Engendering Law- Essays in Honour of Lotika Sarkar', 1999, ...tern Book Company, Lucknow.

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Principles of Criminal Liability

Introduction

It is now rather unfathomable to start any write up in law with definitions. One reason for this is the difficulty frequently encountered in defining the subject matter of a particular branch of the law, and nowhere has this been more greatly felt than in the Criminal Law. But as this write up is about principles of criminal liability, and if it did not at least attempt to tell the reader what a crime is, it would be deficient.

Many attempts have been made to define crime, but they all fail to help us in identifying what kind of act or omission amounts to a crime. Perhaps, this is because of the chameleon nature of crime from time to time and place to place. The very definition and concept of crime varies not only according to the values of a particular group and society, its ideals, faith, religious attitudes, customs, traditions, and taboos, but also according to the form of Government, political and economic structure of the society and a number of other factors. For instance, what is an offence against property in a capitalist culture may be a lawful way of living in a socialist society. What is permissible in a free and an affluent society may be a pernicious vice in a conservative set up. Criminal law serves the purpose of protecting elementary socio-ethical values. Any act, which is a crime today, may not be a crime tomorrow, if the legislature so decides. For instance, polygamy, dowry, untouchability are now crimes, which was not so a few years ago. Suicide was a crime in England until the Suicide Act 1961, and in India from 1996 to early 1996, when it became lawful to kill oneself.[1]

Crime Defined

A precise definition of crime is by no means an easy task. However different jurist tried to defined it. Accordingly to the legal definition, 'crime' is any form of conduct which is declared to be socially harmful to a state and as such forbidden by law under pain of some punishment.

Crime as a Procedural Wrong: According to Kenny, "crimes are wrongs whose exaction is punitive, and is in no way remissible by any private person, but is remissible by the Crown alone, if remissible at all".

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[1] P Rathinam/Gopalakrishna Pillai V. Union of India AIR 1994 SC 1844 Section 309 of the IPC, attempt to commit suicide was held to be a cruel and irrational provision violating Art 21 of the Constitution of India by the Supreme Court. The Court, in Chan Kaur V. State of Punjab AIR 1996 SC 946, however again upheld the validity of S 309 and overruled its earlier decision of 1994. Thus attempt to commit suicide became punishable as before. However once again we could see the change in law recently recently the Government of India decriminalised attempt to suicide and brought this act under the Mental Health Care Act as Mental illness to be treated by doctors and not to be punished.

Crime as a Social Wrong: John Gillin defines crime as an act that has been shown to be actually harmful to the society or that is believed to be socially harmful by a group of people that has power to enforce its beliefs and that places such act upon the ban of positive penalties.

Crime as a Public Wrong: According to Blackstone, a crime is an act committed or omitted, in violation of a public law either forbidding or commanding it.

Crime as a moral Wrong: Raffeale Garafalo, defines, 'crime as immoral and harmful act that is regarded as criminal by public opinion because it is an injury to so much of the moral sense as to community- a measure which is indispensable for the adaptation of the individual to society.'

Crime as a Conventional Wrong: Edwin Sutherland, defines Crime in terms of criminal behaviour. He says, "Criminal behaviour is a behaviour in violation of the criminal law. No matter what the degree of immorality, reprehensibility, or indecency of an act, it is not a crime unless it is prohibited by the criminal law." The criminal law, in turn, defined conventionally as a body of specific rules regarding human conduct which have been promulgated by political authority, which apply uniformly to all members of the classes to which the rules refer, and which are enforced by punishment administered by the state.

No definition above is free from criticism for obvious reason that no one can give us perfect definition due to changing notion of crime. However, from the foregoing definitions, it may be said that a crime is a wrong to society involving the breach of a legal wrong which has criminal consequences attached to it i.e. prosecution by the State in the criminal court and the possibility of punishment being imposed on the wrongdoer.

An act to become a crime must conform to **two cardinal principles of criminal liability**, namely:

(i) NullumCrimen Sine Lege,

(ii) NullaPoena Sine Lege.

According to the first principle, no one is held criminally liable unless he has done an act which is expressly forbidden under the existing criminal law of the land and has a reprehensible state of mind to do it. The second principle suggests that no one can be punished for an act unless it is made punishable under the law. Thus it is doubtful whether a swimmer who keeps on watching a child drowning in apond but makes no effort to save the life, can be punished under the criminal law for his omission to rescue the child.

Classification of Offences under I.P.C.

Under the Indian Penal Code, various offences have been classified into seven broad categories.

1. Offences against person.
2. Offences against property.
3. Offences relating to documents.
4. Offences affecting mental order.
5. Offences against public tranquillity.
6. Offences against State.
7. Offences relating to Public Servants.

Fundamentals of Modern Criminal Law

The fundamental principles of modern criminal law are founded on rules of equity, justice and fair play. These rules provide adequate guidelines for the formulation of a rational penal policy and at the same time ensure even-handed dispensation of justice to litigants.

The fundamental principles governing criminal law administration may briefly be summarised as follows:-

1. **Mens Rea And Actus Rea :** An 'act' in order to become a crime must be committed with criminal intent which is legally termed as mens rea. This principle is contained in the well known maxim, 'actus non facitreum nisi mens sit rea'. It is to be noted that mens rea or criminal intent consists in doing some act voluntarily with the knowledge that it is fraudulent, dishonest or injurious to another. However, an act done under a bonafide belief, though criminal, shall be a good defence.[89] Thus, no act shall be a crime without mens rea or guilty mind of the doer. It must be stated that the mens rea in case of a murder consists in malice aforethought, for rape in forcible connection with a woman without her consent, for theft in an intention to steal and for procuring stolen goods with the knowledge that the goods was a stolen one. The cases of D.P.P. V. Smith[90] ; Shaw V. D.P.P.[91], State V. Dr.Vimladevi,[92] can be cited in support of this connection.

   The juristic concept 'actus reus' represents the physical aspect of crime while mens rea, its mental aspect. The concept of mens rea comprises several other states of mind, namely, will, intention, motive and so on. Thus, it covers a wide range of mental attitudes and conditions the existence of which would give rise to

89 R.Tolson, (1889) 23 QBD 168; See also Nathulal V. State of Madhya Pradesh, AIR 1966 SC 43.

90 (1960) 3 WLR 56.

91 (1961) 2 All ER 446.

92 AIR 1963 SC 1572.

actus reus. Sometimes mens rea refers to foresight of the consequences of an act and at others it consists in the act per se irrespective of its consequences.[93]

In some cases mens rea also denotes inattention of the doer of the criminal act which can otherwise be called his recklessness. Thus, in case of manslaughter by negligence, the accused causes death of the victim due to his negligence, nevertheless, he is held criminally liable.[94]

Though mens rea is an essential ingredient of every offence, there are certain exception to it:-

(i) Cases not criminal in any real sense but for punishment in view of the public welfare.

(ii) Public Nuisance

(iii) Cases which are criminal in form but for which summary mode of enforcement shall be adequate in view of the urgency and importance of the protection of civil rights violated thereby. Thus, a legitimate exercise of right of private defence[95] may exclude many intentional acts which would otherwise be offences. Again a delicate surgical operation being the only remedy to save the life of a patient, if done with this object but with full knowledge that it can also be fatal, would not be an offence because the intention of the operating surgeon is to save the life of the patient.

2. Ignorance of Fact and Ignorance of Law: Another important principle of criminal law is embodied in the maxim "ignorantia fait excusat, ignorantia juris non excusat". It suggests that mistake of fact is a good defence[96] in law of crime but not the mistake of law. Thus, a man before going to Church left his gun unloaded. After he left, another man used it for a shoot and thereafter kept it loaded. On return of the first man from the Church, still thinking the gun to be unloaded as he left it, pulled the trigger with the result his wife was shot dead. The Court held that he was not liable for murder under an excuse of mistake of fact. But there are certain statutory absolute liability cases which afford no excuse to the accused for his ignorance of fact. Thus, in R. V. Prince,[97] the accused took an unmarried girl under the age of sixteen years out of the possession, and against the will of her father. The defence of the accused that he bona fide and honestly believed that the girl was older than sixteen as appeared from her physical built, was not a strict duty

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93 GirjaNath V. State, ILR (1945) 2 All 215

94 Section 304-A, IPC.

95 DeoNarain V. State of U.P., AIR 1973 SC 473.

96 Sec.76, IPC.

97 (1875) ER 2; CCR 154.

and holds the offender liable under criminal law. If a man trespasses on someone's land thinking that land to be his own, he shall nevertheless be liable.

As regards mistake of law, the criminal law affords no defence but it is a good evidence of mental condition of the offender. The reason for non-admissibility of mistake of law as a defence is that if it were so, everyone would plead it and criminal law administration would be reduced to a sheer farce.

3. Ex Post Facto Legislation: The law of crimes does not permit ex post facto legislation. That is to say, all those acts which may lead to punishment shall be duly notified and no one can be punished for an act which is not listed as crime at the time of its commission, but has become so subsequently.

4. Presumption of Innocence: Another important principle of criminal law is that everyone shall be presumed innocent unless his guilt is specifically proved within the provisions of law. This is intended to afford every possible opportunity to the accused to defend himself.

5. Group Liability: Under the criminal law an accomplice is treated at par with the principal accused and is punished equally.

6. Fair Trial: There are certain rights and protections afforded to the accused person not only during trial but also before and after trial. They and protections aim at providing a fair trial to an accused and eliminate possible abuse of judicial process resulting into miscarriage of justice. They include right to be produced before the Magistrate,[98] right to bail,[99] release on bond,[100] right to counsel and legal aid,[101] etc.

The safeguards extended to an accused in course of trial are protection against self-incrimination and double jeopardy.[102] The former suggest that no person accused of any offence shall be compelled to be a witness against himself while the latter makes it clear that no person shall be punished twice for the same offence. This is expressed in the well knownlatin maxim nemo debetbisvexarisiconstat curiae quod sit pro una et eadem causa.

Modern legislation on criminal law permits sufficient discretion to judicial authorities to meet the exigencies of time thus making the law more elastic and adaptable. Likewise, there has been a tendency to substitute indeterminate sentence for determinate one through correctional methods such as probation, parol, reformatories, open air

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98 Art. 22 of Constitution of India adnSec.76, Cr.P.C.

99 First Schedule of Cr.P.C.

100 Sec. 440(i), Cr.P.C.

101 Art. 22 (3) and Art. 39-A of Constitution of India; see also Secs. 303 &304 of Cr.P.C.

102 Art. 20 (3) of Constitution of India, see also Sec. 20 Evidence Act and Sec. 316 of the Code of Criminal Procedure, 1973.

camps, etc. Justifying this approach Prof.Vold observes: "It is not the humanity within the criminal but the criminality within the human being, that needs to be crushed, the wrongdoer must be given a chance to improve". Dr. Freud, however, suggests that law in fact is one of the agencies of social control, the efficient enforcement of which entirely rests with the institutions such as the Police, prosecutors, courts, judges, jurors, probation officers etc. It is for this reason that effectiveness of criminal law cannot be accurately assessed.

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Certificate

This is to certify that the article "Principles of Criminal Liability" published in study material on subject Law & Judicial Process by VANAMATI on page no. 72 to 77 for trainees of CPTP-IV, 2017 is authored by Dr. Sandhya Kalamdhad, Professor of Law, at Ambedkar Law College, Nagpur.

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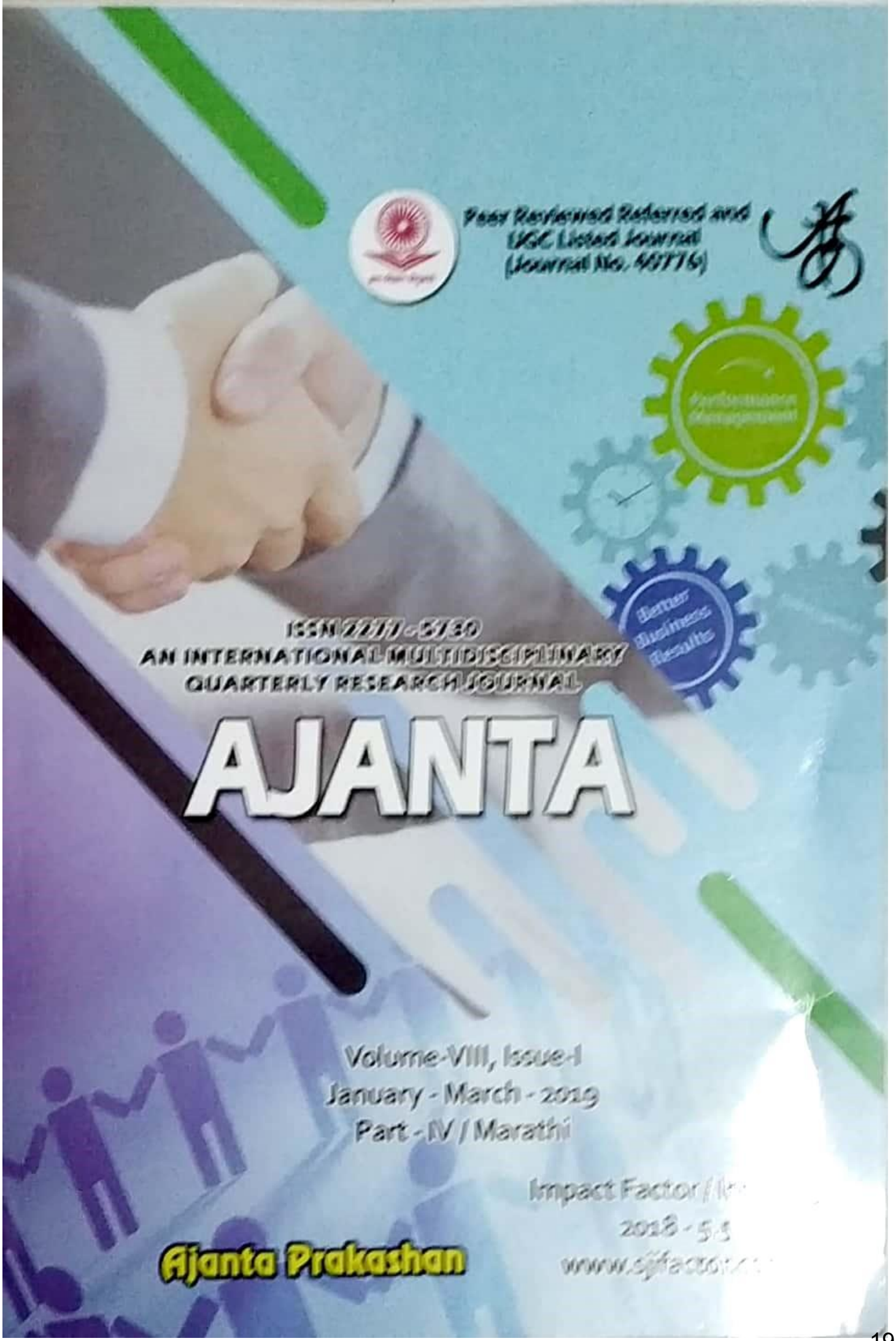

8. Impact of Artificial Reproductive Technology on Women's Health: A Study form Human Right Perspective

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Abstract

Artificial Reproductive Technology includes different techniques or procedure designed to enhance fertility. These technologies have been adopted at rapid pace all across the globe. However it has brought plethora of vexing and controversial legal, ethical and social issues including violation of human rights of women and children. Available literature on ART shows that life threatening physical and mental risks are involved into ART procedure. Undoubtedly, ART is a boon for infertile couple and law should not create any hindrances in accessing these technology by infertile couple. However this should not happen at the risk of women's health. Therefore, researcher intends to study the implications of Artificial Reproductive Technology on women's health and its impact on human rights of women. So to suggest that interest of all the parties can be protected by providing proper health care policies and legal intervention, for example by ensuring the right to receive information or right to give informed consent, which is also enshrined in International instruments. Researcher also wants to create awareness that in absence of this, there will be gross violation of women's human rights that is right to life and right to sexual and reproductive health. Though there are also concerns about the health of children born out of ART, the present study primarily intended to study the health and human rights of women.

Introduction

Women's sexual and reproductive health is related to multiple human rights, including the right to life, the right to be free from torture, the right to health, the right to privacy, the right to education and the prohibition of discrimination. The Committee on Economic, Social and Cultural Rights and the committee on the Elimination of Discrimination against Women have both clearly indicated that Women's right to health include their sexual and reproductive health.

This means that States have obligations to respect, protect and fulfil rights related to women's sexual and reproductive health.

The Convention on the Elimination of All Forms of Discrimination against Women guarantees women equal rights in deciding "freely and responsibly on the number and spacing of their children and to have access to the information, education and means to enable them to exercise these rights" (Art.16). Article 12 of Convention on Economic, Social and Cultural Rights states that, "every human being is entitled to the enjoyment of the highest attainable standards of health conductive to living a life in dignity." The Beijing Platform for action states that, "the human rights of women include their right to have control over and decide freely and responsibly on matters related to their sexuality, including sexual and reproductive health, free of coercion, discrimination and violence." This clarifies that, state is under obligation to protect women's basic human right i.e., "the right to control one's health and body including sexual and reproductive freedom."

Despite these obligations, violations of women's sexual and reproductive health rights are frequent. These take many forms, such as denying access to services that only women require, providing poor-quality services, subjecting access to third party authorization or performing procedures without the woman's consent, including forced sterilization, forced virginity examinations and forced abortions. Women's sexual and reproductive health rights are also at risk when they are subjected to forced treatment for infertility or going for any artificial reproductive technology without informed consent or without knowing the health hazards.

Any "procedure or method designed to enhance fertility or to compensate for infertility" outside the traditional means of procreation can be labeled as assisted reproductive technology. The term "Artificial Reproductive Technologies" (A.R.T.s) encompasses various procedures, ranging from the relatively simply intrauterine insemination (IUI) to variants of in-vitro fertilization and embryo transfer (IVF-ET), also referred to as IVF and more commonly known as "test tube baby technology" and cryopreservation egg and sperm donation, surrogacy and more recently cloning. Since the latter half of the 20th century, these technologies have developed at a rapid pace. They have also influenced the way in which society views pregnancy, reproduction and motherhood.

When artificial reproductive technology came into existence, it was highly argued that now it will be of great use to the infertile couple, especially it came to rescue the woman who

can't be a mother naturally. This is more so because child birth is considered as the task of women and if she fails in her task, she won't be in a position to enjoy the womanhood. And therefore child birth if naturally not possible it is enforced on women through artificial reproductive technology. Nobody wishes to think from the point of view of a woman that, whether she really want to go through this procedure or not? Is it really of more use to the woman folk or to the doctors or male partners?

Not only is this, but life threatening risk is involved in A.R.T. like multiple gestation, ectopic pregnancy and spontaneous abortion. Unhygienic and unscreened storage of sperm banks might also lead to health complications for the women resorting to A.R.T. Very often women are not told the side effects of the "treatment" and the social pressures operating upon them force repeated "trial and error". Another issue is that preliminary research has indicated that women are often poorly informed about choices regarding treatment. This is nothing less than violation of her basic human right. However, the researcher does not want to suggest to create any hurdle in enjoying ones procreative liberty that is to avail the technology to have a child by infertile couples. The researcher wishes to address this issue in harmony with the interest of all the participants in the technology. Therefore, researcher intends to study the implications of Artificial Reproductive Technology on women's health and its impact on human rights of women. So to suggest that interest of all the parties can be protected by providing proper health care policies and legal intervention, for example by ensuring the right to receive information or right to give informed consent, which is also enshrined in International instruments. Researcher also wants to create awareness that in absence of this, there will be gross violation of women's human rights that is right to life and right to sexual and reproductive health. Though there are also concerns about the health of children born out of ART, the present study primarily intended to study the health and human rights of women.

Impact of Medical Science and Technology on Women's Right

In more modern times, women in labour have been subject to a variety of interventions. Caesareans for instance are today performed quite indiscriminately. Whereas they began to be used as necessary surgical procedure for saving both the mother and the baby in difficult situations, today statistics shows that an increasing number of private nursing homes in India treat every pregnancy to surgery. Without going to the complex problems of this issue, the point

to be made here is that although technologies are often generated to solve particular problems, they do come to be used indiscriminately.

Similarly there are whole ranges of new technologies used in anti-natal care, which although very useful in some exceptional instances, are today being used routinely and unnecessarily as in the case of amniocentesis. This was a technique evolved to obtain more information about the foetus. Mainly it is used for diagnosing chromosomal abnormalities by drawing out and examining cells in the amniotic fluid. Part of this chromosomal information is also about the sex of the foetus. Today a technique so useful in some ways is being overused and misused. This ill effect is compounded by the fact that the technique itself presents hazards to the mother and to the baby.

One other factor needs to be kept in mind – that the increasing use of new and complex technologies, which often require the services of not only the gynecologists, but also of a specialist in its use, will tend to mystify medical practice and remove it from the realm of control by woman. This is to show how technologies are misused under the guise of helping out to the women. These examples are given to draw home the point that even A.R.T. which prima facie shown as a help to woman also adversely affects the health of woman.

Artificial Reproductive Techniques and its Impact on Women's health

There are different technologies in use as techniques for assisted reproductive technology. One is artificial insemination by donor. While donor insemination is performed in a medical setting, people can do it in the privacy of their home. This requires lot of patients and outer intervention which might create some anxiety in women's mind resulting into mental trauma.

The second technology, which clearly is not very technological, however it involves complicated procedure is called as Surrogate motherhood. Before the procedure, the woman who donates the egg has to undergo a host of tests. There is usually exploratory surgery to be sure the ovaries are accessible. She is routinely treated with hormones, so-called fertility drugs, to know the time at which the ovary is going to release the eggs and to stimulate it to produce more than one egg. Nowadays it is considered better to fertilize several eggs and transfer several embryos into the uterus at the same time to improve the chances that one will implant. The process of implantation is the weakest link in the in vitro sequence. Moreover, retrieving a large number of eggs requires hyper stimulating the ovaries by injecting hormonal drugs, which often entails

serious medical complications for women. The retrieval procedure is highly invasive, ... result in serious harm to the woman undergoing it.

What you have to consider, then, is a whole set of preliminary procedures that ... woman to find out whether she is even a reasonable candidate for invitro and screen for ... see if he has enough sperm. These screening are followed by exploratory surgery and ... intervention, after which comes the surgical procedure, called laparoscopy, by which the ... removed from the ovary. It has to be done under anesthesia which carries its own ...

Surrogate mothers in India are preferred due to cheap cost and easy availability ... surrogates. However, most of the surrogates are poor and illiterate, sometime forced to ... in laws or husband. They don't understand the consequences or hidden sufferings ... involved into this practice. Also, surrogate women are routinely implanted with ... embryo to improve the chances of a pregnancy. This may result into more complications ... treatment and threat to the health of mother as well foetus.

Dr. Patel, one of the doctor who is active in artificial reproductive procedures in ... India, concedes that, implanting five embryos heightens the risk for infants and mother ... she is now lowering the number to three to four. But she says downside of fewer embryos ... lower pregnancy success rate. When multiple embryos develop into viable pregnancies ... Patel's policy is to reduce them by selective abortion. Aside from possible religious ... this process could present medical risk to the surviving fetuses.

Women's Reproductive Rights Information Campaign in Britain is concerned about ... technologies such as surrogacy would affect women in the Third World countries. Poor ... in Africa, Asia and South America would be paid a pittance for the use of their womb ... Westerners, who would not consider asking other Western women to do the same. Third ... countries could become bases for manufacturing embryos. Surrogacy denies even the ... of the woman's biological contribution. For this reason, surrogacy is often called 'baby ... and surrogates 'wheres'. It is seen as a way of exploiting women for the benefit of men ... ensure that the baby has their genes. It turns a normal biological function of a woman's body ... a commercial contract. Surrogate services are advertised. Surrogates are recruited and ... agencies make large profits. The commercialism of surrogacy raises fears of black market ... selling and breeding farms, turning impoverished women into baby producers and the poor ...

of selective breeding at a price, which ultimately raises concerns about the health and human rights of the surrogate.

ICSI (intracytoplasmic sperm injection), which was "successful" in humans before it was tried in animals, is the microscopic injection of a single sperm into a single egg. It is now employed in approximately 40% of IVF cases. Recent research has shown an increased risk of birth defects in the children conceived in this manner. Mothers are burdened with the knowledge that their children may be impaired for life due to their choice to use this technology.

One major, well-documented risk associated with A.R.T. is multiple pregnancy (MP). Although there are other factors (such as increased maternal age) that contribute to this growing problem, the vast majority of higher-order multiple pregnancies (63 to 80%) are a direct result of the use of A.R.T. While A.R.T. births represent only 2% of singleton pregnancies, they constitute 35% of twin and 77% of triplet-plus pregnancies. Multiple pregnancies are almost ten times more common with IVF than with unassisted reproduction. For IVF, the incidence of twins is 18.3%, triplets 2.4%, and quadruplets 0.6%, as compared to spontaneous rates of 1.05 to 1.35% for twins and 0.01 to 0.017% for triplets. The greater likelihood of multiple pregnancies is a matter for concern because MPs are associated with a wide range of complications for both the pregnant woman and the fetus/neonate. Multiple pregnancies are known to be associated with increased incidence of preeclampsia, placenta previa, placental abruption, premature rupture of the membranes, postpartum hemorrhage, and Cesarean section, all of which increase morbidity. Moreover, particularly for older women undergoing IVF, multifetal pregnancy may produce an unbearable overload for the cardiovascular and renal functions, among other body systems. Multiple preganany is also associated with perinatal mortality. One response to the increased rates of multiple pregnancies produced by Artificial Reproductive Technologies is the highly controversial procedure of selective reduction or termination of pregnancies. Usually this entails an injection of potassium chloride into the heart of the fetus (or fetuses) to be aborted. In some cases, selective termination has been carried out in multiple pregnancies in which one of the fetuses has been diagnosed through ultrasound as abnormal. More frequently it is used in the first trimester to reduce the number of fetuses a woman is carrying in order to reduce the risk of preterm delivery to the woman and the remaining fetuses.

Concern over selective reduction takes several forms. First, the procedure carries medical risks: "This technique has both an overall fetal loss rate before 24 weeks gestation and a rate of

premature deliveries at 32 weeks or earlier of over 16%. As a result, a woman undergoing selective reduction risks losing all the fetuses being carried. Second, selective reduction obviously has a high psycho-logical price, particularly for women who have struggled for years to become pregnant and must then face risking the pregnancy.

In addition to the higher probability of multiple pregnancies with A.R.T.s, spontaneous abortion and ectopic pregnancies are also more frequent. The high incidence of abortion with IVF could be attributed to the increased age of the patients, which is associated with increased prevalence of chromosomal aberrations, or to early identification of these pregnancies and subsequent close monitoring. In addition to fetal loss during pregnancy, there is an increased incidence of first and second trimester bleeding, anemia, fetal growth retardation, and stress as well as pregnancy-induced hypertension. Cesarean section rates among IVF babies are high as reflected in New Zealand/Australian figures of 42% for singletons versus 62% for multiple pregnancies.

The fourth technology is embryo flushing and transfer, which is used much less than in vitro fertilization. Embryo flushing is being developed entirely in private hands, for profit. It is standard agricultural practice used for cattle and other farm animals. A few days after artificial insemination, the embryo is flushed out through the cervix. That embryo can be frozen and stored for later transfer, or transferred directly to the gestating cow or woman. The medical reasons for doing this with people would say, if a woman cannot produce eggs and perhaps does not have intact fallopian tubes but has an intact uterus, or she can produce eggs but cannot gestate an embryo. In either case, you can get donation of the embryo that is a transfer of the embryo from the woman who has eggs to the woman who can gestate. The point is that the gestating woman is different from the woman who provides the egg. The health risks have to do with repeated lavage or flushing of the uterus to collect the embryo, which carries with it discomfort and the risk of infection.

Diane Beeson, Professor at the Department of Sociology and Social Services at California State University and Abby Lippman, Professor at the Department of Epidemiology, Biostatistics, and Occupational Health at McGill University are concerned that the hormonal drugs used in fertility clinics to harvest eggs from women have not been adequately studied for their long-term effects on women's health. In their report, "Egg Harvesting for Stem Cell

Research: Medical Risks and Ethical Problems," they highlight research that has linked infertility treatment with ovarian and other cancers as well as a variety of other serious health problems.

A.R.T., Women and Psychological Effects

Considering the structure of Indian society, woman is complete only if she conceives and gives birth to a child. This notion of society itself causes lot of tension and stress on Indian woman, if at all due to any reason, she is unable to conceive. Non-fulfillment of the expectation of the family members and society takes her to great pain and mental trauma.

The survey conducted in Vidharbha region suggest that, most of the women do not wish to undergo assisted reproductive process but due to pressure from the family members they have to undergo this treatment which puts lot of mental pressure on her. Her study reveals that 89.66% women do not actually wish to undergo any treatment but she has to go for this due to family pressure. Her study further shows that, most of the time woman is not aware of what treatment she is going through. Husband only asks the doctor not to disclose this fact to the wife. Therefore most of the time she is unable to understand what exactly is happening with her, which causes additional trauma. Complications in the procedure like she has to take injections and need to go constant medical interventions, pressurizes her physically as well mentally. She lost enjoyment in sexual conduct and continuously under thought of conceiving, which also puts lot of mental pressure, anxiety and sometime even depression.

Much of the research into the psycho-social aspects of A.R.T. focuses on the period in which a couple is undergoing treatment. Infertility in itself is acknowledged to be highly stressful for many of those affected. Seeking treatment introduces another set of stresses. The process is long and drawn out and involves a loss of privacy, medicalization, and effects on marital and sexual relationships. Stress is also caused by the rigorous use of techniques used and by the knowledge that the chance of a successful outcome is uncertain. As the man and the woman involved are vulnerable, they may find it difficult to support each other and they may be isolated from their familial and social circle. Anxiety, depression, grief, self-blame, anger and loss of self-esteem may all occur.

A number of studies show that for those who achieve a child through A.R.T., the joy of having a child outweighs the stresses. However, even when pregnancy is successfully achieved, many women and men continue to be anxious about such things as whether the pregnancy will

go to term, whether the child will be born healthy, and they may be ambivalent about parenthood.

Thus, liability to conceive is extremely stressful for women who want to have a family. This notion is also shown by a study published in the 'Human Reproduction' journal of Patients. Juan Garcia Velasco, one of the authors of the study, who is also director of Infertility Institute of Valencia and lecturer in Obstetrics & Gynecology at the Ruy Juan Carlosde Madrid University says, "Infertility causes a series of varied emotions that have a negative impact on important aspects of woman's life," he further said, "it is linked to depression, anxiety, anger, cognitive imbalance and low self esteem." The study not only analyses the emotional impact of infertility on women but also identifies those aspects of ovary stimulation that contribute to the physical and psychological stress amongst many patients.

SAMA resource group for women and Health after their research found that the women going through the process of IVF or IUI had affected their sexual life which had become a mechanical way of procreation under the medical 'gaze'.

All these possible health risks incurred to women are a topic of much concern, to be resolved immediately. Focus of the government should be on protecting the basic human rights of poor Indian women who are providers of egg or womb in artificial reproductive process.

Legislative Initiatives on ART

Many countries across the globe has some legislation in regard to A.R.T. in one or the other form. However, India is having only National Guidelines that too made in 2005, having doubtful force of law, as most of doctors practicing A.R.T. are even not aware of the presence of it. There is no 'body' which compels the registration of these types of clinics in India. As well there is no need to maintain any record in regard to use of artificial reproductive technology. After very long time urgency was felt to have legislation in India to regulate A.R.T. clinics and practices. With the initiatives of the Indian Medical Council and Research the Bill was drafted for the first time in 2008. However there were some serious lacunas into the Bill and therefore Bill was again redrafted in 2010. Again there were certain concerns about the Bill and new Bill was drafted in 2013 and again in 2017. Thus the new Bill was introduced to provide for a national framework for the accreditation, regulation and supervision of assisted reproductive technology clinics, for prevention of misuse of artificial reproductive technology, for safe and ethical practice of artificial reproductive technology services and for matters connected therewith

and incidental thereto. Prima facie the Bill sounds good piece of legislation and answers many moral and ethical questions that surrounds A.R.T. especially, the various Consent Forms are an important step towards minimizing exploitation of people who seek these technologies. Also, the clauses regarding prohibition of advertising by Assisted Reproductive Technology (A.R.T.) clinics, making breach of surrogacy contracts punitive, prohibition of unapproved research on embryos, cloning and other such strict clauses are indicators of a good legislation. However the present Bill also suffers through certain lacunas. Further rules of Ministry of India made in February 2013 made the issue more complicated and confusing. For example, now there is lots of confusion in respect of A.R.T. practices like to whom it shall be made applicable, what are the rules in respect of surrogacy etc. However as this is not a part of the present study let's focus upon the issues of women's health.

Surprisingly, the new billstates that "A.R.T. carry small risks both to the mother and the offspring" and mentions the risks for women which include multiple gestation, ecotopic pregnancy, spontaneous abortion and Ovarian Hyper Stimulation Syndrome (OHSS). This is really apathetic that life threatening risks like multiple gestation, ecotopic pregnancy and spontaneous abortion are treated as small risks. It only reflects the extent of concern for women's well-being in a document that actually seeks to regulate these technologies and ensure their safe delivery. In fact these risks further entail serious implications, which have not been mentioned in the bill. For example, multiple gestation pregnancies can lead to toxemia, early labour, placental dysfunction, cesarean sections, increased stillbirth, and late miscarriages, low birth weight babies and prenatal mortality. The other risk include prolonged hospitalization (and cost associated with it) as premature babies are kept in intensive care. Similarly there is a morbid risk due to multiple gestations such as uterine bleeding, infection, premature labour and loss of all fetuses.

Risks associated with ecotopic pregnancy include internal bleeding, pelvic and abdominal pain, scar tissue formation leading to problems in conception in the future, risk of future ecotopic pregnancies, and even shock and death. Systematic analysis of the available medical literature reveals that many of the physical side effects of A.R.T. are direct by-products of drugs like Pergonal and Clomiphene that are used to stimulate the ovaries to produce eggs. Severe form of OHSS may lead to renal impairment, liver dysfunction, thromboembolic phenomena and shock. There are also increased risks of pregnancy loss, premature delivery, infant abnormalities, pregnancy-induced hypertension and haemorrhage. Complications may also occur during egg

harvesting procedures. The removal of eggs through an aspirating needle entails a risk of bleeding, infection and damage to the bladder, or a blood vessel and to the bowel.

Conclusion

The point is that new technologies such as these cannot be evaluated and judged for all time and for all societies. In a more egalitarian society, where all people have equal access to knowledge etc. such technologies can become boons. But in the context of societies where the economic and social disparities are tremendous, and where health care is increasingly in private hands, and where monitoring and inspection are merely notions, should there not be a more stringent attitude to them?

Various studies suggest that A.R.T. has adversely affected the health of women and children, which suggest the gross violation of basic human rights. However, except for feminist groups there is virtually no sympathy for the physical and psychological traumas to which women are subjected during ART procedure. The physical health hazards and mental trauma adversely affects the dignity of woman as a human being and therefore is a gross violation of right to live a dignified life. There is a need to understand woman in the context of new reproductive technology. To draw sound lines one needs a realistic sense of what these techniques involve, how it might help people in realizing their reproductive plans and how it might harm them, their offspring or society. But answers to these questions would be heavily influenced by more basic attitudes or normative stances that one takes towards the use of technology in reproduction.

This can probably be achieved if state ensures the safety of women by allowing her to be well informed about available options and the expected harms and benefits of these options so that competent women can decide for themselves whether they want to use ART. As well research need to be encouraged and done to ensure women's safety. There shall be public and private insurance coverage of ART. State shall provide accurate information of ART and access to comprehensive reproductive health care services.

However unfortunately the law in India has been slow in catching up the A.R.T. as a consequence of which A.R.T has today brought about plethora of vexing and controversial legal questions, especially in respect of women's human rights, which remains unanswered even after more than three decades of A.R.T.'s inception in India.

The above opinions are articulated with a great optimism that what is needed today is a coherent legal framework that is comprehensive in its scope regulating A.R.T. and sensitive to ethical, social and cultural values prevalent in Indian society in this new reproductive era. Thus the policies shall reflect social justice and human rights values and principles. So that it can protect the human rights of all the participants in ART process including women.

Law Commission of India has prepared a detailed report on, "Need for Legislation To Regulate A.R.T. Clinics As Well As Rights and Obligations of Parties To A Surrogacy", in August 2009. As well proposed Draft Assisted Reproductive Technology (Regulations) Bill and Rules-2008, 2013 & 2017, prepared by the Indian Council of Medical Research (ICMR), are [illegible] essential actions which are devoted towards regulating artificial reproductive technology and protecting the human rights of women. However, the concern is when this will see the light.

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GREEN ECONOMY: A STRATEGIC TOOL FOR SUSTAINABLE DEVELOPMENT

DR. PRATIMA LOKHANDE

INRODUCTION

Green Economy is a development strategy which harmonizes both economic development and ecological sustainability. It is a way of putting a price on the use of natural resources previously considered as free. The new concept of Green Economy is neither to replace the holistic and inclusive idea of Sustainable Development, nor can it be considered independent of that guiding principle, rather the Green Economy needs to be understood as a means to the end of achieving the goals and principles that have been set out within the concept of Sustainable Development. The Green Economy implies poverty eradication and social justice as the main purposes of an ecologically sound economic system. For an environmentally sustainable future, India needs to value its natural resources, and ecosystem services. Environmental sustainability is becoming a growing challenge. Thus, a low-emission, resource-efficient greening of the economic strategy is needed.India can make green growth a reality by putting in place strategies to reduce environmental degradation. Green economy is important to prevent future crisis. A "green economy"[2] gives the impression of an economy that is environmentally-friendly, sensitive to the need to conserve natural resources, minimize pollution and emissions that damage the environment in the production process, and produces products and services the existence and consumption of which do not harm the environment. This paper thus highlights that the concept of green economy should be seen as consistent with the broader and older concept of sustainable development. The specificities of the broader concept are its holistic character, as it encompasses the three pillars of development - economic, social and environmental - and its particular focus on inter-generational equity. This is reflected in UNEP's definition of a green economy as "one that results in improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities".

MOVING TOWARDS GREEN ECONOMY

The green economy is more than just environmental in scope; it is also about development and the economy. From a development perspective there are a number of ways in which a green economy might benefit both developed and developing countries. A green economy should not only maintain, but should enhance the value that the poor in developing countries derive from agriculture, fisheries and forest harvest - all activities that depend fundamentally on a sound environment. It should help reduce energy poverty through the provision of low-cost distributed renewable energy systems. And if successful it should help reduce the vulnerability of the poor to the impacts of unchecked climate change, desertification ocean degradation and loss of biodiversity, as well as the impacts of local air, soil and water pollution. A shift to a green economy will also generate economic. One obvious potential advantage to a green economy is the opening up of new export markets. Well-known examples include significant new markets for biofuels, and for renewable energy technologies such as solar panels and wind turbines. Opportunities in these markets may be driven by demand in export markets alone, or by a combination of foreign demand and domestic capacity development in response to stringent domestic environmental standards.

Green economy values and invests in natural capital. Ecosystem services are better conserved, leading to improved safety nets and household incomes for poor rural communities. Ecologically friendly farming methods improve yields significantly for subsistence farmers. And improvements in freshwater access and sanita-

...and innovations for non-grid energy (solar electricity, biomass stoves, etc) add to the suite of green economy ...gies, which can help alleviate poverty. A green economy substitutes clean energy and low carbon technolo... ...for fossil fuels, addressing climate change but also creating decent jobs and reducing import dependencies. ...technologies promoting energy and resource efficiency provide growth opportunity in new directions. ...ource efficiency becomes a driving proposition - both energy and materials use - be it in better waste man... ...ment, more public transportation, green buildings or less waste along the food chain. Regulations, standards ...targets are important to provide direction. However, developing countries must be allowed to move at their ...speed, respecting their development objectives, circumstances and Constraints. Developed nations have a ...role to play in building skills and capacity in developing countries and in creating international market and ...infrastructure for a green economy. Enabling conditions have to be managed and adequate finance pro... ...for successful transitioning to a green economy, but both are eminently achievable. Environmentally and ...harmful subsidies are a deterrent, and they should be phased out. In select circumstances and over ...periods however, rational use of subsidies can facilitate the transition to a green economy. Taxes and ...market-based instruments can be used to stimulate the necessary investment and innovation for funding ...transition. A green economy can generate as much growth and employment and yield significantly more ...environmental and social benefits. Of course, there are many risks and challenges along the way. Moving to... ...ds a green economy will require world leaders, civil society and leading businesses to engage in this transi... ...collaboratively. It will require a sustained effort on the part of policy makers and their constituents to ...think and redefine traditional measures of wealth, prosperity and well-being.

...THWAY TO SUSTAINABLE DEVELOPMENT:

A strategic policy agenda that integrates greening of a range of key economic sectors takes advantage of ...ergies and promotes long-term growth by mitigating scarcities. Policies that focus only on individual sectors ...will not benefit from linkages between them. Energy and GHG emissions reduction is a strong example where ...creasing the use of renewable energy on the supply side is reinforced by energy efficiency measures in key ...ctors, such as buildings, transport and manufacturing. Additional forestland can positively affect agriculture ...production and rural livelihoods by improving soil quality and increasing water retention. Integrating recycling ...and remanufacturing operations can reduce the need for expanding waste management, allowing investments ...in that sector to concentrate on areas such as waste to energy. Water demand is highly linked to energy use, and ...the reverse is also true. With the Rio+20 Earth Summit merely a few weeks away Green economy and inclusive ...growth - the core agenda of the summit - is fast becoming a buzzword in India. At a glance, India has a great ...profile for building a low-carbon, green economy. In 2012 it is rated by Ernst and Young[3] that India is the fourth ...most attractive country for renewable energy investment. The country also has the world's second largest pool ...of scientists and engineers which has instilled confidence in the global investors looking for safe investment ...destinations. Also, India's achievements in information technology, professional services and communications ...in the past decade all added to its profile. The traditional form of economy has so far helped India perform well ...in the economic sector and amass wealth, but failed to bridge the gap between the rich and the poor. In fact, ...increasing industrialization has led to an increasing number of conflicts of different types. The most alarming of ...them is the conflict between farmers/forest dwellers and industrialists, especially the miners. This conflict has ...strengthened violent rebellions like the Maoist uprising which is now officially the biggest threat to India's ...internal security. Obviously, this is not the desired future path for an emerging economic power. A path leading ...to sustainable development, therefore, is the urgent need of the hour for India. The level of environmental ...awareness will be raised, thus leading to the drafting of new legislations to support the environment. For ex... ...ample, India has just drafted two new legislations on mining (The Mines and Minerals Development and Regu... ...lation Act 2013) and land acquisition for industrial development (The Land Acquisition, Rehabilitation and ...Resettlement Act 2013) which are results of this increased environmental awareness. However, despite these ...high expectations, it would be naïve to think that an enthusiastic participation in the Rio+20 conference or active ...engagement of its agenda alone will propel India into the league of developed nations. For India, where more

than 300 million people live below the poverty line and where over 50 percent of the population does not have access to safe drinking water, medical care and basic amenities , the main challenge is not the development of a concept, but rather its systematic implementation at the ground level. One example of this is India's solid waste management (SWM) sector. According to the Government of India, urban India produces over 115,000 mega tons of solid waste each day. Currently there is a nationwide effort to better manage this waste and the government has roped in several private sector companies who have an impressive pool of SWM experts. On the national level, the whole effort is focused on keeping the country clean and green, while generating jobs. Yet, at ground level this has threatened the livelihood of at least 15 million poor people who make a living by recycling the waste, but are not recognized for their skills. This is a case where the concept of green economy and inclusive growth is failing to tackle poverty or unemployment because there is no holistic approach to its implementation. Sustainable development is about integration among the three pillars: social, economic and environmental and ensuring their consistency. But in practice, this is not easy because our problems and challenges do not specialize. At a press meet in New Delhi, Indian Minister for Environment and Forests, Jayanthi Natarajan,[4] stated that while India was highly interested in the issue of green economy and inclusive growth, three factors would be crucial for the agenda to work well on ground. Firstly , reaffirming the Rio Principles, secondly striking a balance between the three pillars of sustainable development by building institutional capacities at all levels - global, regional and local and, thirdly prioritize programs for the inclusion and betterment of socio-economically weaker sections of the society. Also, according to the minister, if Rio+20 is to work, nations must work together. The minister's statement sums it up well for India; the country has a high level of interest and a need for a green economy. Green economy, at this point, is the most sensible way forward for India. Regarding the environment (and many other things), all of the technology and knowhow in the world is useless without strong implementation of policies. In many ways, India should be poised for an effective environmental governance program. According to the World Bank ,[5] "India has strong environment policy and legislative framework and well-established institutions at the national and State level". Furthermore, democratic countries with strong public participation are often considered best at identifying and reacting to environmental problems. India lacks other widespread mechanisms for public participation. Poverty is one encumbrance to having a large, vocal public effectively able to make its needs known; combined with this is a lack of technological infrastructure. Moreover, barriers of distance, language, literacy, and connectivity - all the factors of particular relevance to India due to the remoteness of many habitations, multiple languages, and significant illiterate population - can also prevent full participation. In addition, corruption (often in the form of kickbacks to government officials) is seen as strongly hindering the implementation of environmental policies and laws in this democracy are violated, or manipulated, perhaps as often as they are obeyed. Much of the problem is credited to weak implementation of laws and regulations. One crucial instrument of environmental policy is Environmental Impact Assessment (EIA)[6] which analyzes the likely impact of various actions on the environment. EIAs originated in the United States in 1969 and have become one of the most successful legal mechanisms for protecting the environment globally. At the heart of EIA is public participation, the belief that local people know best their own needs and understand the impact of environmental degradation upon their lives.

International collaboration

Beyond support to developing countries in meeting the challenges of a green economy, there are ways in which international cooperation or agreement is needed to allow the global community to move toward green economic growth :[7]

- Agreement at the WTO on reduction or elimination of tariffs and non-tariff barriers to trade in environmental goods and services. There should be some constrained flexibility for developing countries intent on fostering national champions in particular sectors, but the concerns over liberalizing dual-use goods should take a back seat to the urgency of need for new technologies.
- Agreement on a concerted effort to "oil the innovation chain" - to get new technologies more quickly to

...et. This might include global demonstration programs; support for open innovation programs and na... commitments to make public research common intellectual property; international R&D cooperation; ...ly backed patent pools; support for financing, etc.

... Agreement that IPR regimes, including TRIPS, should be sensitive to the country's level of development, ...ecting the reality that strong national-level innovative capacity is in the global interest.

... Agreement, based on economic evidence, that some specific forms of performance requirements are accept... practice (particularly in developing countries) since they can be (have been) effectively used to foster glo... competitive firms that can positively contribute to a green economy.

... Agreement on what should be acceptable (and/or best) practice in the pursuit of the green economy with ...ect to PPM-based measures such as BCA and carbon footprint labelling, and with respect to subsidies de... to foster national champions. At the end of the day in some cases this might simply re-affirm the current ...O rules, but widespread "stretching" of those rules suggests the need for a dedicated dialogue. In the case of ...idies, for example, we might think about the careful revival of non-actionable subsidies as a category in the ...O SCM Agreement.

...NCLUSION:

...Green economy is a dynamic concept that will require the involvement of certain agents of change, i.e., the ...rnment, private sector players, and the civil society. The role played by each of these drivers influences the ...ies targeted towards achieving a green economy. Movement towards a green economy has the potential of ...ieving sustainable development. Developed countries should remove trade barriers and provide training ...capacity building to facilitate the access to, and diffusion of clean energy technologies in developing coun... A differentiated time path of setting up of environmental standards is needed for the developing countries, ...India to avoid or reduce any negative environmental, social, and economic impacts. Public policy interven... like regulatory and pricing policies, taxes and subsidies to limit pollution and over-exploitation of natural ...urces are required for improvement of income distribution, as the market forces left alone would continue ...oduce according to the existing demand pattern which in turn is shaped by the existing income distribution ...unsustainable consequences. Large-scale investments in skill development and capacity building are needed ...ieve a wide adoption of these technologies and materials in new construction and renovation. The govern... should adopt important roles in making prices better reflect environmental values, focusing on all the ...s towards a sustainable development pathway, whilst protecting the access of the poor to essential goods ...services to promote a green and more inclusive economy. Since inclusive economic growth is an imperative ...India, it will require a high level international investment, support and solidarity to boost finance, technol... and institutional capacity for lowering the carbon content of economic activity and build resilience to un...dable climate changes.

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LIBRARIES AND COPY RIGHT LAW IN INDIA: A PERSPECTIVE

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ABSTRACT

With the advent of the information and technology in every field, the copy right laws consider as one of the most dynamic and fast growing area of law in India.In the present scenario, IPR awareness is the key to technological innovations. The need for creating awareness among the creators of information and knowledge about IPR has become imperative because in the digital environment it becomes difficult to prove its violation.When we study the law on copyright, we couldfind that libraries and copyright protections both are having hand in hand with each other. And it is the copyright law which provides reconciliation among both by providing the provisions of preventing the unfair use and unlawful gain from another's literature, while libraries aim at distributing knowledge from this literature and other creative works. Libraries in their own way, help in preserving this literature and make it freely accessible for bonafide and genuine purposes like simply reading or research. In this paper the researcher aims to study the interrelation between libraries and copyright protection under the copyright legislation in India and discussed few issues of copyright in digital/ electronic era.

INTRODUCTION

Copyright is related with a creative artistic or literary expression. The copyrighted material can be a book, a picture, a sculpture, a painting, jewellery designs, a motion picture, music, or anything that is the result of a person's intellect that take a concrete shape and has no function other than the beauty and creativity of the thing itself. Copyright is protection on the expression of an artistic idea that is "Fixed in any tangible medium of expression". However, copyright only protects the expressive elements of a broad range of works– including books, graphical works, dramatic works, choreography, musical compositions, sound recordings, films, sculpture, architectural works, and computer programmes. It does not extend to facts, ideas, or utilitarian aspects of such works in the form of an article, paper or a book, not the idea as such.

Copy right law: In Indian scenario

The Indian Copyright Act, 1957 enumerates certain activities which are 'exclusive' rights for the authors of the works who can do or otherwise someone to do all or a part of those activities. These, when done by unauthorised persons or without the explicit permission of the copyright holders, amounts to a breach or infringement of copyright. These include:

1. To produce the work in any material form including the storing of it in any medium by electronic means;

2. To perform the work in or communicate to public;
3. To issue the copies of (publish) the work to public not being in circulation.
4. To produce and publish any translation of the work;
5. To make any translation or adaptation of the work;
6. To make any cinematography film, or a sound recording; and
7. To do in relation to a translation or adaptation of the work any of the above specified acts.
8. In case of a computer programme, in addition to the above mentioned provisions, the Act also means to do or authorise.
9. To sell or give on hire, or offer for sale or hire any copy of the computer programme, regardless of whether such copy has been sold or given on hire on earlier occasions.

Exceptions to Copyright infringement

Section 52 of the Indian Copyright Act enumerates five categories of acts which when performed do not fall under the infringement of the copyright.

They are:

1. Reproduction in the course of fair dealing (i.e. private use, research, criticism, review, reporting, broadcast, etc.);
2. Reproduction for educational purposes;
3. Reproduction for official (judicial, legislative, etc.) purpose
4. Reproduction where there is remote relation to the original which does not cause any loss to the copyright holder; and
5. Reproduction for private entertainment.

The technological developments taking place the world over pose a constant challenge to the copyright protection- To check the piracy of the literary or artistic works, necessary provisions have been made treating piracy of books, computer software etc. a non-bailable offense. Incase of infringement, the publishers or authors (or both) have to file a suit in a court of law against the infringer of copyright who can be an individual, a company or an institution.

Fair Dealing

Many people mistakenly refer the multiple copies taken in libraries as "fair dealing". "Fair dealing" is a defence against a copyright infringement action. We use the term "fair dealing" that any copying activity that is permitted under the terms of the Act not to require permission from or to pay fees to the copyright owner, irrespective of which Clause of the Act specifically applies. An individual can claim this defence so long as the copying was "fair" - in other words does not damage the legitimate commercial interests of the copyright owner, and so long as it was for one of several purposes, such as for research or private study.

Limitations to Fair dealing:

One can use any copyright materials without the permission of the copyright holder for the following reason

1. Single copy for private, personal or non-commercial use – research and study.
2. Teaching
3. Quotations
4. Criticism or review
5. Judicial proceedings

In other instances, the limitation takes the form of a "compulsory license" under which certain limited uses of copyrighted works are permitted upon payment of specified royalties and compliance with statutory conditions.

University Libraries and Electronic Libraries:

Since the beginning the author by his intellect creates the work which by the way of publication by authorised publisher makes the copies and make it available to the market by the way of distribution and selling of the work. On the other hand the libraries select, collect, preserve, organize and disseminate the works of intellectual and artistic content in order to facilitate their use. Now a day due to the global competition, with ever increase in new computing and communications technologies the libraries are facing the major shifts. This includes the transition of paper work into electronic means which is now considered as an effective, efficient and handy.

Also, due to the reason of information explosion, hike in the cost of publications, devaluation of rupees on account of increase in the conversion rates of foreign currency, shrinking of library budgets due to the financial cuts on the allocation of funds especially to the higher education institutions, etc.

Copyright Issues In Digital Libraries

In recent time the information is increasingly captured, processed and produced in digital form. Digital information can be copied at almost zero cost–at lightning speed, and without any loss of quality–making information available in digital form can be unattractive both for authors and distributors. However, electronic (digital) information has certain characteristics which are easy for copyright infringement:

1. **Non permanence:** It is easily amenable to revise, modify, re-revise, re-modify without leaving any resemblance to the original work of the respective author.

2. **Issue of ownership:** In the electronic (digital) information the ownership is non-ascertainable and sometimes questionable. Participants in computer conferencing, sharing ideas with strangers risk having their own ideas taken and used. Computer conferencing is largely based on trust and electronic messages are implicitly copyrighted in the name of the person who inputs them, but there is no way of knowing their copying and reuse.

3. **Piracy issue:** In the electronic (digital) information the large volumes of data can be copied and stored in different media without difficulty. The high-use of internet

resources has also resulted in an increased number of violations of rights, and data and network security problems. Since internet facilitates easy mass distribution of digital (electronic) material, it is difficult to control them and bring them under the copyright protection.

In some cases, strict application of law in its current form can even result in severe restrictions that eliminate advantages brought by technology. A key problem in electronic publishing is that current legislation does not deal with the intricacies of computer-based networked systems, resulting in many gray areas.

Of course, it is possible to reinterpret existing law in its application to intellectual works in a digital networked environment. Organizations often lack the intellectual property rights and permissions to the materials they hold. Permission seeking for selected materials begins immediately after selection. One of the serious problems in creating digital libraries is to acquire copyright permissions.

Conclusion

We can now well say that it is the copyright law where we could find that libraries and copyright law both are having hand in hand with each other. And it is the copyright law which provides reconciliation among both by providing the provisions of preventing the unfair use and unlawful gain from another's literature, while libraries aim at distributing knowledge from this literature and other creative works. Libraries in their own way, help in preserving this literature and make it freely accessible for bonafide and genuine purposes like simply reading or research. In the face of technological developments, the present copyright laws will not be able to prevent piracy or infringement of rights. So it is now worth to suggest that the digital environment is to be tightened to assure the creators, prevent piracy and plagiarism, and encourage use. Also, the current notions about copyright will have to be heavily modified to suit to the electronic environment. The IPR and the copyright laws should help in enhancing and not preventing the access and usage of electronic information. The library and information science professionals should have the same kind of fair dealing arrangement as in the case of printed books. They should be able to read or browse electronic information without having to pay for it; preserve in digital format copyright material held in their collections; and fulfil inter-library document requests electronically.

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Fractional Heat Conduction in a Thin Circular Plate With Constant Temperature Distribution and Associated Thermal Stresses

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In this work, a fractional-order theory of thermoelasticity by quasi-static approach is applied to the two-dimensional problem of a thin circular plate whose lower surface is maintained at zero temperature, whereas the upper surface is insulated and subjected to a constant temperature distribution. Integral transform technique is used to derive the solution in the physical domain. The corresponding thermal stresses are found using the displacement potential function. [DOI: 10.1115/1.4035442]

Keywords: quasi-static, thermoelasticity, fractional, integral transform, thermal stresses

Introduction

Recent advances in fractional calculus are dominated by modern examples of applications in differential and integral equations, physics, signal processing, fluid mechanics, viscoelasticity, mathematical biology, and electrochemistry. It is generally known that integer-order derivatives and integrals have clear physical and geometric interpretations. However, in the case of fractional-order integration and differentiation, it is not so. Since the appearance of the idea of differentiation and integration of arbitrary (not necessary integer) order, there was not any acceptable geometric and physical interpretation of these operations for more than 300 yr. In Ref. [1], it is shown that geometric interpretation of fractional integration is "'Shadows on the walls' and its Physical interpretation is 'Shadows of the past.'"

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The classical theory of thermoelasticity has aroused much interest in recent times. The heat conduction of classical coupled theory of thermoelasticity is parabolic in nature and hence predicts infinite speed of propagation of heat waves. Clearly, this contradicts the physical observations. Hence, several nonclassical theories, such as Lord–Shulman theory [2] and Green Lindsay theory [3], have been proposed, in which the Fourier law and the parabolic heat conduction equation are replaced by more complicated equations, which are hyperbolic in nature predicting finite wave propagation. Green and Naghdi [4] developed the theory of thermoelasticity without energy dissipation. Chandrasekharaiah [5] gave review of thermoelasticity with second sound. Tripathi et al. [6–8] studied problems in generalized thermoelastic theories. Recently, Tripathi et al. [9] studied a dynamic problem in fractional-order thermoelasticity with finite wave speeds. In the last decade, study on quasi-static thermoelasticity incorporating the time fractional derivative has gained momentum. The work on quasi-static fractional-order thermoelasticity can be found in the literature [10–15]. Raslan [16] studied the application of fractional-order theory of thermoelasticity in a thick plate under axisymmetric temperature distribution. The fractional-order theory of thermoelasticity was developed by Sherief et al. [17]. Raslan [18] solved a problem for cylindrical cavity. Aouadi [19] studied a generalized thermoelastic problem for coupled theory of thermoelasticity in context with Lord–Shulman with mass diffusion, while Povstenko [20] studied fractional heat conduction in space with a source varying harmonically in time and associated thermal stresses without numerical illustration. Kulkarni et al. [21] discussed a quasi-static uncoupled thermoelastic problem in a thin hollow circular disk and discussed thermal stresses due to heat generation. Deshmukh et al. [22] studied a quasi-static thermal deflection problem of a thin-clamped circular plate due to heat generation. A brief note on heat flow with arbitrary heating rates in a hollow cylinder was studied by Deshmukh et al. [23].

In this study, a mathematical model of a fractional-order thermoelastic problem for a finite thin circular plate under constant temperature distribution is developed. Copper material is chosen for numerical purposes, and the results for temperature, stresses, and displacement are discussed and illustrated graphically for weak, moderate, and strong conductivity for a copper material.

Formulation of the Problem

Consider a thin circular plate of thickness h occupying space D defined by $0 \le r \le b$ and $0 \le z \le h$, whose lower surface is maintained at zero temperature, whereas the upper surface is insulated. The constant heat flux Q_0 is applied on the fixed circular boundary $(r = b)$, and a mathematical model is prepared considering nonlocal Caputo type time fractional heat conduction equation of order α for a thin circular plate.

The definition of Caputo type fractional derivative is given by [10]

$$\frac{\partial^\alpha f(t)}{\partial t^\alpha} = \frac{1}{\Gamma(n-\alpha)} \int_0^t (t-\tau)^{n-\alpha-1} \frac{d^n f(\tau)}{d\tau^n} \, d\tau \,, \quad n-1 < \alpha < n \tag{1}$$

For finding the Laplace transform, the Caputo derivative requires knowledge of the initial values of the function $f(t)$ and its integer derivatives of the order $k = 1, 2, ..., n-1$

$$L\left\{\frac{\partial^\alpha f(t)}{\partial t^\alpha}\right\} = s^\alpha f^*(s) - \sum_{k=0}^{n-1} f^{(k)}(0^+) s^{\alpha-1-k} \,, \quad n-1 < \alpha < n \tag{2}$$

where the asterisk denotes the Laplace transform with respect to time, and s is the Laplace transform parameter.

The temperature of the plate $T(r,z,t)$ satisfies time fractional-order differential equation

$$a\left(\frac{\partial^2 T}{\partial r^2}+\frac{1}{r}\frac{\partial T}{\partial r}+\frac{\partial^2 T}{\partial z^2}\right)=\frac{\partial^\alpha T}{\partial t^\alpha},\quad 0\le r\le b, 0\le z\le h \tag{3}$$

with boundary conditions

$$k\frac{\partial T}{\partial r}=Q_0\quad \text{at}\quad r=b \tag{4}$$

$$T=0\quad \text{at}\quad z=0,\quad t>0 \tag{5}$$

$$k\frac{\partial T}{\partial z}=0\quad \text{at}\quad z=h,\quad t>0 \tag{6}$$

and under zero initial condition

$$T=0\quad \text{at}\quad t=0,\quad 0<\alpha<2 \tag{7}$$

$$\frac{\partial T}{\partial t}=0\quad \text{at}\quad t=0,\quad 1<\alpha<2 \tag{8}$$

Following Kulkarni et al. [21], we assume that a circular plate of small thickness h is in a plane state of stress. In fact, "the smaller the thickness of the circular plate compared to its diameter, the nearer to a plane state of stress is the actual state." The displacement equations of thermoelasticity have the form

$$U_{i,kk}+\left(\frac{1+\nu}{1-\nu}\right)e_{,i}=2\left(\frac{1+\nu}{1-\nu}\right)\cdot a_t\cdot T_{,i}\qquad e=U_{k,k};\quad k,i=1,2 \tag{9}$$

where U_i is the displacement component, e is the dilatation, T is the temperature, and ν and a_t are, respectively, the Poisson's ratio and the linear coefficient of thermal expansion of the circular plate material.

Introducing $U_i=\psi_{,i}$, $i=1,2$, we have

$$\nabla_1^2\psi=(1+\nu)a_tT,\quad \text{where}\quad \nabla_1^2=\partial^2/\partial {x_1}^2+\partial^2/\partial {x_2}^2$$
$$\sigma_{ij}=2\mu(\psi_{,ij}-\delta_{ij}\psi_{,kk}),\quad i,j,k=1,2 \tag{10}$$

where μ is the Lamé constant, and δ_{ij} is the Kronecker symbol.

In the axially symmetric case, $\psi=\psi(r,t)$, $T=T(r,t)$, and the differential equation governing the displacement potential function $\psi(r,z,t)$ is as follows:

$$\frac{\partial^2\psi}{\partial r^2}+\frac{1}{r}\frac{\partial\psi}{\partial r}=(1+\nu)a_tT \tag{11}$$

with $\partial\psi/\partial r=0$ at $r=b$, for all time t.

The stress functions σ_{rr} and $\sigma_{\theta\theta}$ are given by

$$\sigma_{rr}=\frac{-2\mu}{r}\frac{\partial\psi}{\partial r} \tag{12}$$

$$\sigma_{\theta\theta}=-2\mu\frac{\partial^2\psi}{\partial r^2} \tag{13}$$

In the plane state of stress within the circular plate

$$\sigma_{rz}=\sigma_{zz}=\sigma_{\theta z}=0$$

Equations (3)–(13) constitute the mathematical formulation of the problem.

Solution

To obtain the expression for temperature function $T(r,z,t)$, we first define the finite Fourier transform and its inverse transform over the variable z in the range $0\le z\le h$ defined in Ref. [21] as

$$\overline{T}(r,\eta_p,t)=\int_{z'=0}^{h}K(\eta_p,z')\cdot T(r,z',t)\,dz' \tag{14}$$

$$T(r,z,t)=\sum_{p=1}^{\infty}K(\eta_p,z)\cdot\overline{T}(r,\eta_p,t) \tag{15}$$

where

$$K(\eta_p,z)=\sqrt{\frac{2}{h}}\sin(\eta_pz)$$

and $\eta_1,\eta_2,\ldots..$ are the positive roots of the transcendental equation $\cos(\eta_ph)=0$, $p=1,2,\ldots.$

Second, we define the finite Hankel transform and its inverse transform over the variable r in the range $0\le r\le b$ as

$$\overline{\overline{T}}(\beta_m,\eta_p,t)=\int_0^b r'\cdot K_0(\beta_m,r')\cdot\overline{T}(r',\eta_p,t)\,dr' \tag{16}$$

$$\overline{T}(r,\eta_p,t)=\sum_{m=1}^{\infty}K_0(\beta_m,r)\,\overline{\overline{T}}(\beta_m,\eta_p,t) \tag{17}$$

where $K_0(\beta_m,r)=(\sqrt{2}/b)J_0(\beta_mr)/J_0(\beta_mb)$ and $\beta_1,\beta_2,\ldots..$ are the positive roots of the transcendental equation $J_1(\beta_mb)=0$.

Applying Fourier, Hankel, and Laplace transform and their inversions to Eq. (3) and making use of the transformed boundary and initial conditions (4)–(8), one obtains the temperature distribution function expressed as follows:

$$T(r,z,t)=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)\,K_0(\beta_m,r)\,abK_0(\beta_m,b)\times Q_0\frac{\sqrt{2}}{\eta_ph}\left[1-\cos\eta_ph\right]\left[1-E_\alpha\left(-a\left(\beta_m^2+\eta_p^2\right)t^\alpha\right)\right] \tag{18}$$

Here, $E_\alpha(.)$ represents the Mittag–Leffler function.

Displacement Potential and Thermal Stresses

Using Eqs. (11) and (18), we get the displacement potential function as follows:

$$\frac{\psi(r,z,t)}{X}=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)\,K_0(\beta_m,r)\frac{1}{\beta_m^2}\,abK_0(\beta_m,b)\times Q_0\frac{\sqrt{2}}{\eta_ph}\left[1-\cos\eta_ph\right]\left[1-E_\alpha\left(-a\left(\beta_m^2+\eta_p^2\right)t^\alpha\right)\right] \tag{19}$$

Using Eqs. (12), (13), and (19), we obtain the radial and angular stresses as follows:

$$\frac{\sigma_{rr}}{Y}=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)\,K_1(\beta_m,r)\frac{1}{r\beta_m^2}\,abK_0(\beta_m,b)\times Q_0\frac{\sqrt{2}}{\eta_ph}\left[1-\cos\eta_ph\right]\left[1-E_\alpha\left(-a\left(\beta_m^2+\eta_p^2\right)t^\alpha\right)\right] \tag{20}$$

$$\frac{\sigma_{\theta\theta}}{Y}=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)\,K_2(\beta_m,r)\frac{1}{\beta_m^2}\,a\,b\,K_0(\beta_m,b)\times Q_0\frac{\sqrt{2}}{\eta_ph}\left[1-\cos\eta_ph\right]\left[1-E_\alpha\left(-a\left(\beta_m^2+\eta_p^2\right)t^\alpha\right)\right] \tag{21}$$

where

$$K_1(\beta_m,r)=-\frac{\sqrt{2}\,\beta_m}{b}\frac{J_1(\beta_mr)}{J_0(\beta_mb)}$$

$$K_2(\beta_m, r) = -\frac{\sqrt{2}\,\beta_m^2}{b}\frac{1}{J_0(\beta_m b)}\left[J_0(\beta_m r) - \frac{J_1(\beta_m r)}{\beta_m r}\right]$$

Results and Discussion

Dimensions. For the sake of convenience, we choose the radius of a thin circular plate to be $b = 1$ m, the thickness of a thin circular plate is $h = 0.1$ m, and the central circular paths of the circular plate in the radial and axial directions are $r_1 = 0.5$ m and $z_1 = 0.05$ m.

Material Properties. The numerical calculation has been carried out for a copper (pure) thin circular plate with the material properties as thermal diffusivity $\alpha = 112.34 \times 10^{-6}(\mathrm{m^2 s^{-1}})$, thermal conductivity $k = 386\,(\mathrm{W/m\,K})$, density $\rho = 8954\,\mathrm{kg/m^3}$, specific heat $c_p = 383\,\mathrm{J/kg\,K}$, Poisson ratio $\nu = 0.35$, coefficient of linear thermal expansion $a_t = 16.5 \times 10^{-6}\,1/\mathrm{K}$, and Lamé constant $\mu = 26.67$. We set for convenience, $X = (1+\nu)a_t$ and $Y = 2(1+\nu)a_t\mu$.

The graphs are plotted for fractional-order parameter $\alpha = 0.5$, 1, and 1.5 depicting weak, normal, and strong conductivity and fixed time $t = 0.5$. Figures 1–3 depict the distributions of temperature, radial stress, and angular stress along the radial direction for various values of fractional-order parameter α. The numerical calculation has been carried out in MATLAB 2013 a programing environment. The Mittag–Leffler functions used in this paper were evaluated following Podlubny [24].

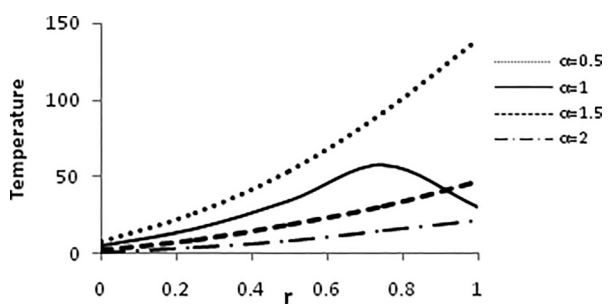

Fig. 1 Temperature distribution function

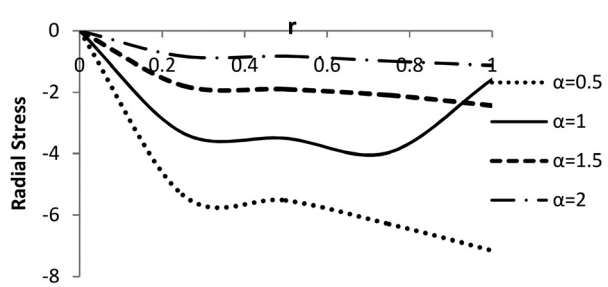

Fig. 2 Radial stress function σ_{rr}/Y

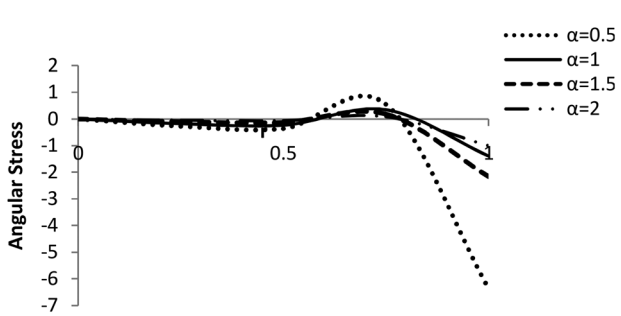

Fig. 3 Angular stress function $\sigma_{\theta\theta}/Y$

Figure 1 represents the temperature distributions along the radial direction. For the cases $\alpha = 0.5$, 1.5, and 2, the values of the temperature show an increase with respect to radius. Whereas for the case $\alpha = 1$, the values of the temperature initially increase up to $r = 0.72$ and then decrease between $0.72 \le r \le 1$.

Figure 2 represents the radial stress distributions along the radial direction. It is observed that the radial stresses are compressive in nature. For the cases $\alpha = 0.5$, 1.5, and 2, the values of the radial stress initially decrease in the ranges $0 \le r \le 0.25$ and $0.25 \le r \le 0.45$, whereas it shows a gradual increase in the range $0.25 \le r \le 0.45$. For the case $\alpha = 1$, the values of the temperature show an decreasing pattern in the ranges $0 \le r \le 0.25$ and $0.45 \le r \le 0.7$, whereas temperature increases in the ranges $0.25 \le r \le 0.45$ and $0.7 \le r \le 1$.

Figure 3 represents the angular stress distributions along the radial direction. For the cases $\alpha = 0.5$, 1.5, and 2, angular stresses are compressive in the ranges $0 \le r \le 0.55$ and $0.8 \le r \le 1$ and tensile in the range $0.55 \le r \le 0.8$. For the case $\alpha = 1$, angular stresses are compressive in the ranges $0 \le r \le 0.6$ and $0.85 \le r \le 1$ and tensile in the range $0.6 \le r \le 0.85$.

For the case $\alpha = 1$, depicting classical thermoelasticity, the pattern of graphs is completely different as compared to fractional thermoelasticity $\alpha = 0.5$, 1.5, and 2. It should be noted that for the range $0 < \alpha < 1$, the graphs show weak conductivity; for $\alpha = 1$, the graphs describe normal conductivity; and for $1 < \alpha < 2$, the graphs depict strong conductivity. The case $\alpha = 2$ coincides with Green and Naghdi theory. It is noted from the graphs that changing values of fractional-order parameter α, the speed of wave propagation is affected. Hence, it can be an important factor for designing new materials applicable to real-life situations.

Conclusions

This work is based on time fractional-order heat conduction equation. We will restrict ourselves to the quasi-static uncoupled theory neglecting the inertia term in the equation of motion. Neglecting the mechanical term implies that no account has been taken of mechanical oscillations. The quasi-static statement of a thermoelastic problem is possible if the relaxation time of mechanical oscillations is considerably less than the relaxation time of the heat conduction process. Time fractional differential operator describes memory effects, and space fractional differential operator deals with the long-range interactions. The heat conduction equation considered here is parabolic in nature which predicts infinite wave propagation in terms of heat energy. The motivation behind the consideration of the fractional theory is that it predicts retarded response to physical stimuli, as seen in nature, as opposed to the instantaneous response predicted by the generalized theory of thermoelasticity. Hence, we have discussed in this paper the effect of fractional heat conduction with their thermoelasticity by quasi-static approach.

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Fractional Order Generalized Thermoelastic Problem in a Thick Circular Plate with Periodically Varying Heat Source

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Abstract

This paper is concerned with fractional order thermoelastic response due to a heat source whose magnitude varies periodically with time within the context of generalized thermoelasticity with one relaxation time. Traction free boundary conditions are considered and the thick circular plate is subjected to a given axisymmetric temperature distribution. Integral transform technique is used to derive the solution in the transformed domain. Laplace transforms are inverted using a numerical scheme. Mathematical model is prepared for Copper material and results for temperature, displacement and stress distributions are computed and represented graphically.

Keywords: *Fractional order; thermoelastic; thick plate; relaxation time; heat source.*

1. Introduction

In 1967, Lord and Shulman [1] were the first to generalize Biot's theory of coupled thermoelasticity. This theory ensures finite speed of propagation for waves. Due to the experimental validation available in favor of the finite speed of propagation of heat waves, generalized thermoelasticity theory is receiving serious attention.

Mallik and Kanoria [2] studied the two dimensional problem in generalized thermoelasticity for a transversely isotropic thick plate having heat source. A two dimensional problem for a half space and thick circular plate with heat sources have been solved by El-Maghraby [3]. Tripathi et al. [4] discussed the temperature distribution and thermal stresses in a semi-infinite cylinder whose upper and lower surfaces are traction free and subjected to a given axisymmetric temperature distribution within the context of Lord-Shulman theory. Recently, Tripathi et al. [5, 6] studied problems for a thick circular plate and a half space within the context of generalized thermoelastic diffusion with one relaxation time.

During recent years, several interesting models have been developed by using fractional calculus to study the physical processes particularly in the area of heat conduction, diffusion, mechanics of solids, electricity, etc. Various types of definition and approaches of fractional order derivatives have become the main aim of many researchers. The reason behind introduction of the fractional theory is that it predicts retarded response to physical stimuli, as is found in nature, as opposed to instantaneous response predicted by the generalized theory of thermoelasticity. Povstenko [7-10] studied various applications of theory of the fractional order thermoelasticity. Youssef [11] established the fractional order generalized thermoelasticiy in the context of thermoelasticity with one relaxation time. Ezzat and Karamany [12, 13] established a new model of fractional heat conduction equation based on Taylor's series expansion of time fractional order. Sherief et al. [14] also established a new model by using the Lord-Shulman model of generalized thermoelasticity. Bachher [15] discussed the deformation due to periodically varying heat sources in a reference temperature dependent thermoelastic porous materials with a time fractional heat conduction law. Islam and Kanoria [16] dealt with the problem of magneto-thermoelastic interaction in a perfectly conducting elastic medium where the boundary is stress free and subjected to a thermal loading in the context of fractional order two temperature generalized thermoelasticity. Raslan [17] studied the fractional order theory of thermoelasticity to the two dimensional problem of thick plate whose lower and upper surfaces are traction free and subjected to a given axisymmetric temperature distribution in the context of Lord-Shulman theory. Tripathi et al. [18], dealt with a generalized thermoelasticproblem of mass diffusion in a thick circular plate under the effect of a heat source. Sarkar [19], studied the wave propagation in an initially stressed elasticsolid half-space under time-fractional order two-temperature magneto-thermoelasticity. Tripathi et al. [20] discussed a dynamic problem of fractional order thermoelasticity for a thick circular plate with finite wave speeds. Warbhe et al. [21], studied fractional order heat conduction and its associated thermal stresses in a thin circular plate with constant temperature distribution. Recently, Xiong, and Yanbo [22] established a fractional-order generalized themoelastic diffusion theory for anisotropic and linearly thermoelastic diffusive media.

In this paper, we have modified the work of Tripathi et al. [4] and Raslan [17] and studied time fractional generalized thermoelastic problem in a thick circular plate under axisymmetric temperature distribution with periodically varying heat source in the context of Lord-Shulman theory.

*Corresponding Author

Mathematical model is prepared for Copper material and the numerical inversion of Laplace transform is performed using Gaver-Stehfast algorithm [18-20]. All the integrals involved in the problem are evaluated using Romberg integration technique [21] with variable step size. Numerical results are computed and represented graphically for temperature, displacement and stress distribution due to a periodically varying heat source using codes developed in Matlab programming environment.

2. Formulation of the Problem

We take the axis of symmetry as the z axis and the origin of the system of co-ordinates is at the middle plane between the upper and lower faces of the plate. The problem is studied using the cylindrical polar co-ordinates (r,φ,z). Due to the rotational symmetry about the z axis, all quantities are independent of the co-ordinate φ.

Consider a thick circular plate of thickness $2b$ occupying the space D defined by

$$D=\{(r,\phi,z):\ 0\le r\le\infty,\ -b\le z\le b\}$$

The problem is thus two-dimensional with all functions considered depending on the spatial variables r and z as well as on the time variable t.

The displacement vector, thus, has the form $\vec{u}=(u,0,w)$. The equations of motion can be written as

$$\mu\nabla^2u-\frac{\mu}{r^2}u+(\lambda+\mu)\frac{\partial e}{\partial r}-\gamma\frac{\partial T}{\partial r}=\rho\frac{\partial^2u}{\partial t^2} \tag{1}$$

$$\mu\nabla^2w+(\lambda+\mu)\frac{\partial e}{\partial z}-\gamma\frac{\partial T}{\partial z}=\rho\frac{\partial^2w}{\partial t^2} \tag{2}$$

The generalized equation of heat conduction has the form [4, 11]

$$k\nabla^2T=\left(\frac{\partial}{\partial t}+\tau_0\frac{\partial^{\alpha+1}}{\partial t^{\alpha+1}}\right)(\rho c_ET+\gamma T_0e)-\rho\left(1+\tau_0\frac{\partial^{\alpha}}{\partial t^{\alpha}}\right)Q \tag{3}$$

where T is the absolute temperature and e is the cubical dilatation given by the relation [4]

$$e=\frac{u}{r}+\frac{\partial u}{\partial r}+\frac{\partial w}{\partial z}=\frac{1}{r}\frac{\partial}{\partial r}(ru)+\frac{\partial w}{\partial z} \tag{4}$$

$$\nabla^2=\frac{\partial^2}{\partial r^2}+\frac{1}{r}\frac{\partial}{\partial r}+\frac{\partial^2}{\partial z^2} \tag{5}$$

The following constitutive relations supplement the above equations

$$\sigma_{rr}=2\mu\frac{\partial u}{\partial r}+\lambda e-\gamma(T-T_0) \tag{6}$$

$$\sigma_{zz}=2\mu\frac{\partial w}{\partial z}+\lambda e-\gamma(T-T_0) \tag{7}$$

$$\sigma_{rz}=\mu\left(\frac{\partial u}{\partial z}+\frac{\partial w}{\partial r}\right) \tag{8}$$

We shall use the following non-dimensional variables

$$r'=c_1\eta r,\ z'=c_1\eta z,\ u'=c_1\eta u,\ w'=c_1\eta w,\ t'=c_1^{\,2}\eta t$$

$$\tau'_0=c_1^{\,2\alpha}\eta^{\alpha}\tau_0,\ \sigma'_{ij}=\frac{\sigma_{ij}}{\mu},\ \theta=\frac{\gamma(T-T_0)}{(\lambda+2\mu)},\ Q'=\frac{\rho\gamma Q}{kc_1^{\,2}\eta^2(\lambda+2\mu)}$$

where $\eta=\dfrac{\rho c_E}{k}$ $c_1=\sqrt{\dfrac{\lambda+2\mu}{\rho}}$ is the speed of propagation of isothermal elastic wave.

Using the above non-dimensional variables, the governing equations take the form (dropping the primes for convenience)

$$\nabla^2u-\frac{u}{r^2}+(\beta^2-1)e-\beta^2\frac{\partial\theta}{\partial r}=\beta^2\frac{\partial^2u}{\partial t^2} \tag{9}$$

$$\nabla^2w+(\beta^2-1)\frac{\partial e}{\partial z}-\beta^2\frac{\partial\theta}{\partial z}=\beta^2\frac{\partial^2w}{\partial t^2} \tag{10}$$

$$\nabla^2\theta=\left(\frac{\partial}{\partial t}+\tau_0\frac{\partial^{\alpha+1}}{\partial t^{\alpha+1}}\right)(\theta+\varepsilon e)-\left(1+\tau_0\frac{\partial^{\alpha}}{\partial t^{\alpha}}\right)Q \tag{11}$$

where $\dot{o}=\dfrac{T_0\gamma^2}{(\lambda+2\mu)\eta k}$

The constitutive relations (6)-(8), become

$$\sigma_{rr}=2e_{rr}+(\beta^2-2)e-\beta^2\theta \tag{12}$$

$$\sigma_{zz}=2e_{zz}+(\beta^2-2)e-\beta^2\theta \tag{13}$$

$$\sigma_{rz}=2e_{rz} \tag{14}$$

$$\sigma_{r\varphi}=\sigma_{\varphi r}=0 \tag{15}$$

Here $\beta^2=\dfrac{(\lambda+2\mu)}{\mu}$

Combining Eqs. (9) and (11), we obtain upon using Eq. (4),

$$\nabla^2e-\nabla^2\theta=\frac{\partial^2e}{\partial t^2} \tag{16}$$

We assume that the initial state is quiescent. The thermal and mechanical boundary conditions of the problem at $z=\pm h$ are taken as

$$\sigma_{zz}(r,\pm h,t)=0 \tag{17}$$

$$\sigma_{rz}(r,\pm h,t)=0 \tag{18}$$

$$\theta(r,\pm h,t)=f(r,t) \tag{19}$$

where $f(r,t)$ are known function of r and t. Eqs. (1)-(19) constitute the generalized thermoelastic formulation of the problem on a thick circular plate of infinite extent and finite thickness.

2. Solution of the Problem

Applying the Laplace transform defined by the relation,

$$\overline{f}(r,z,s)=L[f(r,z,t)]=\int_0^{\infty}e^{-st}f(r,z,t)\,dt \tag{20}$$

to all the non-dimensional Eqs. (9)-(19), we get,

$$\nabla^2\bar{u}-\frac{\bar{u}}{r^2}+\left(\beta^2-1\right)\bar{e}-\beta^2\frac{\partial\bar{\theta}}{\partial r}=\beta^2 s^2\bar{u} \tag{21}$$

$$\nabla^2\bar{w}+\left(\beta^2-1\right)\frac{\partial\bar{e}}{\partial z}-\beta^2\frac{\partial\bar{\theta}}{\partial z}=\beta^2 s^2\bar{w} \tag{22}$$

$$\nabla^2\bar{\theta}=\left(\mathrm{s}+\tau_0 s^{\alpha+1}\right)(\theta+\varepsilon\bar{e})-\left(1+\tau_0 \mathrm{s}^{\alpha}\right)\bar{Q} \tag{23}$$

$$\left(\nabla^2-s^2\right)\bar{e}=\nabla^2\bar{\theta} \tag{24}$$

$$\bar{\sigma}_{rr}=2\frac{\partial\bar{u}}{\partial r}+\left(\beta^2-2\right)\bar{e}-\beta^2\bar{\theta} \tag{25}$$

$$\bar{\sigma}_{zz}=2\frac{\partial\bar{w}}{\partial z}+\left(\beta^2-2\right)\bar{e}-\beta^2\bar{\theta} \tag{26}$$

$$\bar{\sigma}_{rz}=\left(\frac{\partial\bar{u}}{\partial z}+\frac{\partial\bar{w}}{\partial r}\right) \tag{27}$$

$$\bar{\theta}=\bar{f}\left(r,s\right) \tag{28}$$

$$\bar{\sigma}_{zz}=\bar{\sigma}_{rz}=0 \tag{29}$$

Eliminating $\bar{e}$ between the Eqs. (23) and (24), we get,

$$\begin{aligned}&\{\nabla^2-(s^2+s\left(1+\tau_0 s^{\alpha}\right)(1+\varepsilon))\nabla^2+s^3\left(1+\tau_0 s^{\alpha}\right)\}\bar{\theta}\\&=-\left(1+\tau_0 s^{\alpha}\right)\left(\nabla^2-s^2\right)\bar{Q}\end{aligned} \tag{30}$$

After factorization the above equation can be written as,

$$\left(\nabla^2-k_1^{\,2}\right)\left(\nabla^2-k_2^{\,2}\right)\bar{\theta}=-\left(1+\tau_0 s^{\alpha}\right)\left(\nabla^2-s^2\right)\bar{Q} \tag{31}$$

where $k_1^{\,2}$and $k_2^{\,2}$are the roots with positive real parts of the characteristic equation

$$k^4-\left(s^2+s\left(1+\tau_0 s^{\alpha}\right)(1+\varepsilon)\right)k^2+s^3\left(1+\tau_0 s^{\alpha}\right)=0 \tag{32}$$

The solution of Eq. (31) is written in the form,

$$\bar{\theta}=\bar{\theta}_1+\bar{\theta}_2+\bar{\theta}_p \tag{33}$$

where $\bar{\theta}_i$ is a solution of the homogenous equation,

$$\left\{D^2-\left(k_{\mathrm{i}}^{\,2}+\mathrm{q}^2\right)\right\}\bar{\theta}_i^{\,*}=0, i=1,2 \tag{34}$$

and $\bar{\theta}_p$ is a particular integral of Eq. (31).

In order to solve the problem, the Hankel transform of order zero with respect to r is used. The Hankel transform of a function $\bar{f}\left(r,z,s\right)$ is defined by the relation,

$$\bar{f}^{\,*}\left(\mathrm{q},z,s\right)=H\left[\bar{f}\left(r,z,s\right)\right]=\int_0^{\infty}\bar{f}\left(r,z,s\right)rJ_0(\mathrm{qr})dr \tag{35}$$

where J_0 is the Bessel function of the first kind of order zero and q is the Hankel transform parameter.

The inversion of Hankel transform is given by

$$\begin{aligned}&\bar{f}\left(r,z,s\right)=H^{-1}\left[\bar{f}^{\,*}\left(q,z,s\right)\right]\\&=\int_0^{\infty}\bar{f}^{\,*}\left(q,z,s\right)qJ_0\left(q\,r\right)dq\end{aligned} \tag{36}$$

Applying the Hankel transform to Eq. (34), we get,

$$\left\{D^2-\left(k_{\mathrm{i}}^{\,2}+\mathrm{q}^2\right)\right\}\bar{\theta}_i^{\,*}=0, i=1,2 \tag{37}$$

where $D=\partial/\partial\mathrm{z}$. The solution of Eq. (37) can be expressed as,

$$\bar{\theta}_i^{\,*}=A_i\left(\mathrm{q},s\right)\left(k_i^{\,2}-s^2\right)e^{-\mu_i z} \tag{38}$$

where $\mu_i=\sqrt{\mathrm{q}^2+k_i^{\,2}}$

Applying Hankel transform to the Eq. (31), we get,

$$\left(D^2-\mu_1^{\,2}\right)\left(D^2-\mu_2^{\,2}\right)\bar{\theta}_p^{\,*}=-\left(1+\tau_0 \mathrm{s}^{\alpha}\right)\left(\mathrm{D}^2-\mu^2\right)\bar{Q}^{*} \tag{39}$$

where $\mu=\sqrt{\mathrm{q}^2+s^2}$

The periodically varying heat source $Q\left(r,z,t\right)$ in cylindrical co-ordinates is taken in the following form

$$\begin{aligned}Q\left(r,z,t\right)&=Q_0\frac{\delta\left(r\right)}{2\pi r}\frac{\sin\pi t}{\tau},\ 0\le t\le\tau\\&=0\qquad\qquad,\ t>\tau\end{aligned} \tag{40}$$

where Q_0 is the strength of the heat source and $\delta\left(r\right)$ is the well known Dirac's delta function.

On applying Laplace transform and Hankel transforms to Eq. (40), we get,

$$\bar{Q}^{*}=\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{\left(s^2\tau^2+\pi^2\right)} \tag{41}$$

Using Eq. (41), we arrive at the particular integral of equation (39) as follows,

$$\bar{\theta}_p^{\,*}=\frac{\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{\left(s^2\tau^2+\pi^2\right)} \tag{42}$$

Using Eq. (33), we obtain the complete solution for dimensionless temperature in the transformed domain as follows,

$$\begin{aligned}\bar{\theta}^{*}\left(\mathrm{q},z,s\right)&=A_i\left(\mathrm{q},s\right)\left(k_i^{\,2}-s^2\right)\cosh\mu_{\mathrm{i}}z\\&+\frac{\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{\left(s^2\tau^2+\pi^2\right)}\end{aligned} \tag{43}$$

On applying the inverse Hankel transform to Eq. (43), we get,

$$\bar{\theta}\left(r,z,s\right)=\int_0^{\infty}\left\{\begin{aligned}&\sum_{i=1}^{n}A_{\,i}\left(q\ ,s\right)\left(k_i^{\,2}-s^2\right)\cosh\mu_i z\\&+\frac{(1+\tau_0 s^{\alpha})\mu^2}{\mu_1^2\mu_2^2}\frac{Q_0\pi\tau(1+e^{-s\tau})}{(s^2\tau^2+\pi^2)}\end{aligned}\right\}qJ_0\left(qr\right)dq \tag{44}$$

Similarly, eliminating θ between Eqs. (23) and (24), we get,

$$\left(\nabla^2-k_1^{\,2}\right)\left(\nabla^2-k_2^{\,2}\right)\bar{e}=-\left(1+\tau_0 s^{\alpha}\right)\nabla^2\bar{Q} \tag{45}$$

On applying Hankel transform to Eq. (45), we get,

$$\left(D^2-\mu_1^{\,2}\right)\left(D^2-\mu_2^{\,2}\right)\bar{e}^{*} = -\left(1+\tau_0 s^{\alpha}\right)\left(D^2-\mu^2\right)\bar{Q}^{*} \tag{46}$$

Complete solution of Eq. (46) can be expressed as,

$$\bar{e}^{*}\left(\mathrm{q},z,s\right) = \sum_{i=1}^{2} A_i\left(\mathrm{q},s\right) k_i^{\,2}\cosh\mu_i z + \frac{\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{\left(s^2\tau^2+\pi^2\right)} \tag{47}$$

Taking the inverse Hankel Transform of Eq. (47), we get,

$$\bar{e}\left(r,z,s\right) = \int_0^{\infty}\left\{\sum_{i=1}^{2} A_i\left(q,s\right)k_i^{\,2}\cosh\mu_i z + \frac{\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{\left(s^2\tau^2+\pi^2\right)}\right\} qJ_0\left(qr\right)dq \tag{48}$$

On applying Hankel transform to Eq. (22) and then using Eqs. (43) and (47), the axial displacement component is expressed as,

$$\bar{w}^{*}\left(\mathrm{q},z,s\right) = Csinhmz + \sum_{i=1}^{2} A_i\left(\mathrm{q},s\right)\mu_i\sinh\mu_i z \tag{49}$$

where $m=\sqrt{q^2+\beta^2 s^2}$

On applying the inverse Hankel transform to Eq. (49), we get,

$$\bar{w}\left(r,z,s\right) = \int_0^{\infty}\left[C\sinh mz - \sum_{i=1}^{2} A_i\mu_i\sinh\mu_i z\right] qJ_0\left(qr\right)dq \tag{50}$$

Let, $\bar{u}=\dfrac{\partial\bar{\phi}}{\partial r},\bar{\phi}$ (51)

Taking the Laplace Transform of Eq. (4) and making use of Eq. (51), we get,

$$\bar{e} = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial\bar{\phi}}{\partial r}\right)+\frac{\partial\bar{w}}{\partial z} \tag{52}$$

On applying the Hankel transform to Eq. (52), we get,

$$\bar{\phi}^{*} = \frac{1}{q^2}\left(\frac{\partial\bar{w}^{*}}{\partial z}-\bar{e}^{*}\right) \tag{53}$$

On applying the inverse Hankel transform to Eq. (53), we get,

$$\bar{\phi}^{*} = \int_0^{\infty}\frac{1}{q}\left(\frac{\partial\bar{w}^{*}}{\partial z}-\bar{e}^{*}\right)J_0(qr)dq \tag{54}$$

Substituting Eq. (54) in Eq. (51) and making use of Eqs. (48) and (49), we get,

$$\bar{u} = -\int_0^{\infty}[C_m coshmz + \sum A_i q^2\cosh\mu_i z - \frac{\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{s^2\tau^2+\pi^2}]J_1\left(qr\right)dq \tag{55}$$

Substituting from Eqs. (44), (48), (49) and (54) into (26) and (27), we get,

$$\sigma_{zz} = \int_0^{\infty}[2C_m coshmz + \sum A_i\left(q^2+m^2\right)\cosh\mu_i z - 2\frac{\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{s^2\tau^2+\pi^2}]qJ_0\left(qr\right)dq \tag{56}$$

and

$$\sigma_{rz} = -\int_0^{\infty}[2\sum A_i q^2\mu_i\sinh\mu_i z + C\left(m^2+q^2\right)Sinhmz]J_1\left(qr\right)dq \tag{57}$$

Also, we take,

$$\bar{\theta}\left(r,\pm h,s\right) = \frac{1}{s}\theta_0\left(r\right) \tag{58}$$

where, $\theta_0\left(r\right)=\begin{cases} c_0 & 0<r<a \\ 0 & otherwise \end{cases}$

It implies that both the upper and lower surfaces of the thick circular plate are suddenly heated on a circle surrounding the z-axis while the rest of the surfaces were kept at the reference temperature $\theta=0$ i.e. $T=T_0$.

On applying Hankel transform to equation (58), we get,

$$\bar{\theta}^{*} = \frac{c_0 aJ_1\left(aq\right)}{sq} \tag{59}$$

Using transformed boundary conditions given by equations (28)-(29) and making use of Eqs. (44), (56), (57) and (59), we get,

$$\sum A_i\left(q^2+m^2\right)\cosh\mu_i h + 2CmCosh\left(mh\right) - \frac{2\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{s^2\tau^2+\pi^2}=0 \tag{60}$$

$$2\sum A_i q^2\mu_i\sinh\mu_i h + C\left(m^2+q^2\right)\sinh\left(mh\right)=0 \tag{61}$$

$$\sum_{i=1}^{2} A_i\left(q,s\right)\left(k_i^{\,2}-s^2\right)\cosh\mu_i z + \frac{\left(1+\tau_0 s^{\alpha}\right)\mu^2}{\mu_1^{\,2}\mu_2^{\,2}}\frac{Q_0\pi\tau\left(1+e^{-s\tau}\right)}{\left(s^2\tau^2+\pi^2\right)} = \frac{c_0 aJ_1\left(aq\right)}{sq} \tag{62}$$

Eqs. (60)-(62) is a system of linear equations with $A_1(\eta,s)$, $A_2(\eta,s)$ and $B(\eta,s)$ as unknown parameters. On solving these equations, we get the complete solution of the problem in the transformed domain.

3. Inversion of Double Transforms

The Laplace transform of a continuous function $f(t)$ is given by

$$\bar{f}(s)=\int_0^{\infty} e^{-st} f(t)dt \tag{63}$$

for $t>0$ and $s=x+iy$. If the solution is given in the Laplace domain, the inversion integral is used to find the original function $f(t)$

$$f(t)=\int_{\gamma-i\infty}^{\gamma+i\infty} e^{-st}\bar{f}(s)dt \tag{64}$$

where the contour must be taken to the right of any singularities of $\bar{f}(s)$. The direct integration of Eq. (64) is normally difficult and in many cases analytically not possible. By this method the inverse $f(t)$ of the Laplace transform $\bar{f}(s)$ is approximated by,

$$f(t)=\frac{\ln 2}{t}\sum_{j=1}^{K} D(j,K)\,F\left(j\frac{\ln 2}{t}\right) \tag{65}$$

with

$$D(j,K)=(-1)^{j+M}\sum_{n=m}^{\min(j,M)}\frac{n^M(2n)!}{(M-n)!n!(n-1)!(j-n)!(2n-j)!} \tag{66}$$

where K is an even integer, whose value depends on the word length of the computer used. $M=K/2$ and m is the integer part of the $(j+1)/2$. The optimal value of K was chosen as described in Gaver-Stehfast algorithm [23-25], for the fast convergence of results with the desired accuracy. This method is easy to implement and very accurate for functions of the type $e^{-\alpha t}$. The Romberg numerical integration technique [26] with variable step size was used to evaluate the integrals involved. All the programs were made in mathematical software Matlab.

4. Numerical Results and Discussion

For numerical calculations, we take

$$f(r,t)=\theta_0 H(a-r)H(t)$$

where θ_0 is a constant. On taking Hankel and Laplace transform of the above function, we get,

$$\bar{f}^{*}(\alpha,s)=\frac{a\theta_0 J_1(\eta a)}{\eta s}$$

Copper material was chosen for purposes of numerical computations, with the physical data given as [20]

$\rho=8954\ kg.m^{-3}$, $\eta=8886.73\,s.m^{-2}$,

$k=386J.K^{-1}.m^{-1}.s^{-1}$, $\tau_0=0.025$, $T_0=293\ K$,

$\lambda=7.76\times10^{10}\ N.m^{-2}$, $\alpha_t=1.78\times10^{-5}K^{-1}$,

$c_E=383.1J.\mathrm{k}\,g^{-1}.K^{-1}$, $\mu=3.86\times10^{10}N.m^{-2}$,

$c_1=4.158\times10^{3}m.s^{-1}$, $\varepsilon=0.0168\,N.m.J^{-1}$,

$\beta^2=4,\ a=7,\ b=1$

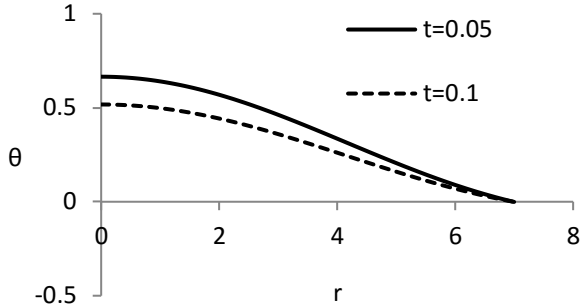

Figure 1. Temperature distribution θ in the middle plane for $\alpha=0.98$.

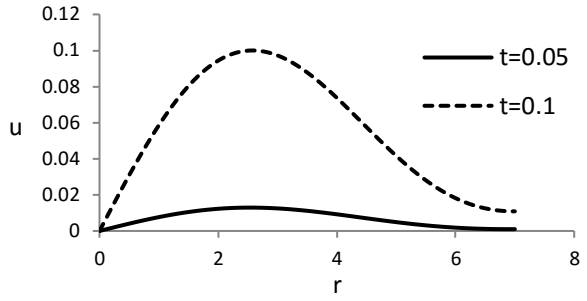

Figure 2. Radial displacement u distribution in the middle plane for $\alpha=0.98$.

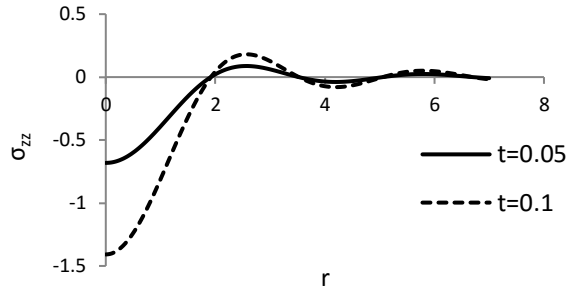

Figure 3. Axial stress component σ_{zz} in the middle plane for $\alpha=0.98$.

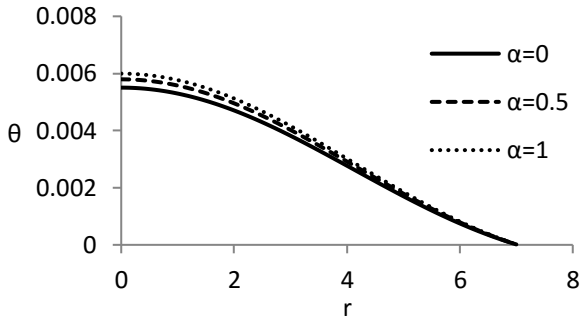

Figure 4. Temperature distribution θ in the middle plane for $t=0.05$.

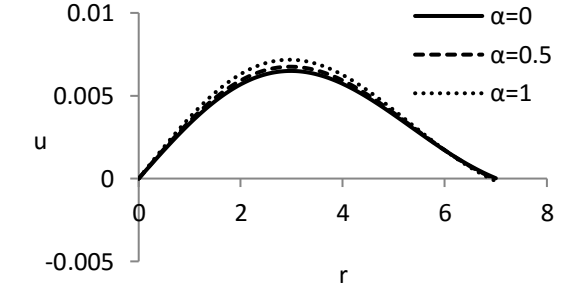

Figure 5. Radial Displacement u in the middle plane for $t=0.05$

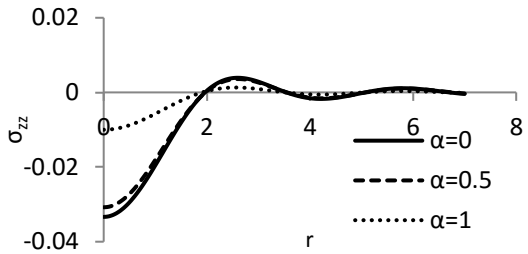

Figure 6. Axial stress component σ_{zz} in the middle plane for $t = 0.05$

Figures 1-3 exhibit the variations of θ, the radial displacement component *u* and the axial stress component σ_{zz} considered as functions of radial distance r at the middle of the plane ($z = 0$) for different time instants $t = 0.05, 0.1$. Since the displacement function *w* is an odd function of z , its value on the middle plane is always zero and it is not represented graphically here. The value of α in these figures was taken equal to 0.98. In these figures, solid line represents the solutions for $t = 0.05$ and dashed line represents the solutions for $t = 0.1$.

Figures 4-6 depict the behavior of θ, *u* and σ_{zz} along the radial direction for the different values of fractional order parameter α and hence shows the variations between the generalized and fractional order thermoelasticity theories. In all these figures the solid line represents the solutions for $\alpha = 0$ and dashed lines represent the solutions for $\alpha = 0.5 \text{ and } 0.1$ respectively.

Figure 1 shows the variation of temperature with radial distance. It is observed that the temperature decreases with radial distance and finally becomes identically zero at $r = 7$. It is also observed that the values of temperature at $t = 0.05$ are more as compared to its values at $t = 0.1$.

Figure 2 depicts the variation of u with the radial distance. It is observed that, u increases with the radial distance up to $r = 2.5$ and then gradually decreases till $r = 7$. In the complete region, the values of u for $t = 0.1$ are less than its values at $t = 0.05$. It is also observed that the radial displacement component u becomes identically zero for $t = 0.05$ at $r = 7$.

Figure 3 shows the variation of axial stress σ_{zz} with radial distance. It is observed that the axial stresses are compressive in the region $0 \le r \le 1.8$ and $3.6 \le r \le 5$. The axial stress component values are tensile in the region $1.8 \le r \le 3.6$ and $5 \le r \le 7$.

Figures 4-6 shows the variations of θ, u and σ_{zz} along the radial direction for different values of the fractional order parameter α . We can clearly observe the effect of different values of α on the velocity of the waves and an inference can be drawn that the speed of waves is directly proportional to the values of fractional order parameter α . Hence, an increase in the conductivity of energy in the material is directly related with the fractional order parameter. For $\alpha \cong 1$, the solutions behave like the generalized theory of thermoelasticity.

5. Conclusion

In this problem, we have used the time fractional order theory of thermoelasticity to solve the problem for a thick circular plate with a periodically varying heat source. A direct approach is used to solve the problem without the use of customary potential functions which helps in eliminating the well-known problems associated with the solutions using potential functions. Due to the presence of one relaxation time in the field equations the heat wave assumes finite speed of propagation. It is concluded that for different values of the fractional order parameter α , the velocity of the wave changes. When $\alpha \cong 1$, the solutions behave like generalized thermoelasticity. The fractional order parameter seems to be directly proportional to the conductivity of the material. The system of equations in this paper may prove to be useful in studying the thermal characteristics of various bodies in real life engineering problems by considering the time fractional derivative in the field equations.

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Fractional Order Theory of Thermal Stresses to A 2 D Problem for a Thin Hollow Circular Disk

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Abstract

A quasi static uncoupled theory of thermoelasticity based on the heat conduction equation with the time fractional derivative of order alpha subjected to a time dependent heat flux at the outer boundary whereas the inner circular boundary is insulated in a 2 D problem of a thin hollow circular disk. The integral transform technique is used to find the temperature distribution in a physical domain with the help of Caputo type fractional derivative. The corresponding stresses are determined by using the displacement function. A mathematical model is constructed for a copper material. The thermoelastic stresses, temperature distribution and the displacement due to a time dependent heat flux is shown graphically and the effect of the fractional order parameter are discussed for the different values of alpha.

Keywords: Quasi-static, thermoelasticity, fractional order, Integral transform, Mittag-Leffler function.

INTRODUCTION

During the second half of the twentieth century, considerable amount of research in fractional calculus was published in engineering literature. Indeed, recent advances of fractional calculus are dominated by modern examples of applications in differential and integral equations, physics, signal processing, fluid mechanics, viscoelasticity, mathematical biology, and electrochemistry. There is no doubt that fractional calculus has become an exciting new mathematical method of solution of diverse problems in mathematics, science, and engineering. It is generally known that integer-order derivatives and integrals have clear physical and geometric interpretations. However, in case of fractional-order integration and differentiation, it is not so. Since the appearance of the idea of differentiation and integration of arbitrary (not necessary integer) order there was not any acceptable geometric and physical interpretation of these operations for more than 300 year. In [1], it is shown that geometric interpretation of fractional integration is "'Shadows on the walls' and its Physical interpretation is 'Shadows of the past' ".

The classical theory of thermoelasticity has aroused much interest in recent times due to its numerous applications in engineering discipline such as nuclear reactor design, high energy particle accelerators, geothermal engineering, advanced aircraft structure design, etc. The heat conduction of classical coupled theory of thermoelasticity is parabolic in nature and hence predicts infinite speed of propagation of heat waves. Clearly, this contradicts the physical observations. Hence, several non-classical theories such as, Lord-Shulman theory [2], Green Lindsay theory [3] have been proposed, in which the Fourier law and the parabolic heat conduction equation are replaced by more complicated equations, which are hyperbolic in nature predicting finite wave propagation. Green and Naghdi [4] developed the theory of thermoelasticity without energy dissipation. Chandrasekaraiah [5] gave review of thermoelasticity with second sound. Tripathi et al. [6-8] studied problems in generalized thermoelastic theories. Povstenko [9-14] studied problems of quasi static fractional thermoelasticity based on time fractional heat conduction equation in cylindrical coordinate for a long cylinder, an infinite solid with a long cylindrical cavity and a half space under various prescribed boundary conditions. The solutions are obtained employing integral transform technique. Recently, Tripathi et al. [15] studied a dynamic problem in fractional order thermoelasticity with finite wave speeds. In the last decade, study on Quasi-static thermoelasticity incorporating the time fractional derivative has gained momentum. Kulkarni et al. [16] discussed a quasi-static uncoupled thermoelastic problem in a thin hollow circular disk and discussed thermal stresses due to heat generation. Deshmukh et al. [17] studied quasi-static thermal deflection of a thin clamped hollow circular disk due to heat generation. A brief note on

heat flow with arbitrary heating rates in a hollow cylinder was studied by Deshmukh et al. [18]. Raslan [19] studied the application of fractional order theory of thermoelasticity in a thick plate under axisymmetric temperature distribution. The fractional order theory of thermoelasticity was developed by Sherief et al. [20].Youssef and Abbas [21] solved a one dimensional problem of a elastic half space in context of fractional order generalized thermoelasticity. Chunbao Xiong and Ying Guo [22], studied effect of variable properties and moving heat source on magneto thermoelastic problem under fractional order thermoelasticity. Recently, Warbhe et al. [23] solved a fractional heat conduction problem in a thin circular plate with constant temperature distribution and associated thermal stresses within the context of quasi-static theory.

In this paper the work of Warbhe et.al.[23] is modified and prepare the mathematical model of fractional order thermoelastic problem for a finite thin hollow circular disk under the time dependent heat flux at the outer boundary by quasi-static approach . No one has discussed the fractional order thermoelasticity in a thin hollow circular disk in a finite domain by quasi-static approach so far. Hence, this is the new and novel contribution in this field. Copper material is chosen for numerical purposes and the results for temperature, displacement and stresses are discussed and illustrated graphically for different values of alpha i.e. for weak, normal and strong conductivity.

FORMULATION OF THE PROBLEM

Consider a thin hollow disk of thickness h occupying space D defined by $b_1 \le r \le b_2$, $0 \le z \le h$.. The inner circular boundary $(r = b_1)$ is at zero heat flux whereas the heat flux $Q(z)\,\delta(t)$ is applied on the outer circular boundary $(r = b_2)$. Also the upper surface $(z = h)$ and the lower surface $(z = 0)$ of the thin hollow disk are at zero temperature. A mathematical model is prepared considering non-local Caputo type time fractional heat conduction equation of order α for a thin hollow disk.

The definition of Caputo type fractional derivative is given by [10]

$$\frac{\partial^{\alpha} f(t)}{\partial t^{\alpha}} = \frac{1}{\Gamma(n-\alpha)} \int_0^t (t-\tau)^{n-\alpha-1} \frac{d^n f(\tau)}{d\tau^n} d\tau, \quad n-1 < \alpha < n \tag{1}$$

For finding the Laplace transform, the Caputo derivative requires knowledge of the initial values of the function $f(t)$ and its integer derivatives of the order

$k = 1,2,....,n-1$

$$L\left\{\frac{\partial^{\alpha} f(t)}{\partial t^{\alpha}}\right\} = s^{\alpha} f^{*}(s) - \sum_{k=0}^{n-1} f^{(k)}(0^{+}) s^{\alpha-1-k}, \quad n-1 < \alpha < n \tag{2}$$

Where the asterisk denotes the Laplace transform with respect to time, s is the Laplace transform parameter.

The temperature of the thin hollow circular disk $T(r,z,t)$ is satisfying time fractional order differential equation,

$$a\left(\frac{\partial^2 T}{\partial r^2} + \frac{1}{r}\frac{\partial T}{\partial r} + \frac{\partial^2 T}{\partial z^2}\right) = \frac{\partial^{\alpha} T}{\partial t^{\alpha}}, \qquad b_1 \le r \le b_2, 0 \le z \le h \tag{3}$$

with boundary conditions

$$\frac{\partial T}{\partial r} = 0 \qquad \text{at } r = b_1 \tag{4}$$

$$\frac{\partial T}{\partial r} = Q(z)\,\delta(t) \qquad \text{at } r = b_2 \tag{5}$$

$$T = 0 \qquad \text{at } z = 0, \quad t > 0 \tag{6}$$

$$T = 0 \qquad \text{at } z = h, \quad t > 0 \tag{7}$$

and under zero initial condition

$$T = 0 \qquad \text{at } t = 0, \quad 0 < \alpha < 2 \tag{8}$$

$$\frac{\partial T}{\partial t} = 0 \qquad \text{at } t = 0, \quad 1 < \alpha < 2 \tag{9}$$

Following, Kulkarni et al. [16], we assume that a hollow disk of small thickness *h* is in a plane state of stress. In fact, "the smaller the thickness of the hollow disk compared to its diameter, the nearer to a plane state of stress is the actual state". The displacement equations of thermoelasticity have the form,

$$U_{i,kk} + \left(\frac{1+\nu}{1-\nu}\right)e_{,i} = 2\left(\frac{1+\nu}{1-\nu}\right)\cdot a_t \cdot T_{,i}$$

$$e = U_{k,k}; \quad k,i = 1,2, \tag{10}$$

where U_i – Displacement component,

e – Dilatation,

T – Temperature,

and ν and a_t are respectively, the Poisson's ratio and the linear coefficient of thermal expansion of the thin hollow disk material.

Introducing $U_i = \psi_{,i}$, $i = 1,2,$ we have

$$\nabla_1^{\,2}\psi = (1+\nu)a_t T$$

$$\nabla_1^{\,2} = \frac{\partial^2}{\partial x_1^{\,2}} + \frac{\partial^2}{\partial x_2^{\,2}}$$

$$\sigma_{ij} = 2\mu\left(\psi_{,ij} - \delta_{ij}\psi_{,kk}\right), \qquad i,j,k = 1,2, \tag{11}$$

where μ is the Lamé constant and δ_{ij} is the Kronecker symbol.

In the axially-symmetric case $\psi = \psi(r,t)$, $T = T(r,t)$

and the differential equation governing the displacement potential function $\psi(r,z,t)$ is as

$$\frac{\partial^2\psi}{\partial r^2} + \frac{1}{r}\frac{\partial\psi}{\partial r} = (1+\nu)a_t T \tag{12}$$

with $\dfrac{\partial\psi}{\partial r} = 0$ at $r = b_1$ and $r = b_2$ for all time t.

The stress function σ_{rr} and $\sigma_{\theta\theta}$ are given by

$$\sigma_{rr} = \frac{-2\mu}{r}\frac{\partial\psi}{\partial r} \tag{13}$$

$$\sigma_{\theta\theta} = -2\mu\frac{\partial^2\psi}{\partial r^2} \tag{14}$$

In the plane state of stress within the disk

$$\sigma_{rz} = \sigma_{zz} = \sigma_{\theta z} = 0$$

Equations (3) to (14) constitute the mathematical formulation of the problem.

Solution

To obtain the expression for temperature function $T(r,z,t)$; we first define the finite Fourier transform and its inverse transform over the variable z in the range $0 \le z \le h$ defined as

$$\overline{T}(r,\eta_p,t) = \int_{z'=0}^{h} K(\eta_p,z')T(r,z',t)\,dz' \tag{15}$$

$$T(r,z,t) = \sum_{p=1}^{\infty} K(\eta_p,z).\overline{T}(r,\eta_p,t) \tag{16}$$

where

$K(\eta_p,z) = \sqrt{\frac{2}{h}}\sin(\eta_p z)$ and $\eta_1,\eta_2,.....$ are the positive roots of the transcendental equation $\sin\eta_p h = 0,\quad p = 1,2,....$

Secondly, we define the finite Hankel transform and its inverse transform over the variable r in the range $b_1 \le r \le b_2$ as,

$$\overline{\overline{T}}(\beta_m,\eta_p,t) = \int_{b_1}^{b_2} r'.K_0(\beta_m,r').\overline{T}(r',\eta_p,t)\,dr' \tag{17}$$

$$\overline{T}(r,\eta_p,t) = \sum_{m=1}^{\infty} K_0(\beta_m,r)\,\overline{\overline{T}}(\beta_m,\eta_p,t) \tag{18}$$

where

$$K_0(\beta_m,r) = \frac{\pi}{\sqrt{2}}\,\frac{\beta_m.J_0'(\beta_m b_2).Y_0'(\beta_m b_2)}{\left[1-\frac{J_0'^2(\beta_m b_2)}{J_0'^2(\beta_m b_1)}\right]^{\frac{1}{2}}}\left[\frac{J_0(\beta_m r)}{J_0'(\beta_m b_2)}-\frac{Y_0(\beta_m r)}{Y_0'(\beta_m b_2)}\right]$$

and $\beta_1,\beta_2,.....$ are the positive roots of the transcendental equation $\frac{J_0'(\beta b_1)}{J_0'(\beta b_2)}-\frac{Y_0'(\beta b_1)}{Y_0'(\beta b_2)}=0$.

Applying Fourier, Hankel and Laplace transform and their inversions to equation (3) and making use of the transformed boundary and initial conditions (4)-(9), one

obtains temperature distribution function expressed as follows,

$$T(r,z,t)=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)K_0(\beta_m,r)\,a\,b_2\,K_0(\beta_m,b_2)\times\left(\int_{z=0}^{h}K(\eta_p,z)Q(z)\,dz\right)\left[E_\alpha\left(-a\,(\beta_m^2+\eta_p^2)\,t^\alpha\right)\right]. \tag{19}$$

where $L^{-1}\left[\frac{1}{s^\alpha+a(\beta_m^2+\eta_p^2)}\right]=E_\alpha\left(-a\,(\beta_m^2+\eta_p^2)\,t^\alpha\right)$

Here $E_\alpha(.)$ represents the Mittag-Leffler function.

Displacement potential and thermal stresses

Using equation (12) and (19), we get displacement potential function as follows

$$\frac{\psi(r,z,t)}{X}=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)K_0(\beta_m,r)\frac{1}{\beta_m^2}\,a\,b_2\,K_0(\beta_m,b_2)\times\left(\int_{z=0}^{h}K(\eta_p,z)Q(z)\,dz\right)\left[E_\alpha\left(-a\,(\beta_m^2+\eta_p^2)\,t^\alpha\right)\right]. \tag{20}$$

Using equations (13), (14) and (20), we obtain radial and angular stresses as follows

$$\frac{\sigma_{rr}}{Y}=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)K_1(\beta_m,r)\frac{1}{r\beta_m^2}\,ab_2\,K_0(\beta_m,b_2)\times\left(\int_{z=0}^{h}K(\eta_p,z)Q(z)\,dz\right)\left[E_\alpha\left(-a\,(\beta_m^2+\eta_p^2)\,t^\alpha\right)\right] \tag{21}$$

$$\frac{\sigma_{\theta\theta}}{Y}=\sum_{p=1}^{\infty}\sum_{m=1}^{\infty}K(\eta_p,z)K_2(\beta_m,r)\frac{1}{\beta_m^2}\,a\,b_2\,K_0(\beta_m,b_2)\times\left(\int_{z=0}^{h}K(\eta_p,z)Q(z)\,dz\right)\left[E_\alpha\left(-a\,(\beta_m^2+\eta_p^2)\,t^\alpha\right)\right] \tag{22}$$

where

$$K_0(\beta_m,b_2)=\frac{\pi}{\sqrt{2}}\,\frac{\beta_m.J_0'(\beta_m b_2).Y_0'(\beta_m b_2)}{\left[1-\frac{J_0'^2(\beta_m b_2)}{J_0'^2(\beta_m b_1)}\right]^{\frac{1}{2}}}\left[\frac{J_0(\beta_m b_2)}{J_0'(\beta_m b_2)}-\frac{Y_0(\beta_m b_2)}{Y_0'(\beta_m b_2)}\right]$$

$$K_1(\beta_m, r) = -\frac{\pi}{\sqrt{2}} \frac{\beta_m^2 . J_0'(\beta_m b_2) . Y_0'(\beta_m b_2)}{\left[1 - \frac{J_0'^2(\beta_m b_2)}{J_0'^2(\beta_m b_1)}\right]^{\frac{1}{2}}} \left[\frac{J_1(\beta_m r)}{J_0'(\beta_m b_2)} - \frac{Y_1(\beta_m r)}{Y_0'(\beta_m b_2)}\right]$$

$$K_2(\beta_m, r) = -\frac{\pi}{\sqrt{2}} \frac{\beta_m^3 . J_0'(\beta_m b_2) . Y_0'(\beta_m b_2)}{\left[1 - \frac{J_0'^2(\beta_m b_2)}{J_0'^2(\beta_m b_1)}\right]^{\frac{1}{2}}}$$

$$\times \left\{\frac{1}{J_0'(\beta_m b_2)} \times \left[J_0(\beta_m r) - \frac{J_1(\beta_m r)}{\beta_m r}\right] - \frac{1}{Y_0'(\beta_m b_2)} \times \left[Y_0(\beta_m r) - \frac{Y_1(\beta_m r)}{\beta_m r}\right]\right\}$$

$$\frac{d}{dr} J_0(\beta_m r) = -\beta_m J_1(\beta_m r)$$

$$\frac{\partial^2}{\partial r^2}(J_0(\beta_m r)) = -\beta_m^2 \left(J_0(\beta_m r) - \frac{J_1(\beta_m r)}{\beta_m r}\right)$$

$$\frac{\partial^2}{\partial r^2}(Y_0(\beta_m r)) = -\beta_m^2 \left(Y_0(\beta_m r) - \frac{Y_1(\beta_m r)}{\beta_m r}\right)$$

RESULTS AND DISCUSSION

Setting: $Q(z) = z^2 \times \left(z^2 - h^2\right)^2$

Dimensions:

Inner radius of a thin hollow circular disk $b_1 = 1m$

Outer radius of a thin hollow circular disk $b_2 = 2m$

Thickness of hollow circular disk $z = 0.2m$

Material properties:

The numerical calculation has been carried out for a Copper (Pure) thin hollow disk with the material properties as,

Thermal diffusivity $a = 112.34 \times 10^{-6} (m^2 s^{-1})$.

Thermal conductivity $k = 386(W/mk)$.

Density $\rho = 8954\,kg/m^3$.

Specific heat $c_p = 383J/kgK$.

Poisson ratio $\nu = 0.35$.

Coefficient of linear thermal expansion $a_t = 16.5\times10^{-6}\,\frac{1}{K}$.

Lamé constant $\mu = 26.67$.

We set for convenience, $X = (1+\nu)a_t$ and $Y = 2(1+\nu)a_t\mu$.

The graphs are plotted for fractional order parameter $\alpha = 0.5,1,1.5,2$ depicting weak, normal and strong conductivity and fixed time $t = 0.5$. Figures 1, 2 and 3 depict the distributions of temperature, radial stress and angular stress along the radial direction for various values of fractional order parameter α. The numerical calculation has been carried out in Matlab 2013a programming environment. The Mittag-Leffler functions used in the paper were evaluated following Podlubny [19].

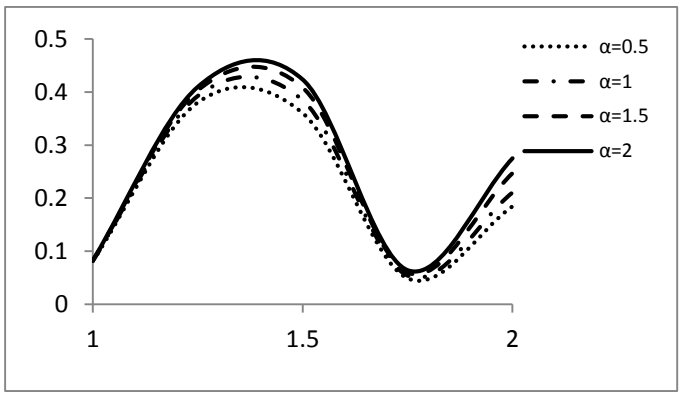

Figure 1: Temperature Distribution Function

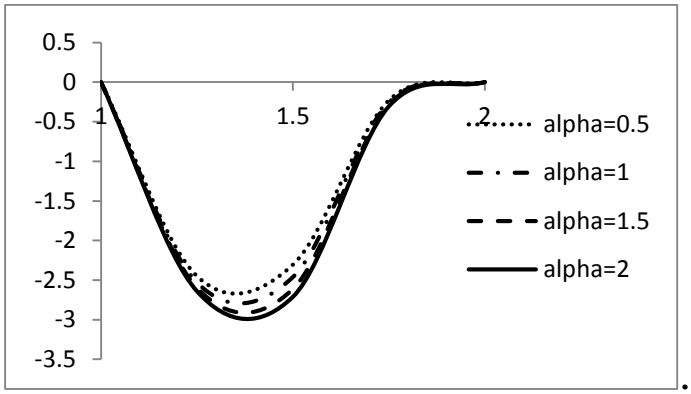

Figure 2: Radial Stress Function $\frac{\sigma_{rr}}{Y}$

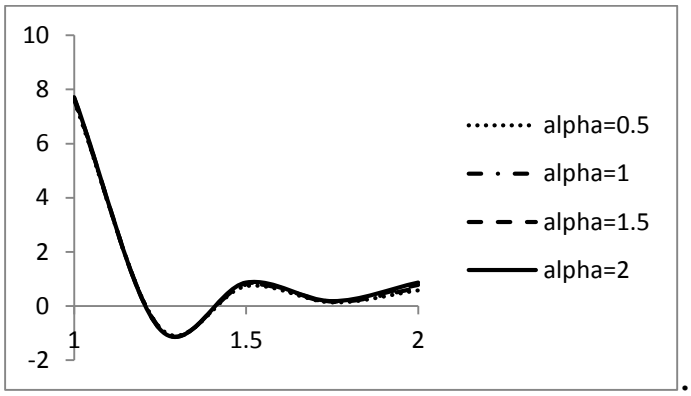

Figure 3: Angular Stress Function $\frac{\sigma_{\theta\theta}}{Y}$

Figure 1 represents the temperature distributions along the radial direction. For the different values of the fractional order parameter $\alpha = 0.5, 1, 1.5, 2$, the values of the temperature follow a non-uniform pattern with respect to radius. It is observed that temperature assumes a non-zero vale at both the inner and outer radii $r = 1$ and $r = 2$ respectively. It is seen that the speed of propagation of the thermal signals is directly proportional to the values of the fractional order parameter α. The temperature increases in the range $1 \le r \le 1.4$ and $1.75 \le r \le 2$ and it decreases in the range $1.4 \le r \le 1.75$.

Figure 2 represents the radial stress distributions along the radial direction. It is observed that the radial stresses are compressive in nature throughout the range $1 \le r \le 2$. The radial stress values initially decrese in the range $1 \le r \le 1.4$ and then

increase in the range $1.4 \le r \le 2$ and finally converges to zero.

Figure 3, represents the angular stress distributions along the radial direction. For different values of fractional parameter α, angular stresses are tensile in the range $1 \le r \le 1.2$ and $1.4 \le r \le 2$ and compressive in the range $1.2 \le r \le 1.4$.

The case $\alpha = 1$, depicts classical thermoelasticity and fractional thermoelasticity for the cases $\alpha = 0.5, 1.5$. The case $\alpha = 2$ coincides with Green and Naghdi theory and the heat conduction equation becomes wave type, admitting the propagation of second sound (see, Chandrasekaraiah [5]). It is noted from the graphs that changing values of fractional order parameter α, the speed of wave propagation is affected. Hence, it can be an important factor for designing new materials applicable to real life situations.

CONCLUSION

The fractional order thermoelasticity is used to control the speed of wave propogation in terms of heat waves and the elastic waves for the weak, normal and strong conductivity.

The theory of thermoelasticity based on time fractional heat wave equation proposed by Povstenko [9] is used to study a problem of thin hollow circular disk. The cases $0 < \alpha < 1$ and $1 < \alpha < 2$ correspond to weak and strong conductivity respectively. While $\alpha = 1$ corresponds to normal conductivity.

We restrict ourselves to the quasi-static uncoupled theory neglecting the inertia term in the equations of motion and the coupling term. Neglecting the mechanical term implies that no account has been taken for mechanical heat waves. Here we observed that the quasi static thermoelastic problem is possible only when the relaxation time of mechanical oscillation is considerably less than the relaxation time of heat conduction process. Also it is observed that the time fractional differential operator describes memory effect with the long range interactions. The heat conduction equation is parabolic in nature which predicts infinite wave propagation in terms of heat waves. Figures 1-3 shows the characteristic features of temperature and stress distributions and represents the whole spectrum of order of fractional operators. The motivation behind the consideration of the fractional theory is that it predicts retarded response to physical stimuli, as seen in nature.

In real life situations, the problems dealing with finite domains are important, unfortunately due to the complexity involved in modeling a finite domain, the literature is limited to problems on infinite domains. Hence, this problem was developed for a finite thin hollow circular disk.

In the case $1 < \alpha < 2$, the time fractional heat conduction equation interpolates the standard parabolic heat conduction equation and the hyperbolic wave equations. Likewise, the thermoelasticity interpolates the classical theory of thermal stresses and that without energy dissipation introduced by Green and Naghdi [4].

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Generalized Thermoelastic Problem of a Thick Circular Plate with Axisymmetric Heat Supply Due to Internal Heat Generation

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ABSTRACT

A two dimensional generalized thermoelastic problem of a thick circular plate of finite thickness and infinite extent subjected to continuous axisymmetric heat supply and an internal heat generation is studied within the context of generalized thermoelasticity. Unified system of equations for classical coupled thermoelasticity, Lord-Shulman and Green-Lindsay theory is considered. An exact solution of the problem is obtained in the transform domain. Inversion of Laplace transforms is done by employing numerical scheme. Mathematical model is prepared for Copper material plate and the numerical results are discussed and represented graphically.

Keywords : Thermoelasticity; Classical coupled; Lord-shulman; Green-lindsay; Internal heat generation; Axisymmetric heat supply.

1 INTRODUCTION

THE last few decades has seen a rapid development of generalized thermoelasticity, so as to overcome the shortcomings in the classical uncoupled and classical coupled thermoelasticity (CCTE) theories [1,2]. The CCTE predicts infinite speed of propagation of thermal disturbances which is contrary to the observed phenomena. It also gives unsatisfactory description of thermoelastic behavior of materials at low temperatures, inaccurate in studying the response of short laser pulse. Thus, the first modification to CCTE was put forth by Lord and Shulman [3] also known as extended thermoelasticity (ETE), wherein one relaxation time was introduced in the Fourier's law of heat conduction to obtain a hyperbolic heat conduction equation. The second modification was made by Green and Lindsay [4] also known as temperature rate dependent thermoelasticity (TRDTE), by the introduction of two different relaxation times into the constitutive relations of stress tensor and entropy equation. In TRDTE, Fourier's law of heat conduction is not violated if the body under consideration has a centre of symmetry. A detailed discussion on dynamic problems of thermoelasticity and theory of thermal stresses in generalized thermoelasticity can be found in [5,6]. Chandrasekariah [7] has referred to the wave like thermal disturbance as "The Second sound". Hetnarski and Ignaczak [8] examined five generalizations to the coupled theory and obtained many of important analytical results. Tripathi et al. [9] discussed a dynamic problem of generalized thermoelasticity in Lord-Shulman theory for a semi-infinite cylinder with heat sources. Maghraby and Abdel Halim [10] studied a problem of generalized thermoelasticity in Lord-Shulman theory for a half space subjected to a known axisymmetric temperature distribution. Aouadi [11] studied the discontinuities in an axisymmetric problem of thermoelasticity

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without heat source in the context of generalized thermoelasticity. Tripathi et al. [12] studied a problem of generalized thermoelastic diffusion interactions in a thick circular plate. Youssef [13] discussed a two dimensional generalized thermoelastic problem for a half space subjected to ramp type heating. Recently, Tripathi et al. [14, 15] discussed problems on generalized thermoelastic diffusion in a half space due to thermal and mechanical sources under axisymmetric distributions.

In the present paper, the work of Tripathi et al. [12] has been modified by considering a continuous axisymmetric heat supply with internal heat generation to a thick circular plate of infinite extent and finite thickness within the context of unified system of equations in classical coupled, Lord-Shulman and Green-Lindsay theory. The exact solutions for temperature distribution, displacement and the stress components are obtained in the Laplace transform domain. Numerical inversion of Laplace transform is performed based on Gaver-Stehfast [16-18] algorithm which is considerably more stable and computationally efficient than inversion using the discrete Fourier transform. All the integrals were calculated using Romberg's integration technique [19] with variable step size. The application of an internal heat generation is of particular interest in many engineering problems like thick-walled pressure vessels, such as a nuclear containment vessel, a cylindrical roller, etc.

2 FORMULATION OF THE PROBLEM

Consider a thick circular plate of thickness *2b* occupying the space *D* defined by $0 \le r \le \infty, -b \le z \le b$. Let the plate be subjected to a continuous axisymmetric temperature field dependent on the radial and axial directions of the cylindrical co-ordinate system. For time $t \succ 0$, heat is generated within the plate at the rate $Q(r,z,t)$. Under these conditions, the thermoelastic quantities in a semi-infinite thick circular plate are required to be determined.

We take the axis of symmetry as the *z* axis and the origin of the system of co-ordinates is at the middle plane between the upper and lower faces of the plate. The problem is studied using the cylindrical polar co-ordinates (r,φ,z). Due to the rotational symmetry about the *z* axis, all quantities are independent of the co-ordinate φ.

The unified field equations governing the displacement, the thermal fields and the stress-strain-temperature relations in the context of TRDTE, ETE and CCTE for a homogeneous and isotropic medium are given by [11]

Equation of motion

$$(r, \mu \ddot{u}_{i,jj} + (\lambda + \mu)\ u_{j,ji} - \gamma\left(1 + \tau_1 \frac{\partial}{\partial t}\right) T_{,i} = \rho \ddot{u}_i \tag{1}$$

Equation of heat conduction

$$KT_{,ii} = \rho C_E \left(\frac{\partial}{\partial t} + \tau_0 \frac{\partial^2}{\partial t^2}\right)\dot{T} + \left(1 + \eta_0 \tau_0 \frac{\partial}{\partial t}\right)\left(T_0 \gamma \dot{u}_{j,j} - \rho Q\right) \tag{2}$$

The constitutive relations

$$\sigma_{ij} = \mu\left(u_{i,j} + u_{j,i}\right) + \left[\lambda u_{i,i} - \gamma\left(T + \tau_1 \dot{T}\right)\right]\delta_{ij} \tag{3}$$

where λ and μ are Lamé's constants, τ_0 and τ_1 are relaxation times, γ is a material constant given by $\gamma = (3\lambda + 2\mu)\alpha_t, \alpha_t$ is the coefficient of linear thermal expansion, T_0 is the reference temperature chosen such that $\left|(T - T_0)/T_0\right| << 1$.

The use of symbol η_0 in Eq.(2) makes these fundamental equations possible for three different theories of thermoelasticity. For classical coupled thermoelasticity (CCTE) theory, $\eta_0 = 1, \tau_0 = \tau_1 = 0$; for the Lord-Shulman (ETE) theory, $\eta_0 = 1,\ \tau_1 = 0, \tau_0 > 0$; for Green-Lindsay (TRDTE) theory, $\eta_0 = 0$, $\tau_1 > \tau_0 > 0$.

The dilatation *e* is given by

$$e_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i}) \text{ and } e = e_{ii} \tag{4}$$

The displacement vector, thus, has the form $\vec{u} = (u, 0, w)$. The equations of motion can be written as:

$$\mu \nabla^2 u - \frac{\mu}{r^2} u + (\lambda + \mu) \frac{\partial e}{\partial r} - \gamma \left(1 + \tau_1 \frac{\partial}{\partial t}\right) \frac{\partial T}{\partial r} = \rho \frac{\partial^2 u}{\partial t^2} \tag{5}$$

$$\mu \nabla^2 w + (\lambda + \mu) \frac{\partial e}{\partial z} - \gamma \left(1 + \tau_1 \frac{\partial}{\partial t}\right) \frac{\partial T}{\partial z} = \rho \frac{\partial^2 w}{\partial t^2} \tag{6}$$

The generalized equation of heat conduction has the form

$$K \nabla^2 T = \rho C_E \left(\frac{\partial}{\partial t} + \tau_0 \frac{\partial^2}{\partial t^2}\right) T + T_0 \gamma \left(\frac{\partial}{\partial t} + \eta_0 \tau_0 \frac{\partial^2}{\partial t^2}\right) e - \rho \left(1 + \eta_0 \tau_0 \frac{\partial}{\partial t}\right) Q \tag{7}$$

where T is the absolute temperature and e is the dilatation given by the relation

$$e = \frac{u}{r} + \frac{\partial u}{\partial r} + \frac{\partial w}{\partial z} = \frac{1}{r} \frac{\partial}{\partial r}(ru) + \frac{\partial w}{\partial z} \tag{8}$$

where the Laplacian operator is given by $\nabla^2 = \frac{\partial^2}{\partial r^2} + \frac{1}{r} \frac{\partial}{\partial r} + \frac{\partial^2}{\partial z^2}$

The following constitutive relations supplement the above equations

$$\sigma_{\phi\phi} = 2\mu \frac{u}{r} + \lambda e - \gamma \left(T - T_0 + \tau_1 \frac{\partial T}{\partial t}\right) \tag{9}$$

$$\sigma_{rr} = 2\mu \frac{\partial u}{\partial r} + \lambda e - \gamma \left(T - T_0 + \tau_1 \frac{\partial T}{\partial t}\right) \tag{10}$$

$$\sigma_{zz} = 2\mu \frac{\partial w}{\partial z} + \lambda e - \gamma \left(T - T_0 + \tau_1 \frac{\partial T}{\partial t}\right) \tag{11}$$

$$\sigma_{rz} = \mu \left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial r}\right) \tag{12}$$

$$\sigma_{r\phi} = \sigma_{z\phi} = 0 \tag{13}$$

We shall use the following non-dimensional variables

$$r' = \eta_0 \, r \, , \; z' = \eta_0 \, z \, , \; u' = \eta_0 \, u \, , \; w' = \eta_0 \, w \, , \; t' = c_1 \eta_0 \, t \, , \; \tau_0' = c_1 \, \eta_0 \tau_0 \, , \; \sigma_{ij}' = \frac{\sigma_{ij}}{\mu},$$

$$\theta = \frac{\gamma (T - T_0)}{(\lambda + 2\mu)} \, , \; \tau_1' = c_1 \, \eta_0 \, \tau_1 \, , \; Q' = \frac{\rho \gamma Q}{K c_1^{\,2} \eta_0^{\,2} (\lambda + 2\mu)}$$

where $\eta_0 = \frac{\rho c_1 C_E}{K}$ is the dimensionless characteristic length, $c_1 = \sqrt{\frac{\lambda + 2\mu}{\rho}}$ is the speed of propagation of longitudinal wave.

Using the above non-dimensional variables, the governing Eqs. (5)-(13) take the form,

$$\nabla^2 u - \frac{1}{r^2}u + (\xi^2 - 1)\frac{\partial e}{\partial r} - \xi^2\left(1 + \tau_1 \frac{\partial}{\partial t}\right)\frac{\partial \theta}{\partial r} = \xi^2 \frac{\partial^2 u}{\partial t^2} \tag{14}$$

$$\nabla^2 w + (\xi^2 - 1)\frac{\partial e}{\partial z} - \xi^2\left(1 + \tau_1 \frac{\partial}{\partial t}\right)\frac{\partial \theta}{\partial z} = \xi^2 \frac{\partial^2 w}{\partial t^2} \tag{15}$$

$$\nabla^2 \theta = \left(\frac{\partial}{\partial t} + \tau_0 \frac{\partial^2}{\partial t^2}\right)\theta + \varepsilon\left(\frac{\partial}{\partial t} + \eta_0 \tau_0 \frac{\partial^2}{\partial t^2}\right)e - \xi^2\left(1 + \eta_0 \tau_0 \frac{\partial}{\partial t}\right)Q \tag{16}$$

$$\sigma_{rr} = 2\frac{\partial u}{\partial r} + \left(\xi^2 - 2\right)e - \xi^2\left(1 + \tau_1 \frac{\partial}{\partial t}\right)\theta \tag{17}$$

$$\sigma_{\phi\phi} = 2\frac{u}{r} + \left(\xi^2 - 2\right)e - \xi^2\left(1 + \tau_1 \frac{\partial}{\partial t}\right)\theta \tag{18}$$

$$\sigma_{zz} = 2\frac{\partial w}{\partial z} + \left(\xi^2 - 2\right)e - \xi^2\left(1 + \tau_1 \frac{\partial}{\partial t}\right)\theta \tag{19}$$

$$\sigma_{rz} = 2\left(\frac{\partial u}{\partial z} + \frac{\partial w}{\partial r}\right) \tag{20}$$

where $\xi^2 = \frac{(\lambda + 2\mu)}{\mu}, \varepsilon = \frac{T_0 \gamma^2}{\rho C_E (\lambda + 2\mu)}$.

Using Helmholtz decomposition theorem, we seek the displacement components *u* and *w* in the form,

$$u = \frac{\partial \phi}{\partial r} + \frac{\partial^2 \psi}{\partial r \partial z} \tag{21}$$

$$w = \frac{\partial \phi}{\partial z} - \left(\frac{\partial^2 \psi}{\partial r^2} + \frac{1}{r}\frac{\partial \psi}{\partial r}\right) \tag{22}$$

where the potential functions ϕ and ψ are the Lame's potentials representing irrotational and rotational parts of the displacement vector $\vec{u}$ respectively.

From Eqs. (4), (21) and (22), we obtain

$$e = \nabla^2 \phi \tag{23}$$

Using Eqs. (21)-(23) into Eqs. (14)-(16), we get,

$$\left(\nabla^2 - \frac{\partial^2}{\partial t^2}\right)\phi - \left(1 + \tau_1 \frac{\partial}{\partial t}\right)\theta = 0 \tag{24}$$

$$\left(\nabla^2 - \xi^2 \frac{\partial^2}{\partial t^2}\right)\psi = 0 \tag{25}$$

$$\left(\nabla^2 - \frac{\partial}{\partial t} - \tau_0 \frac{\partial^2}{\partial t^2}\right)\theta - \varepsilon\left(\frac{\partial}{\partial t} + \eta_0\tau_0 \frac{\partial^2}{\partial t^2}\right)\nabla^2\phi = -\xi^2\left(1 + \eta_0\tau_0 \frac{\partial}{\partial t}\right)Q \tag{26}$$

Eq.(25) for the function ψ represents a wave equation with wave velocity $v = 1/\xi$. This represents a transverse wave and it has no effect on temperature. Eq.(26) represents a longitudinal thermal wave moving with velocity $v_L = 1/\sqrt{\tau_0}$.

We shall assume that the initial state of the medium is quiescent. The boundary conditions of the problem are taken as:

$$\frac{\partial\theta}{\partial z} = \pm g_0 F(r,z), \quad z = \pm b \tag{27}$$

and the traction free surface stress functions,

$$\sigma_{zz} = \sigma_{rz} = 0, \quad z = \pm b \tag{28}$$

3 ANALYTICAL SOLUTION

Applying the Laplace transform defined by the relation,

$$\bar{f}(r,z,p) = L\left[f(r,z,t)\right] = \int_0^\infty e^{-pt} f(r,z,t)dt$$

and the Hankel transform of order zero with respect to *r* of a function $\bar{f}(r,z,p)$ defined by the relation,

$$\bar{f}^*(\alpha,z,p) = H\left[\bar{f}(r,z,p)\right] = \int_0^\infty \bar{f}(r,z,p) r J_0(\alpha r)dr$$

where J_0 is the Bessel function of the first kind of order zero. The inverse Hankel transform is given by the relation

$$\bar{f}(r,z,p) = H^{-1}\left[\bar{f}^*(\alpha,z,p)\right] = \int_0^\infty \bar{f}^*(\alpha,z,p)\ \alpha J_0(\alpha r)d\alpha$$

Applying Laplace and Hankel transform to Eqs. (24)-(26), we get,

$$\left(D^2 - \alpha^2 - p^2\right)\bar{\phi}^* - \left(1 + \tau_1 p\right)\bar{\theta}^* = 0 \tag{29}$$

$$\left(D^2 - \alpha^2 - \xi^2 p^2\right)\bar{\psi}^* = 0 \tag{30}$$

$$\left(D^2 - \alpha^2 - p - \tau_0 p^2\right)\bar{\theta}^* - \varepsilon\, p\left(1 + \eta_0\tau_0 p\right)\left(D^2 - \alpha^2\right)\bar{\phi}^* = -(1 + \eta_0\tau_0\, p)\bar{Q} \tag{31}$$

where $D = \partial/\partial z$. On eliminating $\bar{\theta}^*$ between Eqs. (29) and (31), we get,

$$\left(D^2-k_1^{\,2}\right)\left(D^2-k_2^{\,2}\right)\bar{\phi}^{*}=-\left(1+\tau_1 p\right)(1+\eta_0\tau_0\, p)\bar{Q} \tag{32}$$

where $\pm k_1$ and $\pm k_2$ are the roots of the characteristic equation given by,

$$k^4-\left(f(p)+2\alpha^2\right)k^2+\alpha^2(f(p)+\alpha^2)+p^3(1+\tau_0\, p)=0 \tag{33}$$

where $f(p)=p^2+p(1+\tau_0\, p)+\varepsilon\, p(1+\eta_0\tau_0 p)(1+\tau_1 p)$. The solution of Eq. (32) can be written in the form,

$$\bar{\phi}^{*}=\sum_{i=1}^{2}\bar{\phi}_i^{*}+\bar{\phi}_p^{\,*} \tag{34}$$

where $\bar{\phi}_i^{*}$ is a general solution of the homogeneous differential equation given by

$$\left(D^2-\alpha_i^{\,2}\right)\bar{\phi}_i^{*}=0\quad ,i=1,2. \tag{35}$$

The solution of Eq. (35) can be written in the form

$$\bar{\phi}_i^{*}=C_i(\alpha,p)\cosh(k_i z)\ ,\ i=1,2 \tag{36}$$

and $\bar{\phi}_p^{\,*}$ is the particular integral satisfying the equation

$$\left(D^2-k_1^{\,2}\right)\left(D^2-k_2^{\,2}\right)\bar{\phi}_p^{\,*}=-\left(1+\tau_1 p\right)(1+\eta_0\tau_0\, p)\bar{Q} \tag{37}$$

We take the internal heat generation $Q(r,z,t)$ in the following form

$$Q(r,z,t)=\frac{q_0\delta(t)\,\delta(r)\cosh z}{2\pi r} \tag{38}$$

This is a cylindrical shell heat source releasing heat instantaneously at $t=0$ and situated at the centre $r=0$ varying in the axial direction where q_0 denotes the strength of the internal heat generation. Let $Q_0=\frac{q_0}{2\pi}$.

On applying the Laplace and Hankel transform to Eq. (38), we get,

$$\bar{Q}^{*}=Q_0\cosh z \tag{39}$$

The solution of the Eq. (37) can be represented as,

$$\bar{\phi}_p^{\,*}=-\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z \tag{40}$$

The complete solution ofEq. (32) is given by,

$$\bar{\phi}^{*}=\sum_{i=1}^{2}C_i(\alpha,p)\cosh(k_i z)-\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z \tag{41}$$

On using Eq. (41) into Eq. (29), we get,

$$\bar{\theta}^* = \sum_{i=1}^{2} \frac{k_i^2 - \alpha^2 - p^2}{1+\tau_1 p} C_i(\alpha, p)\cosh(k_i z) - \frac{Q_0\left(1+\eta_0\tau_0 p\right)\left(1-\alpha^2-p^2\right)}{\left(1-k_1^2\right)\left(1-k_2^2\right)}\cosh z \tag{42}$$

On solving Eq. (30), we get,

$$\bar{\psi}^* = D(\alpha, p)\sinh(az) \tag{43}$$

where $a^2 = \alpha^2 + \xi^2 p^2$. In Eqs. (41)-(43), the constants $C_1(\alpha, p), C_2(\alpha, p)$ and $D(\alpha, p)$ depend on both α and p. Using Eqs. (21) and (22) in Eqs. (19) and (20), the stress components $\bar{\sigma}_{zz}^*$, $\bar{\sigma}_{rz}^*$ take the form,

$$\bar{\sigma}_{zz}^* = \left(\xi^2 p^2 + 2\alpha^2\right)\bar{\phi}^* + 2\alpha^2 \frac{\partial \bar{\psi}^*}{\partial z} \tag{44}$$

$$\bar{\sigma}_{rz}^* = H\left\{\frac{\partial}{\partial r}\left[2D\bar{\phi} + \left(2D^2 - \xi^2 p^2\right)\bar{\psi}\right]\right\} \tag{45}$$

where H represents the Hankel transform.

Now applying the Laplace and Hankel transform to the boundary conditions (27) and (28), we get,

$$\frac{\partial \bar{\theta}^*}{\partial z} = \pm g_0 \bar{F}^*(\alpha, z) \qquad , \quad z = \pm b \tag{46}$$

$$\bar{\sigma}_{zz}^* = \bar{\sigma}_{rz}^* = 0 \qquad , \quad z = \pm b \tag{47}$$

Here, we consider the function $F(r,z)$ which falls off exponentially as one moves away from the centre of the plate in the radial direction and increases symmetrically along the axial direction given by, $F(r,z)=z^2 e^{-\omega r}$, $\omega > 0$

On applying Laplace and Hankel transforms to the above function, we get,

$$\bar{F}^*(\alpha, z) = \frac{z^2 \omega}{p\left(\omega^2 + \alpha^2\right)^{3/2}} \tag{48}$$

Making use of the values of $\bar{\theta}, \bar{\sigma}_{zz}$ and $\bar{\sigma}_{rz}$ in the boundary conditions (46)-(47) and with the aid of Eq. (48), we get,

$$\sum_{i=1}^{2} \frac{C_i\left(k_i^2 - \alpha^2 - p^2\right)k_i \sinh(k_i b)}{(1+\tau_1 p)} - \frac{Q_0\left(1+\eta_0\tau_0 p\right)\left(1-\alpha^2-p^2\right)}{\left(1-k_1^2\right)\left(1-k_2^2\right)}\sinh(b) = \frac{g_0 b^2 \omega}{p\left(\omega^2+\alpha^2\right)^{3/2}} \tag{49}$$

$$\left(\xi^2 p^2 + 2\alpha^2\right)\left\{\sum_{i=1}^{2} C_i \cosh(k_i b) - \frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^2\right)\left(1-k_2^2\right)}\cosh(b)\right\} + 2\alpha^2 a D \cosh(ab) = 0 \tag{50}$$

$$2\sum_{i=1}^{2} k_i C_i \sinh(k_i b) - \frac{2Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^2\right)\left(1-k_2^2\right)}\sinh(b) + \left(2a^2 - \xi^2 p^2\right)D\sinh(ab) = 0 \tag{51}$$

On solving Eqs.(49)-(51) which is a system of linear equations with $C_1(\alpha,p), C_2(\alpha,p)$ and $D(\alpha,p)$ as unknown parameters, we get the complete solution of the problem in the Laplace transform domain.

3.1 Inversion of Hankel transform

On applying inversion of Hankel transform to equation (42), we obtain,

$$\bar{\theta}(r,z,p)=\int_0^\infty\left\{\sum_{i=1}^{2}\frac{k_i^{\,2}-\alpha^2-p^2}{1+\tau_1 p}C_i(\alpha,p)\cosh(k_i z)-\frac{Q_0\left(1+\eta_0\tau_0 p\right)\left(1-\alpha^2-p^2\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z\right\}\alpha J_0(\alpha r)\,d\alpha \tag{52}$$

Using Eqs.(41)-(43) in Eqs. (21)-(22) and taking inverse Hankel transform, it yields the solution for displacement components in Laplace transform domain,

$$\bar{u}(r,z,p)=\int_0^\infty -\alpha^2\left[\sum_{i=1}^{2}C_i(\alpha,p)\cosh(k_i z)-\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z+D(\alpha,p)\cosh(az)\right]J_1\left(\alpha r\right)d\alpha \tag{53}$$

$$\bar{w}(r,z,p)=\int_0^\infty\left[\sum_{i=1}^{2}k_i\,C_i(\alpha,p)\sinh(k_i z)-\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\sinh z+D(\alpha,p)\,\alpha^2\sinh(az)\right]\alpha J_0\left(\alpha r\right)d\alpha \tag{54}$$

Applying Laplace transform to Eqs. (17)-(19) and using the solutions given in Eqs. (52)-(54), we obtain the stress components in the Laplace transform domain,

$$\bar{\sigma}_{rr}(r,z,p)=\int_0^\infty\left\{\begin{array}{l}\alpha J_0\left(\alpha r\right)\sum_{i=1}^{2}(\xi^2p^2+2\alpha^2-2k_i^{\,2})C_i(\alpha,p)\cosh(k_i z)+\left(2-2\alpha^2-\xi^2p^2\right)\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z\\ +2\alpha^3\left(\frac{1}{\alpha r}J_1\left(\alpha r\right)-J_0\left(\alpha r\right)\right)\left[\begin{array}{l}C_i(\alpha,p)\cosh k_i z+D(\alpha,p)\,a\,\cosh(az)\\ \sum_{i=1}^{2}-\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z\end{array}\right]\end{array}\right\}d\alpha \tag{55}$$

$$\bar{\sigma}_{\varphi\varphi}(r,z,p)=\int_0^\infty\left\{\begin{array}{l}\alpha J_0\left(\alpha r\right)\left[\sum_{i=1}^{2}(\xi^2p^2+2\alpha^2-2k_i^{\,2})C_i(\alpha,p)\cosh_i(k_i z)+\left(2-2\alpha^2-\xi^2p^2\right)\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z\right]\\ -\frac{2}{r}\left[\sum_{i=1}^{2}C_i(\alpha,p)\cosh(k_i z)+D(\alpha,p)\,a\,\cosh(az)-\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z\right]\alpha^2J_1\left(\alpha r\right)\end{array}\right\}d\alpha \tag{56}$$

$$\bar{\sigma}_{zz}(r,z,p)=\int_0^\infty(\xi^2p^2+2\alpha^2)\left[\begin{array}{l}\sum_{i=1}^{2}C_i(\alpha,p)\cosh(k_i z)-\frac{Q_0\left(1+\tau_1 p\right)\left(1+\eta_0\tau_0 p\right)\left(1-\alpha^2-p^2\right)}{\left(1-k_1^{\,2}\right)\left(1-k_2^{\,2}\right)}\cosh z\\ +2\alpha^2D(\alpha,p)\cosh(az)\end{array}\right]\alpha J_0\left(\alpha r\right)d\alpha \tag{57}$$

Eqs. (52)-(57) present the complete solution of the problem in the Laplace transform domain.

4 INVERSION OF DOUBLE TRANSFORMS

Due to the complexity of the solution in the Laplace transform domain, the inverse of the Laplace transform is obtained using the Gaver-Stehfast algorithm. Gaver [16] and Stehfast [17,18] derived the formula given below. By this method the inverse $f(t)$ of the Laplace transform $\bar{f}(p)$ is approximated by,

$$f(t)=\frac{\ln 2}{t}\sum_{j=1}^{K}D(j,K)F\left(j\frac{\ln 2}{t}\right) \tag{58}$$

with

$$D(j,K)=(-1)^{j+M}\sum_{n=m}^{\min(j,M)}\frac{n^{M}(2n)!}{(M-n)!\,n!(n-1)!(j-n)!(2n-j)!} \tag{59}$$

where K is an even integer, whose value depends on the word length of the computer used. $M=K/2$ and m is the integer part of the $(j+1)/2$. The optimal value of K was chosen as described in Gaver-Stehfast algorithm, for the fast convergence of results with the desired accuracy. The Romberg numerical integration technique [19] with variable step size was used to evaluate the integrals involved. All the programs were made in mathematical software Matlab.

5 NUMERICAL RESULTS AND DISCUSSION

Mathematical model is prepared with Copper material for purposes of numerical computations. The material constants of the problem are given below [11]

$K=386N/Ks$, $\alpha_t=1.78\times10^{-5}K^{-1}$, $C_E=383.1m^2/K$, $b=1$, $\eta=8886.73m.s^{-2}$

$\mu=3.86\times10^{10}N.m^{-2}$, $\lambda=7.76\times10^{10}N.m^{-2}$, $\rho=8954\ kg.m^{-3}$, $c_1=4.158\times10^{3}m.s^{-1}$

$\tau_0=0.02$, $\tau_1=0.08$, $T_0=293\ K$, $\varepsilon=0.0168$, $\beta^2=4$, $\omega=5$, $Q=1$

The numerical values for temperature θ, the radial displacement component u, the axial stress component σ_{zz} have been calculated at the middle of the plane ($z=0$) for different time instants $t=0.1,1.2$ along the radial direction and are displayed graphically for CCTE, ETE and TRDTE theories of thermoelasticity as shown in Figs. 1, 2 and 3 respectively. The displacement component w vanishes at the middle plane of the plate and the differences among the different models for the other stress components are similar to those for the axial stress component σ_{zz}.

From Figs. 1, 2, and 3, it is observed that at time $t=0.1$, the CCTE, ETE and TRDTE theories show different results and for time $t=1.2$, the ETE and TRDTE models are in somewhat agreement. This is due to the arrival of the elastic wave at the middle plane at this time. From Fig. 1, it is clearly seen that the non-dimensional temperature θ drops gradually along the radial direction. It is also observed that at time $t=0.1$ the non-dimensional temperature θ and axial stress σ_{zz} exhibit non-zero values for all the three models of thermoelasticity. In addition, temperature θ and radial displacement u do not become identically zero due to presence of the continuous axisymmetric heat supply and internal heat generation within it. It is further observed from Fig.3 that at time $t=0.1$, the axial stress σ_{zz} is initially tensile in nature and becomes compressive near $r=5$. For time $t=1.2$, the axial stress σ_{zz} is compressive in nature and becomes tensile after $r=5$.

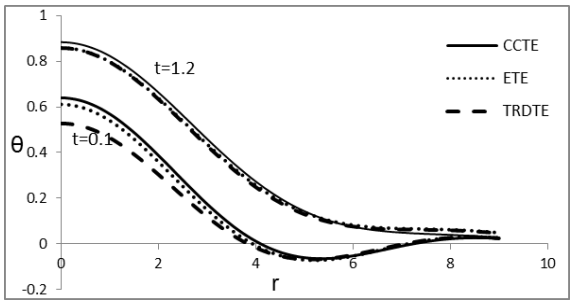

Fig.1
Temperature distribution θ in the middle plane.

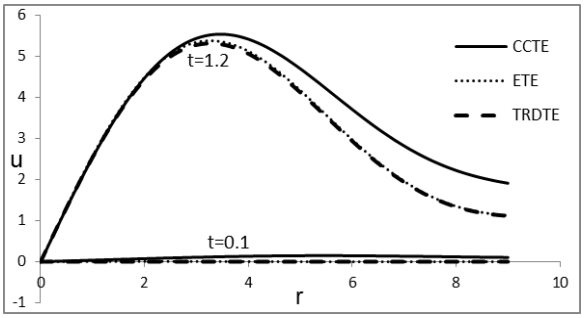

Fig.2
Radial displacement *u* distribution in the middle plane.

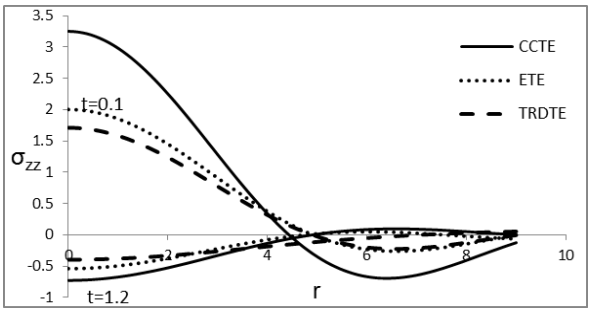

Fig.3
Axial stress component σ_{zz} in the middle plane.

6 CONCLUSIONS

In this study we have used the generalized theories of thermoelasticity i.e. ETE and TRDTE models to solve the problem for thick circular plate of infinite extent with continuous axisymmetric heat supply and internal heat generation within it and compared the models with CCTE. The generalized theories ETE and TRDTE models involve a hyperbolic wave equation, thus predicting finite speeds of heat propagation whereas the CCTE model involves a parabolic heat equation, thus predicting infinite speeds of heat wave propagation. Thus for small time the differences in results between the three theories are more visible as the heat wave takes time to reach the middle plane in ETE and TRDTE models. Thus for studying realistic engineering problems ETE and TRDTE models of generalized thermoelasticity must be studied instead of CCTE theory. As a special case, we have constructed a mathematical model for copper plate with axisymmetric heat supply and internal heat generation. Note that our numerical procedure successfully evaluated the solutions in the time domain. We may also conclude that the system of equations in this paper may prove to be useful in studying the thermal characteristics of various bodies in important engineering problems using the more realistic generalized models of thermoelasticity instead of CCTE.

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Piezoelectricity in Nd^{+3}+K^{+} Double Doped Ferroelectric Lead Germanate Single Crystals

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Abstract

The piezoelectric effect in both pure lead germanate (LG) and Nd^{+3}+K^{+} double doped ferroelectric lead germinate single crystals (DDLG) was studied using Keithley Programmable Electrometer. The Piezoelectric studies were done in four parts. In the first part temperature and stress dependence of pure lead germinates and Nd^{+3}+K^{+} doped ferroelectric lead germinate was performed. In the second part, time dependence of both pure and doped LG was done. In the third part anisotropy of pure and doped samples was studied. In the fourth part, effect of light irradiation was done in both pure and Nd^{+3}+K^{+} doped LG. After that piezoelectric constant with respect to stress was studied.

Keywords:* *Piezoelectricity; Ferroelectric; Lead germinate; Double doping; Domain dynamics

Introduction

After the discovery of piezoelectricity in 1880, the science of piezoelectricity has advanced considerably from being a science to now a technology. The development of barium titanate family of piezoceramics and later the lead zirconate family lead to further strengthening of the technology. All of the advances contributed to establishing an entirely new method of piezoelectric device development, namely tailoring a material for specific application. For technical use however, the most significant material used is the ceramic PZT. These PZT's are marked by high piezoelectric efficiencies. The displacement produced by these materials is of the order of 10 micrometer.

However, lead germanate due to its reported small electromechanical coefficient has not much been explored as a piezoelectric material. In our humble approach, we have tried to open a window into this process by studying piezoelectric effect in pure and Nd^{+3}+K^{+} doped lead germanate.

Piezoelectric studies on lead germanate have been reported by Yamada [1]. They have reported a small electromechanical factor, which made the material unattractive for ultrasonic applications. While reporting temperature characteristics of

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piezoelectric constant d31, they mention that piezoelectric constant vanished above the Curie point (177°C), while d22 remained constant above and below the Curie point.

LG was used to form dense piezoelectric composites with PZT at temperatures below 1000 C by Schulze [2]. The nature of changes in the non-linear piezoelectric constant near the phase transition in LG single crystals [3], Sun measured the ultrasonic velocity of ferroelectric LG single crystal and calculated the piezoelectric coefficient [4]. Piezoelectric properties of LG were utilized for the construction of SAW filters especially in T.V. techniques [5] LG thin film with only 180 domain wall switching coupled with the possibility of a low piezoelectric coefficient, would be appealing to be used for the development of non-volatile FRAM's (Ferroelectric Random Access Memory) and CCD-IR (Charge couple device) image sensors possibly without fatigue and retention problems [6]. A study on the elastic and piezoelectric properties of ferroelectric lead germanate single crystals by the ultrasonic pulsed technique was done by Lee [7]. By applying resonance technique Yamada have measured the values of all elastic, dielectric and piezoelectric constants at room temperature, as well as the temperature dependence of the elastic compliance S11E and of the two piezoelectric constants d31 and d22. Both S11E and d31 show upward directed cusp-like anomalies near Tc, but d22 is approximately independent of temperature [8].

At room temperature $Pb_5Ge_3O_{11}$ belongs to the $R3^{-}$ Laue group, crystals of which have a more complicated elastic behavior than those belonging to the higher symmetry $R3^{-}m$ Laue group. There are seven independent elastic moduli: C11, C33, C44, C12, C13, C14 and C25. The point symmetry changes to 6^{-}=3/m (C3h) at phase transition, decreasing the number of independent elastic constants from seven to five: C11, C33, C44, C12 and C13 [9].

Conclusions were drawn from Abdul Ghani [10] that the unplowed lead germanate shows an elastic anomalies for the elastic moduli C11, C33, C12 and C13 and a small continuous monotonically for the shear moduli C44 and C66 with the increase of temperature. Several of the elastic constants of $Pb_5Ge_3O_{11}$ increase with the increase of temperature just above Curie point. The elastic anomalies for unstiffened elastic constants CE33 and CE13 are larger than the stiffened elastic constants C´33 and C´13 because the piezoelectric correction is large.

High Piezoelectricity ceramic composites were fabricated by Ogawa et al. [11] by utilizing small amounts of PGO glass. In addition, it was found that crystallinity of the PZT powder determines the piezoelectricity of the composite.

Experimental

Pure Lead Geminate (LG) single crystal was prepared by Czochralski's technique. Single crystals of Nd^{+3}+K^{+} doped lead germanate (DDLG) were prepared from high purity PbO (Johnson Matthey, 99.99%) and GeO_2 (Koch-light Laboratory, 99.999%) by the method of controlled cooling of the melt. Having taken the starting materials in 5:3 molar ratio and adding Nd_2O_3 (Indian Rare Earths, 99.99%) and K_2CO_3 (Aldrich Chemical 99.99%) in 0. 2 mol% each the samples were prepared.
The powders were thoroughly mixed and tablets were prepared (10 mm diameter, 5 mm thickness) on a hydraulic press by applying a pressure of 5 tons per square inch. After the tablets were calcined at 550°C for 12 h at 770°C they were crushed to fine powder and the melting point was determined at 765°C. The melt was maintained at thermal equilibrium of 8 h at 770°C, it was cooled at the rate of 1 C/h to 760°C. Thereafter the melt was cooled at a rate of 2°C/h, 5°C/h and 10°C/h successively

cooling down the melt to room temperature. Single crystals of dimension 5 mm × 4 mm × 3 mm were found embedded in the solid. Pure lead germanate was grown by Czochlarski's technique for comparative analysis.

Specimens of pure and doped crystals were prepared by polishing, cleaning and electroding process. Crystal-cutting unit (South Bay Technology, USA) was used for cutting of the crystals. An air drying conducting silver paste was used as electrode. A specially designed spring loaded sample holder along with chromel-alumel thermocouple was used for mounting of the samples.

The Piezoelectric effect in ferroelectric lead germanate single crystals was studied using Keithley Programmable Electrometer Model 6512 (FIG. 1A). A specially designed crystal holder was fabricated for the study of piezoelectric effect. This spring loaded crystal holder contained a special arrangement to keep known weights. The spring loading facility was such that a free flow of the spring could be achieved. Weights could be kept on disc A of the crystal holder. Due to the easy flow of the spring the stress imparted by the weights directly got transferred to the crystal kept below.

FIG.1A. **Single crystal grown by cz technique.**

Results and Discussion

Piezoelectric studies for both LG and DDLG single crystals were done in four parts. In the first part, at room temperature, the load was varied from 0 g in steps of 10 g and the maximum charge was noted each time. The method was repeated for higher fixed temperatures of 50°C, 75°C and 88°C (FIG. 1B - 1C). In the second part, anisotropy study of the crystals was done by measurement of charge in all the 3 directions. In the third part, charge was noted down after every half a minute to study the time dependence of charge. In the fourth part, the crystals were irradiated for about 10 minutes with a uniphase make He-Ne laser beam (Model 155 ASL) having a wavelength of 6328 Å (FIG. 2A - 2B). Again time dependence of the piezoelectric constant was studied.

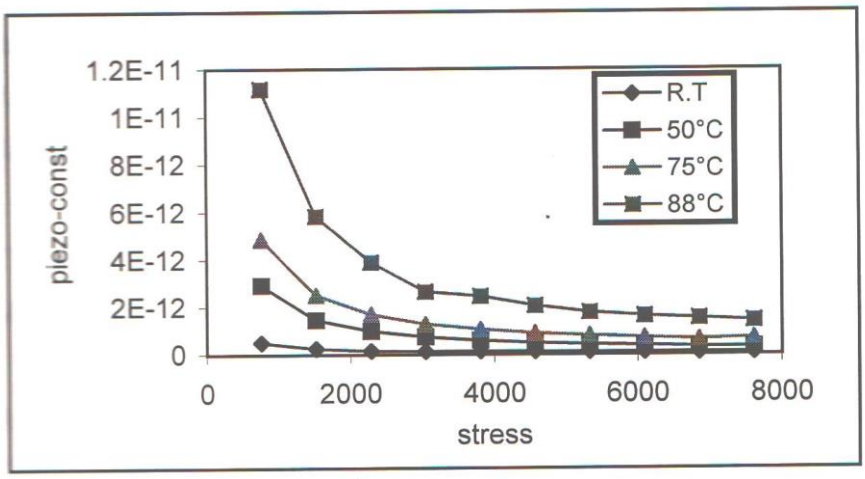

FIG. 1B. **Temperature and stress dependence of piezoelectric constant for LG.**

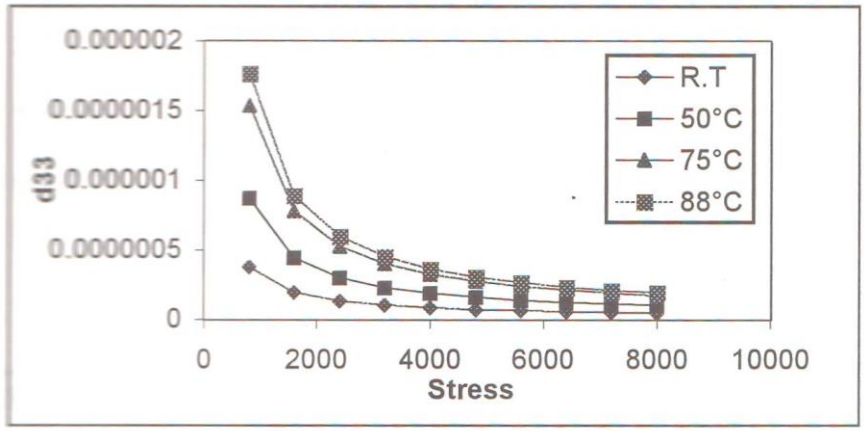

FIG. 1C. **Temperature and stress dependence of piezoelectric constant for DDLG.**

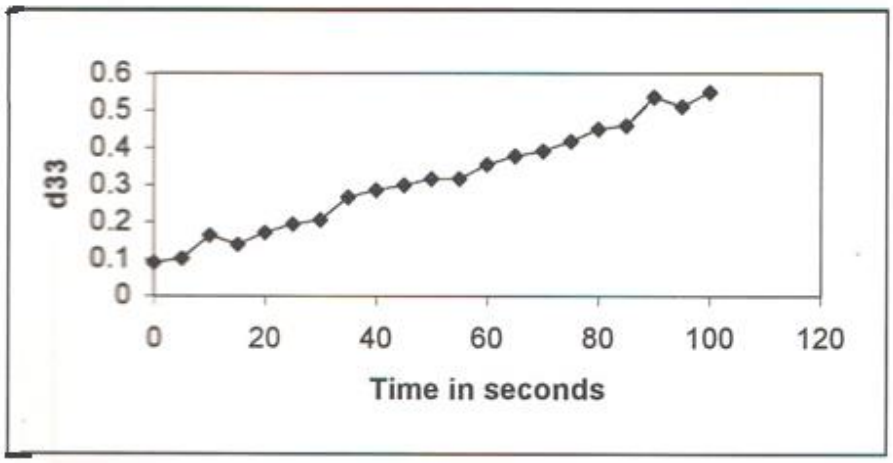

FIG. 2A. **Time dependence for piezoelectric constant for LG.**

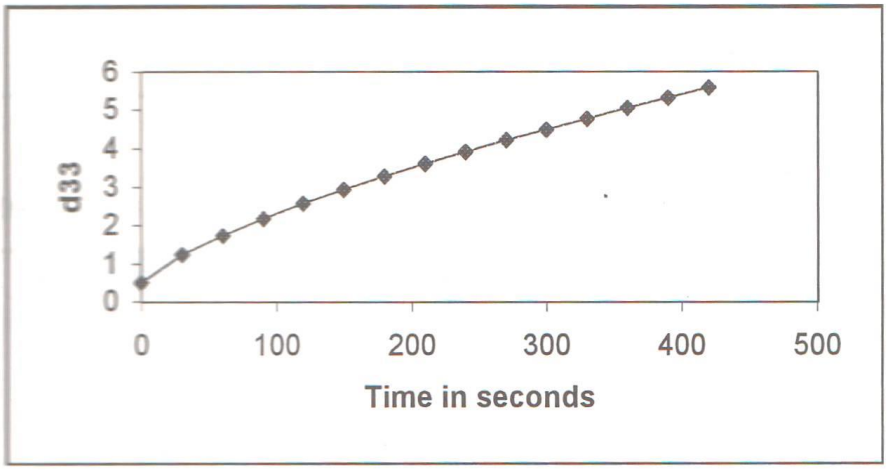

FIG. 2B. **Time dependence for piezoelectric constant for DDLG.**

Piezoelectric studies were done in four parts. In the first part temperature and stress dependence of both pure lead germanates and Nd^{+3}+K^{+} doped lead germanate were performed. In the second part, time dependence of both pure and doped was done. In the third part anisotropy of pure and doped samples were done. In the fourth part, effect of light irradiation was done in pure LG and DDLG. It was concluded that the effect of double doping was that double doping increased room temperature piezoelectric constant. However, it was found that that piezoelectric constant decreases with stress. The time dependency for both LG and DDLG showed that, both pure and doped crystals show increasing tendency with time. Approximately, a faster buildup of charge with time was seen in doped crystals as compared to pure crystals. However, anisotropy results indicate that there is no effect of doping on the crystals and both in pure and doped crystals it was found that the piezoelectric constant was minimum along a-direction while it was maximum along c-direction (FIG. 3A- 3B). In the fourth part i.e. Effect of light irradiation in LG and DDLG crystals, no significant change, in piezoelectric coefficient was observed as a result of irradiation(FIG. 4A - 4B).

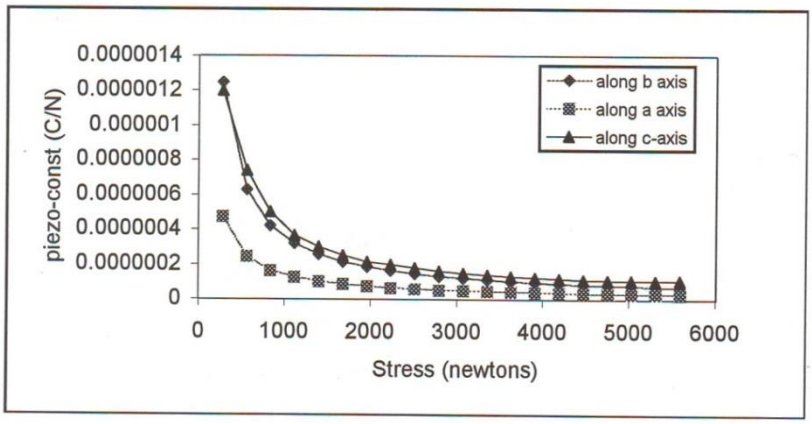

FIG. 3A. **Anisotropy in LG.**

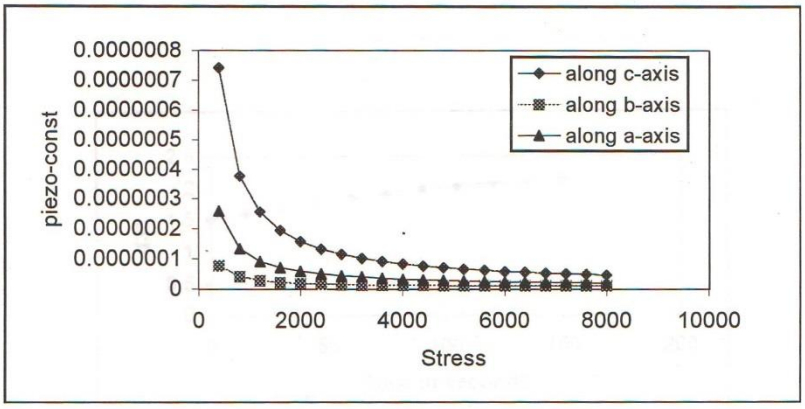

FIG. 3B. **Anisotropy in DDLG.**

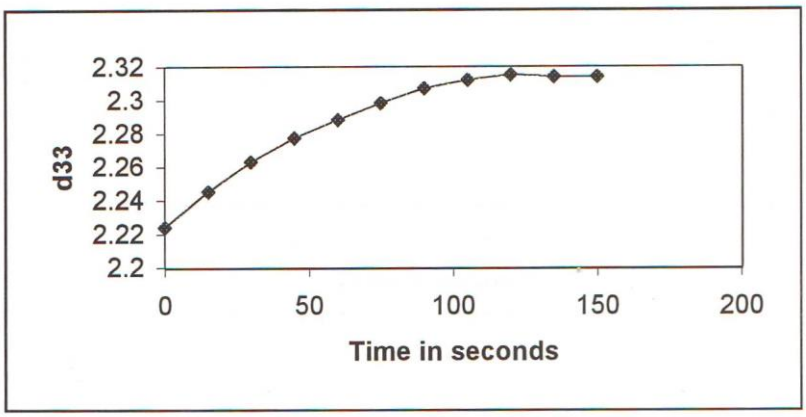

FIG. 4A. **Effect of irradiation in LG.**

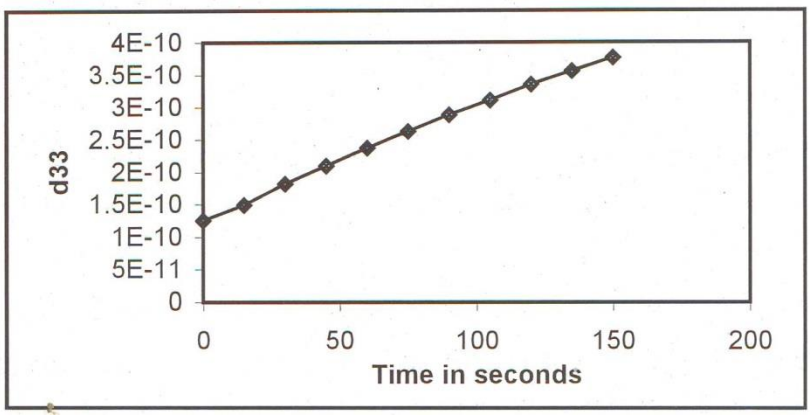

FIG. 4B. **Effect of irradiation in DDLG.**

The range of Keithley Electrometer used to study the piezoelectric effect was from 10 fC to 20 nC in the Coulombs mode, with a lowest resolution of 10 fC and accuracy of +0.4%+4 counts. An irradiation effect less than this order is not detectable and hence with this criterion of least count, it can be safely concluded that irradiation has no effect on the piezoelectric constant of both LG and DDLG.

Decrease in piezoelectric constant with stress was attributed to the movement of domain walls under stress. Also, the effect of increasing temperature and effect of doping can be attributed to the change in domain dynamics. Doping effectively increases both room temperature piezoelectric constant.

TABLE 1 represents the comparison of the values of piezoelectric constant reported of other ferroelectric materials with LG and DDLG. It can be seen from the table that the order of magnitude of our values, agree with those reported by other authors. However, the magnitude of the piezoelectric constant of our crystals, both pure and doped, is far less than the magnitude of the other reported ferroelectric crystals.

TABLE 1. **Comparison of piezoelectric constant values reported of ferroelectric materials with LG and DDLG.**

S. No.	Material	Piezoelectric constant d
1	PZT	93.5×10^{-12} C/N
2	BNTK 16	42.2×10^{-12} C/N
3	BNTK 20	46.9×10^{-12} C/N
4	$KNaNbO_3$	80×10^{-12} C/N
5	$BaTiO_3$	78×10^{-12} C/N
6	PLD PZT	$50\text{-}150 \times 10^{-12}$ C/N
7	Quartz	25×10^{-12} C/N
8	PZN PT	1500×10^{-12} C/N
9	KH_2PO_4	30×10^{-12} C/N
10	LG	0.756×10^{-12} C/N
11	DDLG	2.42×10^{-12} C/N

According to Sugihara [12], the bond strength, bond length, internal field configuration and nature of bonds are all subject to change due to doping. It is thus apparent that the bond strength, bond length and lattice parameters are always subject to change due to impurity substitution. This, in turn can largely influence the piezoelectric behavior. The extent of the influence depends upon the location of the impurity. We have doubly doped our composition with Nd^{+3} and K^{+}. We know that the double dopants in Nd^{+3}+K^{+} doped ferroelectric lead germanate single crystals have changed the lattice parameter in the crystal. According to Iwata, all Ge-O bonds are shorter as compared to all Pb-O bonds. Thus Ge-O bonds are stronger than the Pb-O bonds implying that the Pb-O bonds are comparatively easier to break.

If we compare the ionic radii of the host atom (Pb^{+2}=1.75, O-2=0.65 and Ge^{+4}=1.37 Å) with the ionic radii of the impurities (Nd^{+3}=1.82 Å and K^{+}=2.35 Å) we see that the ionic radii of the impurities are comparable to that of Pb^{+2} only. Thus, on the

basis of bond strength, bond length and ionic radii, we can conclude that the possibility of both the impurity atoms going to Pb^{+2} sites is higher than their going to Ge^{+4} sites.

It is well known that impurities and defects can exert strong influence on the ferroelectric behavior of crystals. From theoretical point of view, the strength of this influence is determined by whether the defects are centrosymmetric or have their dipole moment and whether the dipoles are frozen or can readily change their orientation [13,14].

A dopant can go to Pb^{+2} sites or to the Ge^{+4} sites, its distribution on the two sites being a function of the valence and ionic radius of the dopant and the host atom. The requirement of charge compensation results in the creation of vacancies at the oxygen or lead sites. Katpatal [15] has predicted that the rare earth ion Nd^{+3} enters one or more of the Pb^{+2} sites in lead germanate because of similar ionic radii of lead (1.75 Å) and Neodymium (1.82 Å). This substitution becomes more complicated since for the reason of electro neutrality, $2Nd^{+3}$ ions are equivalent to $3Pb^{+2}$ ions.

Therefore, there is a possibility of the formation of vacancies, presumably at Pb^{+2} positions. This introduces defect states in the lead germanate lattice. In order to compensate for the defect states generated because of non-isovalent substitution of Nd^{+3} at Pb^{+2} site, potassium (K^{+}) has been introduced. It is presumed that K^{+} will occupy the vacancy created at Pb^{+2} sites. Thus the non-isovalent substitution of Nd^{+3}+K^{+} for Pb^{+2} lead to local polarization due to positional disorder. The replacement of Pb^{+2} ions with Nd^{+3} and K^{+} ions changes the binding forces as well as homogeneity in the crystal lattice. Thus, addition of Nd^{+3}+K^{+} leads to microscopic compositional fluctuations and localized disorders.

As stated earlier, the probability of Nd^{+3}+K^{+} entering Pb^{+2} site is most. The double dopants may enter Pb (1) site. The dopants entering the Pb (1) site will affect the bond length between Pb-O and will result in the change in magnitude of displacement of Pb (1), degree of rotation of GeO_4 and twisting and translation of Ge_2O_7 tetrahedral.

In our case, Nd^{+3} and K^{+} both have been substituted and have maximum probability of occupying Pb^{+2} sites. This is also accompanied by creation of defect states of Pb^{+2} ion vacancy and O^{-2} ion vacancy. There is every chance that some of these substitutions may be off-center as suggested by Trubitsyn [16]. There is a high possibility of non-uniform distribution of dopants as well as off-center distribution of Nd^{+3}+K^{+} double dopants in DDLG. Presence of defect states in DDLG envisages space charge formation. This also generates non-uniform distribution of internal field and enhances the ease of domain motion. The increase in the piezoelectric constant as a result of doping can be attributed to the presence of off-center effects and space charge effects.

Conclusion

It was found that there was a decrease in piezoelectric constant with stress. This decrease was attributed to the movement of domain walls under stress. Also the effect of increasing temperature and effect of the role of the double dopants could be attributed to the change in domain dynamics. It was further found that doping effectively increases room temperature piezoelectric constant.

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Nano Structured Single Dipole, Broadband Microstip Antennas at GHz Range

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Abstract

Recent trends and technology demands low profile high bandwidth antenna. The requirement of the antenna is fulfil in multi-crystalline thin film development, which reduce the ground radiations impact on radiation as the radiation become constructive. This research is deal with the thin film development of conducting environment with Fe_20_3, aniline and polyanalline transparent thin film placement as new constructive ground plan below the dipole at certain distance as 1.5mm, 2mm, 2.5mm, and 3mm. These practices implement the reduction in reflection losses with increase in the bandwidth with slightly -6db increase or decreased the reflection coefficient at frequency 4.8GHz. The new thin film is place in layer form as multi layer with the physical dimension less than the effective height of antenna under the dipole. These placements of the film, place the strong environmental element plane for boosting the major lobes radiation and absorber interference for other radiation, which causes the losses. This research deals with the reflection coefficient reduction with the thin film place underneath the feed lines and dipole with the variation of resistance in constructive radiation pattern generation with low profiling and dimension.

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*Keywords:*multicrystalalinity; constructive ground; bandwidth enhancement; interfernce.

1. Introduction

In current wireless communication systems, a growing need for low profile antennas due to their small size and light weight.

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Dipole antennas can be used as low profile antennas; have gained a lot of attention due to their geometrical simplicity, linear polarization and omnidirectional radiation pattern.

However, these antennas do not operate efficiently when placed horizontally close to a PEC (perfect electric conductor) ground plane due to the destructive interference between the radiated fields of the dipole and that of the ground plane. Research is going for a suitable ground plane [1]-[3]. PMC (perfect magnet conductor)- like structures such as umbrella, wire mesh-like structures [3] and electromagnetic band gap (EBG) structure which may provide a PMC effect with a 0^{o} reflection phase [2] have also been looked into. However, the EBG periodic structure would be relatively large and not suitable for communication systems. Also, due to the constructive frequency effect requirement of the EBG structure it is not appropriate for wide band applications.

2. Exponential Technique

The wave absorbing materials, which can absorb the back wave radiation (minor lobes radiation) at a very wide bandwidth, cloud is a better alternative to this problem. The microwave absorbing phenomena of ferrite materials have been reported the use of self-biased Ni-Co ferrite materials for antenna miniaturization [4-6]. Also recently reporting the use of ferrite material for the purpose of enhancing the ground immunity of the dipole antenna[6], we have developed lossy ferrite thin films ($Fe_3O_4^{++}$); fabricated by the low cost thin film technique at, low temperature using spin and spray process, screen printing and spary pyrolysis, in the form of materials on aniline , will not add weight and size the communication system. Also it exhibits a large transmission loss of about -2.5dB at 5.5GHz which place them self as good candidature as wave absorbers in low profile antenna design.

3. Designing and deposition

The designed lossy ferrite film was placed between the dipole antenna and the copper ground plane. The fabricated antennas loaded with Fe_3O_4lossy ferrite films showed greatly enhanced ground immunity, the reflection coefficient of -23.6 dB and -21.8 dB were obtained at the central frequency of antenna with one layer and two layers of ferrite films loading, respectively. The length and diameter of the dipole arm was ~23.5mm and 1.2mm respectively. A quarter wavelength of coaxial cable balun is placed between the dipole and the feeding line. A 221.5 mm×248.5 mm rectangular copper ground plane was placed under the dipole antenna. The schematic of the dipole antenna is shown in Fig 1.1.

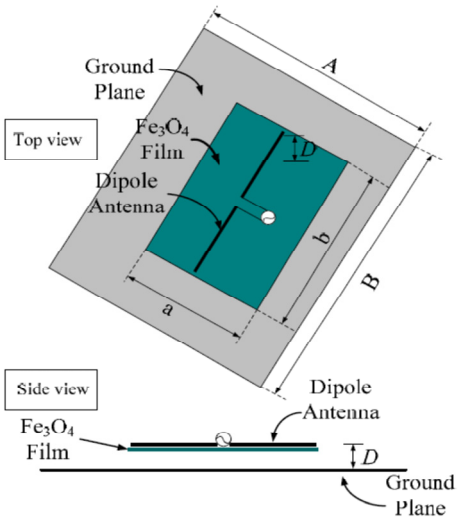

Fig 1.1: Geometry of dipole antenna with Fe3O4 films loaded between antenna and PEC ground plane. A×B=221.5mm×248.5mm, a×b=48mm×52.5mm, D=2mm [7].

1.5,2.0,2.2 µm thick Fe_3O_4 films were deposited onto 48x52.5mm transparency by the spin-spray, screen printing and spray pyrolysis process as described in subsequent topics. The hysteresis loops of the Fe_3O_4 film were measured and showed a coercively of 82 Oe and 177 Oe for the in plane and out plane respectively. The in plane resistivity of the film was 6.32 Ω.cm.6.5 Ω. cm, 6.0Ω.cm To measure the lossy characteristics of our new ferrite films, a coplanar waveguide circuit with 50 Ohm impedance matching on both terminals was employed, as shown in Fig 2 (a), with one layer of Fe_3O_4-ferrite film coated above the coplanar circuit, which as shown in Fig.2 (b). The measured insertion loss at 5 GHz was ~2.44dB as seen in Fig 3, which means that almost half of the transmission energy will be absorbed at 5 GHz. So it is a good candidate of absorbing material for low profile antenna design with enhanced ground immunity.

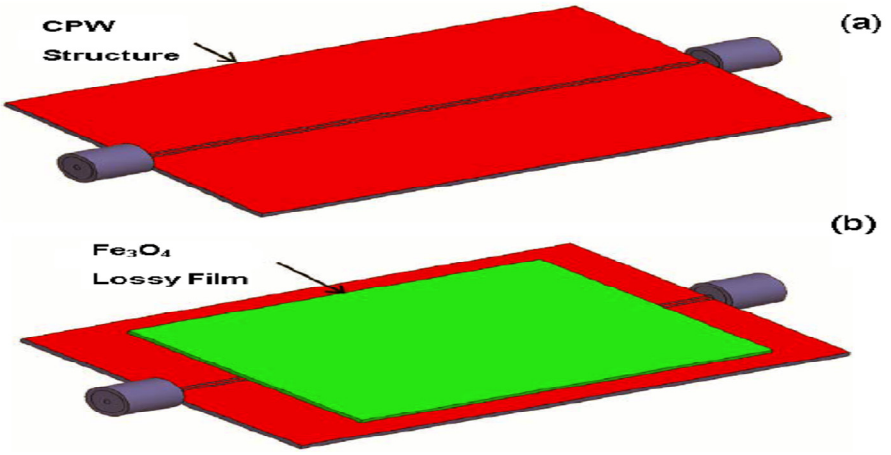

Fig 2: Coplanar waveguide (a) without the ferrite film loading, and (b) with One layer of ferrite film loading

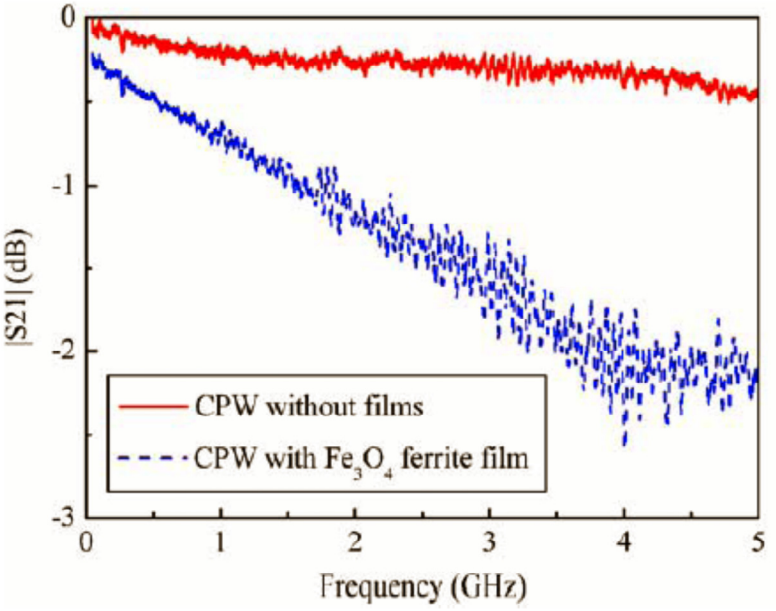

Fig 3: Measured lossy characteristics of Fe_3O_4 ferrite film on the CPW structure[7].

4. Results and discussion

Under the low profile condition of 2mm, four dipole antennas were designed and analyzed; one without the lossy films and PEC ground plane, one with the lossy films but with PEC ground plane, one with the PEC ground plane and one layer of lossy thin films loading and the other with two layers of the Fe3O4 film beneath the dipole. The distance between the films and the dipole was 0.5 mm.

4.1. Reflection losses and bandwidth

The reflection coefficients were measured with the dipole antenna at a fixed position, while the ground plane and Fe3O4 ferrite films were added at different positions. From Fig 5.4, we can see that the central resonant frequency of the non-magnetic antenna is about 5.1 GHz, and the -10 dB bandwidth is 582 MHz. When a copper ground plane was added beneath the dipole antenna at a distance of 2 mm, the reflection coefficient deteriorated to a value of about -6.0 dB at the central frequency. This indicates that at a short distance of 2 mm, the mutual coupling between the dipole antenna and the ground plane is very strong. In order to reduce the mutual coupling between the antenna and the ground plane, one layer of Fe3O4- ferrite film was added just under the dipole antenna. We observed that the resonant frequency shifted to 4.72 GHz, with a slightly enhanced reflection coefficient magnitude of -24.6 dB, indicating the mutual coupling was reduced with loading of lossy ferrite film, and the antenna bandwidth was 465 MHz. When two layers of Fe3O4- ferrite films were added beneath the dipole antenna, the resonant frequency was ~ 4.85GHz, with an S11 magnitude of -20.8 dB.

The antenna bandwidth was about 374 MHz. Clearly, the antenna loaded with lossy ferrite films can indeed enhance the ground immunity between the dipole antenna and the ground plane effectively. In both cases, there were slightly frequency shift, which may be caused by the change of antenna surrounding, i.e. we added the ferrite film at a very short distance, the film itself was a kind of high permittivity material. Therefore effective electric length of dipole with ferrite film was a little bit longer than the dipole without ferrite films. This in turn will result in the frequency shift.

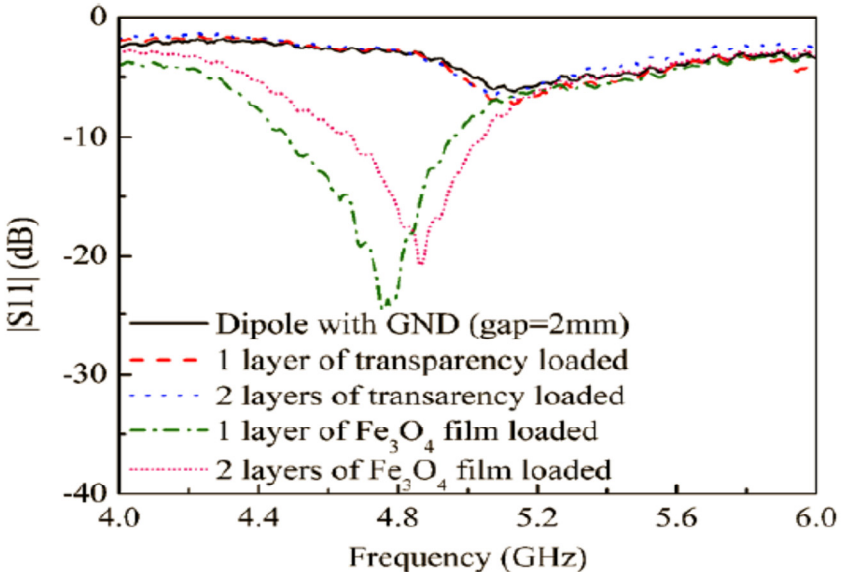

Fig 5.4: Measured reflection coefficient of the antennas with the ground plane 2mm from the dipole [7].

Since the Fe3O4-ferrite film was deposited on the transparency, two dipole antennas with transparency were designed and fabricated in order to analyze the influence of the transparency on the dipole antennas. The transparency was loaded beneath the dipole, at a distance of 0.5mm, just like in the case of the ferrite films. As

shown in Fig 5.4, the reflection coefficient of antenna with transparency is about -6.5 dB. This clearly shows that dipole antennas with one layer or two layers of Fe3O4-ferrite films can improve the ground immunity effectively, while their transparency counterparts have almost nothing to do with the reflection coefficient.

Increasing the distance between the dipole antenna and the ground plane to 3 mm, the reflection coefficients of the antennas were measured. As shown in Fig 5.5, the reflection coefficient is was ~5.15GHz, with an S11 magnitude of -9.5 dB, for the dipole antenna without the ferrite film

loading. When one layer or two layers of transparency were added beneath the dipole antenna, the resonant frequency did not change too much. When two one layer or layers of Fe3O4-ferrite films were added under the dipole antenna, the resonant frequencies were ~4.75GHz and 4.62GHz, respectively. The antenna bandwidth of these two dipole antenna with Fe3O4 ferrite films was 500 MHz. Obviously, the antenna loaded with lossy ferrite films can effectively enhance the ground immunity between the dipole antenna and the ground plane.

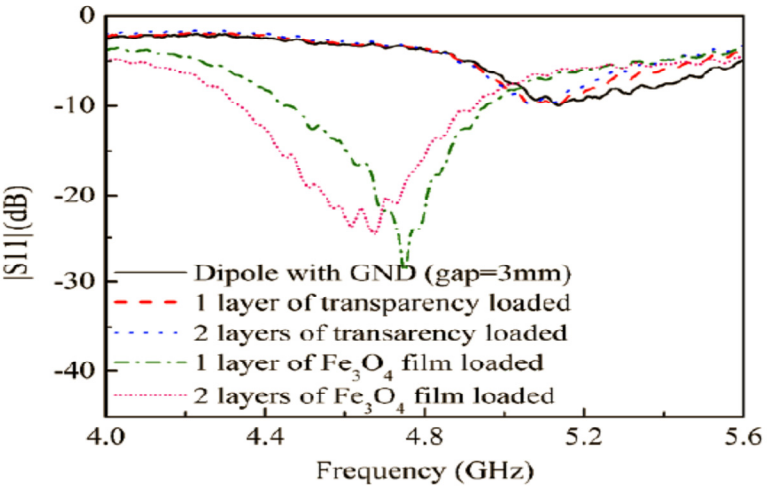

Fig 5.5: Measured reflection coefficient of the antennas with the ground plane 3mm from the dipole [7].

The antenna radiation characteristics were measured in an anechoic chamber with the same input power to the antenna. For the investigation of lossy effects, we measured the received power of the dipole antenna without ground plane, dipole with 1 layer of Fe3O4 film beneath the dipole, and 2 layers of Fe3O4 beneath the dipole. The measured radiation patterns were normalized with the dipole antenna without ground plane, and plotted in Fig 5.6. The received power was about 4.56 mW for the dipole antenna without ground plane. For the ferrite films loading, the received powers were 3.93 mW and 3.69 mW for the 1 layer of Fe3O4 film and 2-layers of Fe_3O_4 film, respectively. This shows that the radiation characteristics are not too affected by the ferrite loading.

Conclusively, a new lossy ferrite film was successful introduced into the design of low profile dipole antenna to enhance its ground immunity by effectively reducing the mutual coupling between the antenna and the ground plane. Since the Fe3O4-ferrite film is very thin, it will neither add weight nor volume to the RF front circuit.

4.2. Improved Performance in GPS Antennas on High-K Materials

Recent widespread use of handheld and wireless communications systems has increased the great demand for smaller, inexpensive antennas [8]. While these requirements can easily be achieved at high frequency bands by using microstrip patch antennas, it may be a design challenge at frequencies in L-band or even lower, due to the relatively large resonant length of the patch. GPS (Global Positioning System) is one such application, where dual frequency operation, bandwidth and circular polarization pose major challenges when using traditional miniaturization techniques [8]-[12]. One of the effective methods to reduce the geometry dimension is by utilizing high permittivity material as the substrate, i.e. using a substrate with a permittivity of 20 or even higher [13].

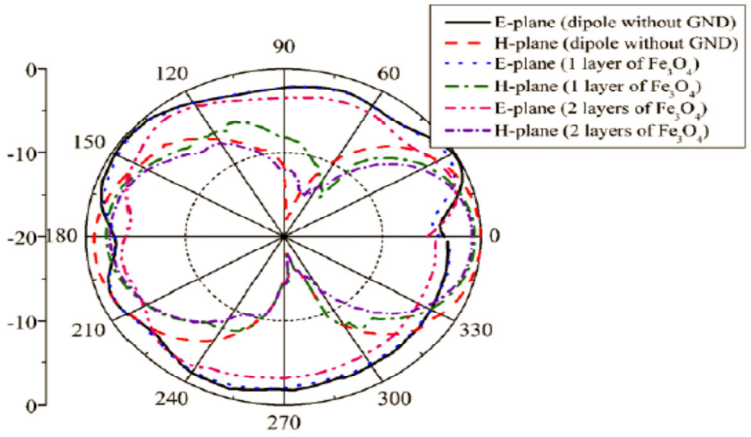

Fig 5.6: Measured radiation patterns of the four antennas [7].

However, probe-fed antennas with high-K materials exhibit several difficulties, especially for the circular polarization antennas, which require an excitation of two near-degenerate orthogonal modes with equal amplitude and 90o phase difference. In order to be practically feasible in miniature antenna applications, such as handheld wireless communication devices, it is important for antenna substrates to be comprised of selfbiased magnetic materials, in which no external bias magnetic field is needed. Magnetic thin films provide a unique opportunity for achieving self-biased magnetic patch antenna substrates with μr>1 at frequencies >1 GHz. Magneto-dielectric substrates with thin magnetic films show great potential in realizing electrically small tunable antennas with improved directivity and higher bandwidth than those realized on dielectric substrates [11]. In this work, we introduce self-biased magnetic films as a practical means to tune a patch antenna by loading a commercially available dielectric substrate.

Novel antenna designs with self-biased ferrite films deposited on Rogers's substrate and High-k substrate were investigated. These magnetic patch antennas have improved the axial ratio from 1.57dB to 0.97dB with respect to the central frequency ranging from 1.575GHz to 1.562GHz, a large radiation frequency tunability of about 40% to 80% of the -10dB bandwidth, and a significantly enhanced directivity. The antenna consists of a rectangular patch with a slot on the right side, and the width of the narrow side of the slot is 0.254 mm, the length is 4.38 mm. A metallic side-wall is adopted to improve the antenna's directivity, with the same height as the dielectric substrate. A circular ground plane with the radius of 101.6 mm is added at the back of the dielectric substrate. The feed point is located on the 45o diagonal, with a distance of 0.38mm along the x-axis. The substrate has relative permittivity of 91.7 and a thickness of 1.0 mm. All the other parameters are listed in the caption of Fig 5.7 (a). 2 μm thick nickel cobalt Ni0.23Co0.13Fe2.64O4) ferrite film was deposited on the substrates by the spin-spray process as described in chapter 2. Using a PVD (physical vapor deposition) system, a 2 μm copper layer as deposited on top of the ferrite layer. Photolithography was then used to develop this copper each of the antennas ground plane. Based on this process four different antennas were designed as shown in Fig 5.7 (b) to (e); one with the ferrite layer above the patch, the second with the ferrite layer below the patch, the third with the ferrite layer above the ground plane and finally with two layers of ferrite film below the patch and above the ground plane. A rectangular patch antenna without any ferrite layer was used as control. In order to prove the validity of this project we first ran detailed HFSS simulations on our material. Fig 5.8(a) shows that the central resonant frequency of the antenna without films is ~1.573 GHz, while the S11 peak magnitude is -14.5 dB. When the ferrite film was added above the patch, the resonant frequency shifted down to 1.572 GHz. With the ferrite film beneath the patch, the resonant frequency is 1.573 GHz with a peak magnitude of - 19.4 dB, indicating a better impedance matching. In the third case, with the ferrite film above the ground plane, the central resonant frequency is 1.568GHz with a magnitude of 20.7 dB, a shift of 5 MHz relative to the non-magnetic antenna.

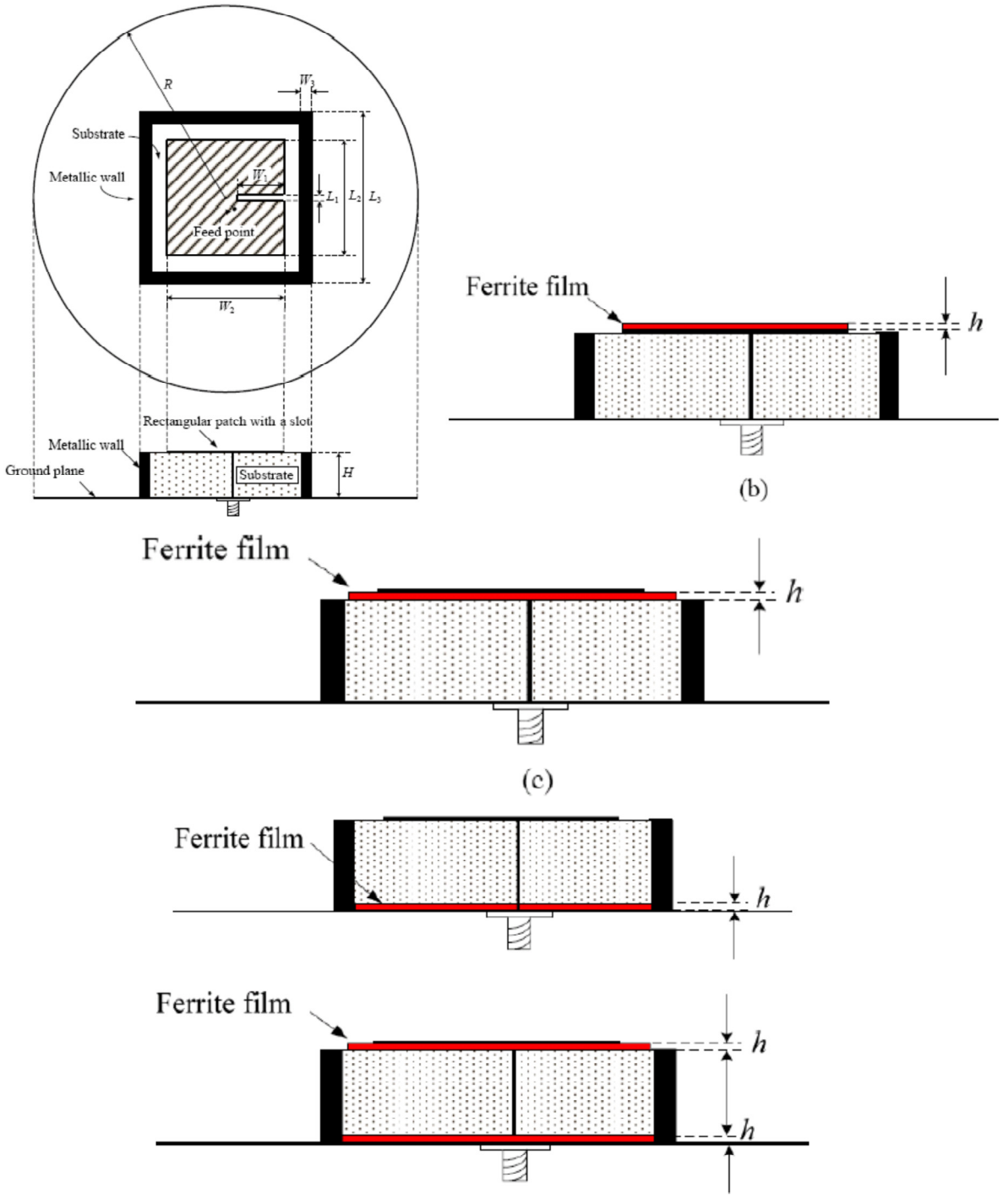

Fig 5.7: Schematic of (a) top and side views of the slot patch antenna with high-K substrate, (b) antenna with magnetic film above the rectangular patch, (c) magnetic film beneath the patch, (d) magnetic film above the ground plane, and (e) magnetic film both above the ground plane and beneath the patch. The thickness of the film ish = 2 μm [17].

Finally with the two films both above the ground plane and beneath the patch, the resonant frequency shifted further down to 1.569 GHz. Therefore the patch antenna combined with ferrite films can improve the impedance matching and shift down the resonant frequency. Also the radiation patterns of these antennas were calculated with the help of HFSS, as shown in Fig 5.8 (b) and (c). We can see that the radiations are unaffected by the ferrite films, thus proving that the miniaturization does not compromise the antenna gain.

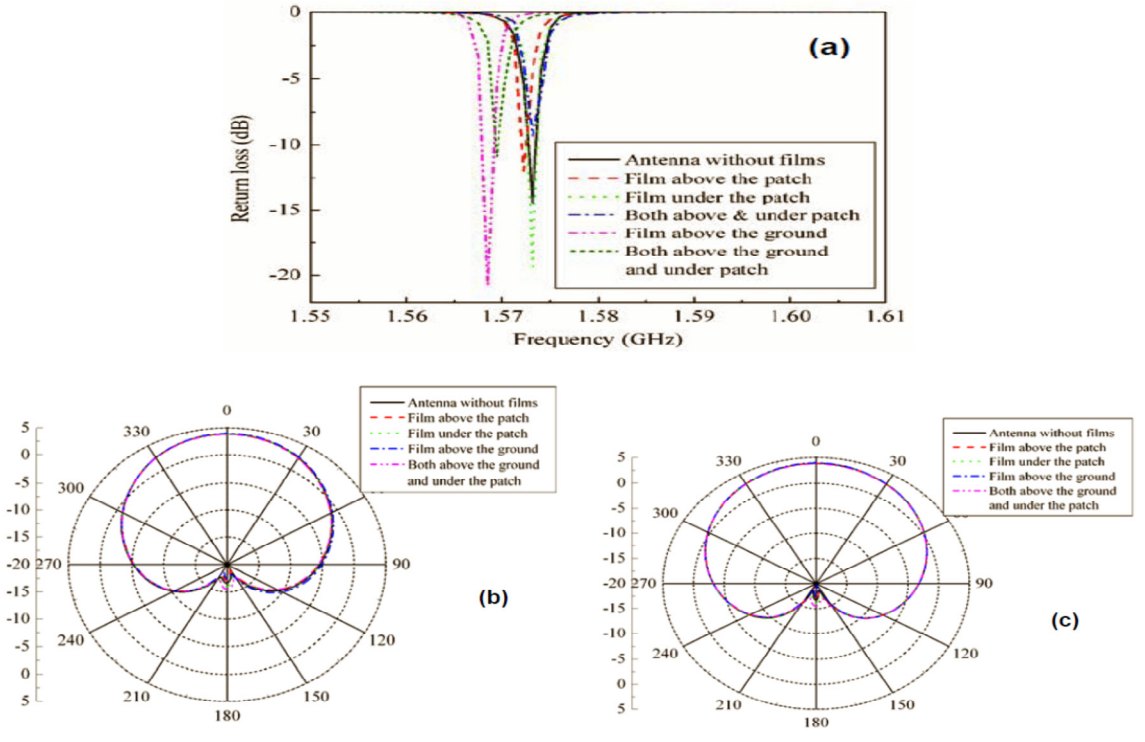

Fig 5.8: (a) Simulated return loss against frequency for the five different cases. (b)Simulated radiation patterns of X-Z plane. (c) Y-Z plane [7].

In this section we have shown that the addition of a spin-spray ferrite layer to the fabrication of a high permittivity substrate patch antenna can help to improve the impedance matching and resonance problems that are generally associated with patch antennas on high dielectric substrates. We have also shown that the microstrip antenna can be minimized by shifting down the resonance frequency with magnetic film loading [7].

4.3. Tuneable Miniaturized Patch Antennas

Achieving relative permeability larger than 1 (μr>1) in antenna substrates can lead to antenna miniaturization, enhanced bandwidth, tunable centre frequency, polarization diversity, and beam steering [16]– [18]. Bulk ferrite materials [19], composites of ferrite particles in polymer matrix, metamaterials with embedded metallic circuits, etc., have been used as antenna substrates for achieving μr>1. However, these bulk ferrite materials or ferrite composites are too lossy to be used at frequencies > 500 MHz under self-bias condition, i.e., no bias magnetic field is needed, and large biasing magnetic fields are needed for these magnetic antennas to operate at higher frequencies. In order to be practically feasible in miniature antenna applications, such as handheld wireless communication devices, it is important for antenna substrates to be comprised of self-biased magnetic materials. However, it has been challenging to achieve self-biased magnetic materials for antenna substrate applications at >500 MHz.

Magnetic thin films provide a unique opportunity for achieving self biased magnetic patch antenna substrates with μr>1 [20]–[22] and operating frequencies >1 GHz. The strong demagnetization field for magnetic thin films, IIdemag = $4\pi Ms$, and large in-plane anisotropy field allow for self-biased magnetization with high ferromagnetic resonance (FMR) frequencies up to several GHz, a necessary condition for operations in the cellular and WLAN bands.

In this section, we report on a patch antenna miniaturized using single layer and multilayer self-biased nickel cobalt (NiCo) ferrite thin films on alumina substrate, thus essentially creating a magneto-dielectric substrate for practical applications. Three different magnetic patch antennas are fabricated by loading the antenna with multilayer ferrite thin films adjacent to the patch. These antennas show enhanced bandwidth and significantly enhanced antenna efficiency. The -5 dBic gain beamwidth is increased from 140o to 155o, 156o, and 160o, for the three magnetic antennas, showing significantly improved omnidirectional performance.

Magnetic patch antennas with self-biased NiCo-ferrite magnetic films were designed, fabricated and tested at 2.1 GHz. The geometry of the patch antenna, designed for operation at 2.1 GHz, is shown in Fig 5.9 (a) and (b). It is a conventional line-fed microstrip patch on an alumina substrate with a thickness of 2 mm. The relative permittivity of the alumina substrate is εr=9.9 and the relative permeability is 1. The copper patch for this non-magnetic antenna has a length $L3$ = 22.2 mm, width $W3$ = 30 mm and thickness of 3 μm. The width of the feed-line is 2.0mm and the length is 22.3mm. All the dimensions are noted in the caption of Fig 5.9.

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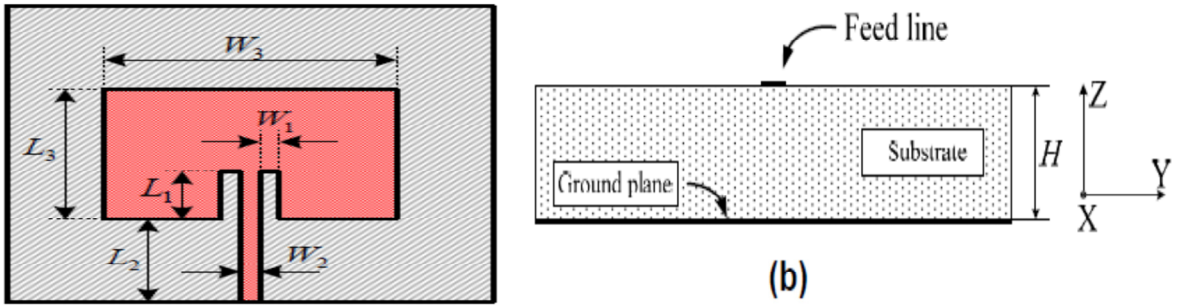

Fig 5.9: Geometry of the non-magnetic rectangular patch antenna. (a) Top view,L1=8.0mm, L2=14.3mm, L3=22.2mm, W1=2.0mm, and W2=2.0mm, W3=30.0mm. (b)Side view, H=2.0mm [7].

2 μm thick, self-biased spinel NiCo ferrite (Ni0.23Co0.13Fe2.64O4) films were deposited by spin-spray processing (as described in chapter 2), onto thin transparency. The films show a pure polycrystalline spinal NiCo-ferrite phase, with no obvious preferential orientations. The films were magnetically anisotropic in the inplane and outplane direction and demonstrated an inplane coercivity of 165 Oe. The in-plane resistivity of the film was 5.6×103 Ω cm, the relative permittivity of the film was 13 and the permeability is ~10. The loss tangent of the NiCo-ferrite film is estimated to be about 0.05 at 2 GHz.

The self-biased Ni-Co-ferrite films were used for magnetic loading on the patch antenna. The large anisotropy field enables a low loss tangent of the ferrite films at several GHz frequencies. Three antennas with single layer and multilayer ferrite films are designed as follows; one layer of the 2 μm Ni-Co ferrite is introduced above the non-magnetic rectangular patch as shown in Fig 5.10 (a), the other two magnetic patch antennas employ either two or three layers of the ferrite film above the patch, as shown in Fig 5.10 (b) and (c), respectively. All the four antennas were fabricated and tested. The measured reflection coefficient for these three antennas with ferrite films is plotted in Fig 5.11, along with that of the non-magnetic patch for comparison. All the measured resonant frequencies and the bandwidth of these four antennas are listed in table 5.1. The non-magnetic patch shows a resonant frequency of 2.146 GHz, and 2:1 VSWR bandwidth of 18 MHz. When one layer of ferrite film is added above the patch; the resonance shifts down to 2.134 GHz, which indicates a tuning range of 12 MHz relative to the non-magnetic substrate.

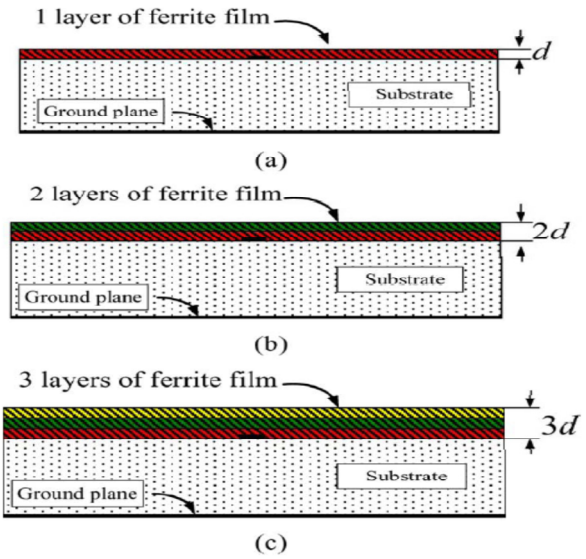

Fig 5.10: Side view of rectangular patch antenna with ferrite films, (a) one layer of ferrite film above the patch, (b) two layers of ferrite film above the patch, and (c) three layers of ferrite film above the patch. d = 2μm [7].

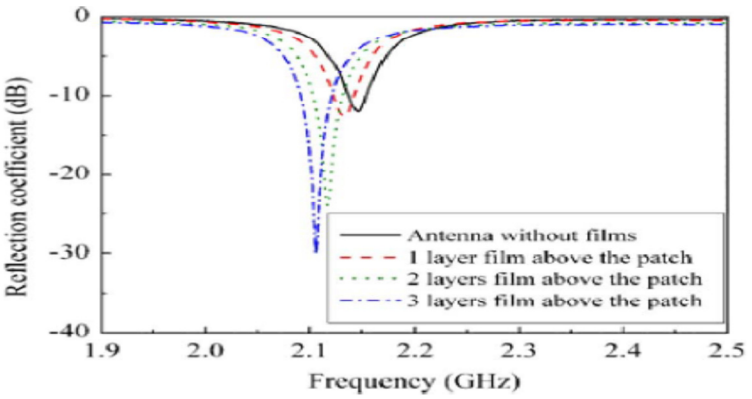

Fig 5.11: Measured reflection coefficient of the patch antennas with/without ferrite films loading.

The bandwidth is 21 MHz with addition of the ferrite film, an increase of 3 MHz compared to non-magnetic antenna. As shown in Fig 5.11, the reflection coefficient also improves with an increase in ferrite film thickness. Clearly the ferrite film loading leads to enhanced bandwidth and improved matching. The addition of two layers of the ferrite film above the patch tunes the resonance down to 2.117 GHz with the minimum reflection coefficient of about -24 dB. The resonant frequency shift is 29 MHz compared with the non-magnetic antenna. Adding three layers of ferrite film above the patch shifts the resonance down to 2.106 GHz, with the best reflection coefficient of -30 dB. We observe a central frequency shift about 40 MHz relative to the baseline non-magnetic patch, and an improved bandwidth of 29 MHz. As summarized in table 5.1, we can see that the antenna efficiency is increased from 41% of the non-magnetic antenna to 56%, 65%, and 74% for the latter three antennas. As mentioned above, substrate loading is one of effective gain enhancement methods for microstrip antennas. The substrate loading of ferrite films combined with the improved impedance matching are the main reasons for the improved efficiency. Also, the films are so thin (2 μm for each layer in our antennas) that the energy loss associated with the loss tangent is not a significant issue in such antennas with an alumina substrate thickness of 2 mm. The antenna gain is enhanced by 0.32, 0.77, and 1.1 dB, respectively, over the non-magnetic antennas.

Table 5. 1: Measured parameters of the four antennas.

	Antenna with film	1 layer of film	2 layers of film	3 layers of film
Resonant Freq. (GHz)	2.147	2.134	2.117	2.106
Bandwidth (MHz)	18	21	28	29
Gain (dBi)	1.3	1.6	2.1	2.4
Efficiency	41%	56%	65%	74%
-5dB Beamwidth (H-plane)	140°	155°	156°	160°

In order to evaluate the antenna gain at the different elevation angles, the gains of the patch antennas with/without ferrite films are plotted in Fig 5.12. From this figure we can see that the gains at the elevation angle of 80o are improved by 1.01, 1.03, and 1.36 dB in the H-plane, and 0.4, 0.74 , and 1.0 dB in the E-plane relative to the unloaded patch, respectively, for the three antennas with ferrite films. The -5 dB gain beam width is increased from 140o to 155o, 156o and 160o, for the three magnetic antennas, showing significantly improved omnidirectional performance.

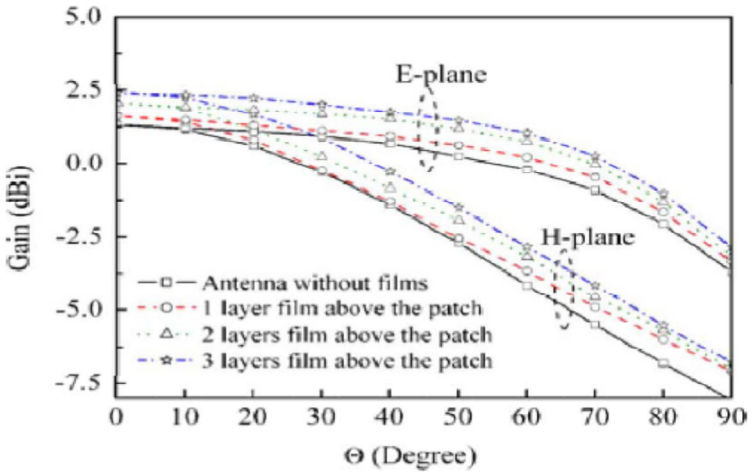

Fig 5.12: The gains of four patch antennas at different elevation angles.

5. Conclusion

A single layer and multilayer self-biased ferrite magnetic films have been introduced as a practical means to tune a patch antenna operating at 2.1 GHz by loading a commercially available substrate. Measurements on magnetic patch antennas demonstrate that the central resonant frequency can be shifted downward over a tuning range of 12–40 MHz, which indicates that self-biased magnetic films do lead to minimized antenna by shifting down the resonance frequency. The antenna bandwidth of the magnetic antennas is enhanced by 3 MHz–11 MHz over the non-magnetic antenna. In addition, the antenna efficiency was increased from 41% to 56%–74% with multilayer ferrite films added onto the antenna. In summary, spin spray deposited self-biased ferrite films provide a unique way

of achieving self-biased magnetic antennas operating at GHz frequency range with significantly enhanced performance.

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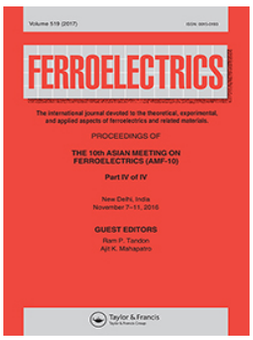

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Structural and magnetic properties of Al substituted nickel ferrite synthesized by sol-gel auto combustion method

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Structural and magnetic properties of Al substituted nickel ferrite synthesized by sol-gel auto combustion method

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ABSTRACT

Nanoparticals of Al substituted nickel ferrite were synthesized by microwave assisted sol-gel auto combustion method and characterised using X-ray diffraction (XRD), transmission electron microscopy (TEM) and vibrating sample magnetometer (VSM). The XRD revealed that the powders obtained are single phase with spinel structure belongs to Fd3m. The average crystallite size calculated using Debey-Scherrer formula found to be in the range of 11–18 nm which were counter verified by using TEM. The magnetic parameters of the synthesized samples were characterised by using VSM. The saturation magnetisation (M_s), coercivity (H_c) was found to decrease with the substitution.

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KEYWORDS
Nickel ferrite; sol-gel; XRD; saturation magnetization; coercivity

1. Introduction

Nickel ferrites have been under intense research as it possesses attractive properties for application as soft magnet and low loss material at high frequencies [1]. Aluminium substituted nickel ferrites are technically important due to their high electrical and low eddy current losses making them more suitable for microwave devices [2].

The structural and magnetic properties of substituted nickel ferrites have been studied by several investigators. Amiradadizadeh et al [3] have reported the decrease in saturation magnetisation and coercivity with increasing aluminium content in nickel cobalt ferrite. It is observed that the decrease is due to replacement of Fe^{3+} by Al^{3+} which weakens the sub lattice interaction. Pissurlekar observed the increase in magnetisation with increase in Zn concentration upto $x = 0.5$ and then decrease for higher Zn concentration in nickel ferite [4]. Singhal et al [5] reported increase in saturation magnetisation and decease in coercivity with increase in cobalt concentration in nickel chromium ferrite.

The present work deals with the synthesis of nanoparticles of aluminium substituted nickel ferrites via sol-gel auto-combustion method and investigation of their structural and magnetic properties by means of X-ray diffraction, TEM and VSM measurements.

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/gfer.

2. Experimental method

Nanoparticles of $NiAl_yFe_{2-y}O_4$ (y = 0.5, 1.5) have been synthesised by sol- gel auto combustion method. The stoichiometric amount of AR grade nickel, iron and aluminium nitrate was used while urea was used as fuel. The mixture of metal nitrate was dissolved in distilled water and the solution was then heated with constant stirring on the magnetic stirrer at 60°C. The wet gel produced fired in a specially designed microwave oven to get the resultant ash powder. The ashes of raw substances obtained were grinded in a pestle mortar for 4 hrs. Finally these samples were annealed at 800°C for several hours at a heating rate of 100° C/hr to get desired nano powder.

The structural characterization of the synthesized samples was carried out by Philips X-ray diffractometer (Model 3710) using Cu K_α radiation of wavelength $\lambda = 1.54$ Å at room temperature.

TEM micrographs were recorded by using transmission electron microscope (Philips model CM 200) to investigate powder morphology as well as grain size.

Magnetic measurements were performed by using commercial Lake – shore vibrating magnetometer (VSM). Magnetic hysteresis was measured at room temperature with maximum applied fields upto 15 KOe. The saturation magnetisation (M_s) and coercivity (H_c) were found from hysteresis loops.

3. Results and discussion

3.1. XRD analysis

The X-ray diffraction patterns of the samples were shown in Figure 1 and 2. The XRD pattern analyzed using X- Powder software and the crystalline phases were identified by comparison with reference data from the JCPDS card No. 520278 for Nickel ferrites ($NiFe_2O_4$). The XRD pattern reveals the single phase cubic spinel structure without any impurity peaks belonging to the space group Fd3m. The particle size of the synthesized ferrite samples has been calculated from the most intense peak corresponding to (311) using the classical Debey-Scherrer formula [6]. The values of the particle size, lattice constant deduced from the X-ray data are given in Table 1.

It was found that the lattice constant decreases with Al^{3+} substitutions. The decrease in the value of the lattice constant with Al^{3+} ion substitution can be explained on the basis of ionic radii. As the larger Fe^{3+} ions (0.67 Å) are replaced by smaller Al^{3+} ion (0.51 Å), the lattice parameter decreases. Similar trend were reported by K. V. Kumar [7].

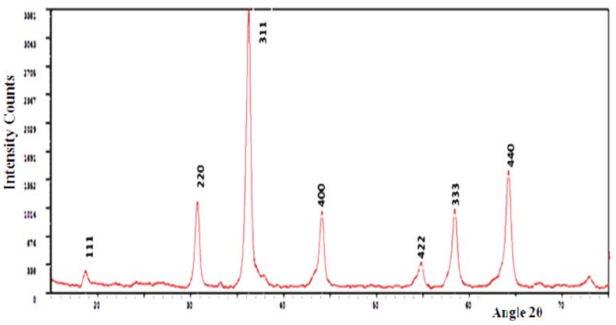

Figure 1. XRD pattern of Ni $Al_{0.5}$ $Fe_{1.5}$ O_4.

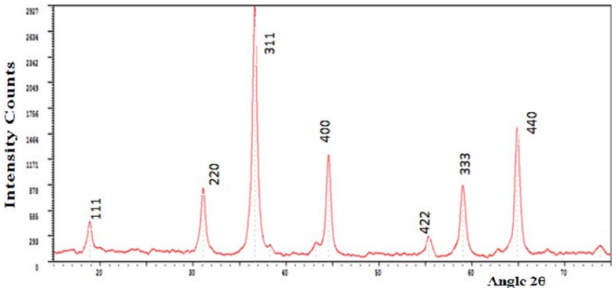

Figure 2. XRD pattern of Ni $Al_{1.5}$ $Fe_{0.5}$ O_4.

Table 1. Lattice parameters, particle size, coercivity and saturation magnetisation of $NiAl_yFe_{2-y}O_4$ (y = 0.5, 1.5).

Sr. no.	Compound	Lattice parameters a (Å)	Particle size (nm)	Coercivity H_c [O_e]	Saturation magnetisation on M_s (emu/g)
1.	Ni $Al_{0.5}$ $Fe_{1.5}$ O_4	8.2487	11.7	230.54	0.0861
2.	Ni $Al_{1.5}$ $Fe_{0.5}$ O_4	8.1243	18.2	234.66	0.0222

3.2. Transmission electron microscope (TEM) analysis

The particle sizes and morphology of $NiAl_{0.5}Fe_{1.5}O_4$ is shown in Figure 3. The particle size determined from TEM was found to be in close agreement with that obtained from XRD studies.

3.3. Magnetic properties

Figure 4 and 5 shows the hysteresis loops for Al^{3+} doped Nickel ferrite with the applied field of 15 KOe. The main magnetic data like saturation magnetisation (M_s), coercivity (H_c) are tabulated in Table 1. It is evident from fig and table that both saturation magnetisation and

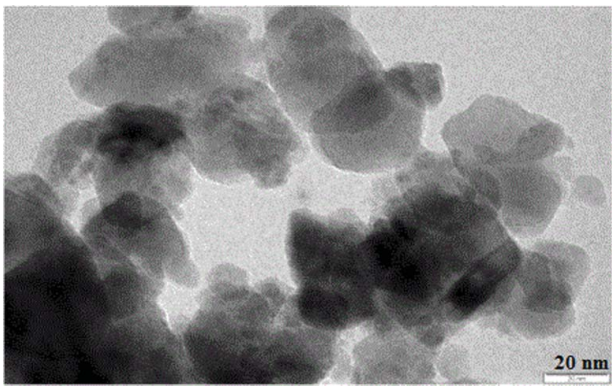

Figure 3. TEM photograph of Ni $Al_{0.5}$ $Fe_{1.5}$ O_4.

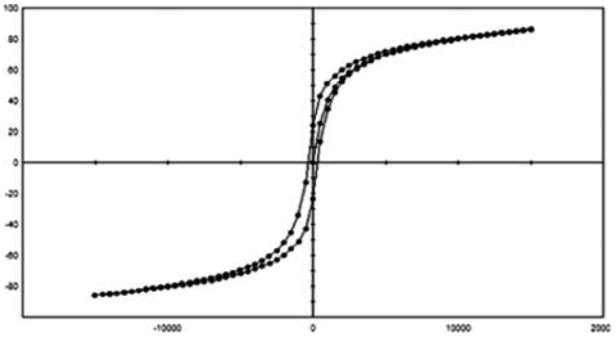

Figure 4. VSM of Ni $Al_{0.5}$ $Fe_{1.5}$ O_4.

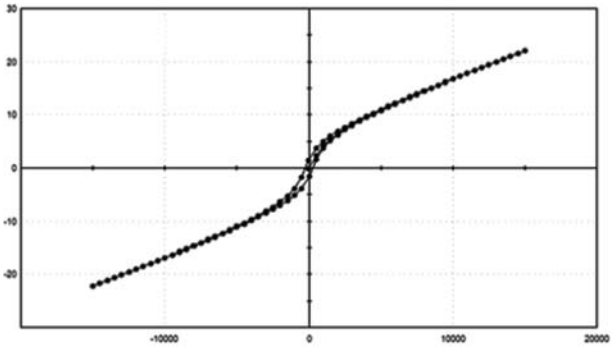

Figure 5. VSM of Ni $Al_{1.5}$ $Fe_{0.5}$ O_4.

coercivity decreases with the increase of Al^{3+} content.The observed decreased in saturation magnetisation could be explained on the basis of cation distribution and exchange interaction between tetrahedral (A) and octahedral (B) sites. Verma et al[8] using Mossbaure's experiment showed that on increasing Al^{3+} concentration, Al^{3+} ion goes to B-site of spinel structure replacing the Fe^{3+} ions from B-site to A-site. According to Neel's two sublattice model, there are three kinds of super exchange interactions in spinel ferrite i.e. A–A, B-B and A-B interaction. The A-B interaction strength is large than A-A and B-B. The net magnetic moment $M = M_B - M_A$ and large M results in higher saturation magnetisation. The substitution of non-magnetic Al^{3+} ion, which has a preferential B site occupancy result in the reduction of super-exchange interaction between A and B sites. The decrease in saturation magnetisation is due to migration of Fe^{3+} ions from B site (M_B) decreases. Therefore the net magnetisation on ($M_B - M_A$) decreases as observed by G. R. Kumar et al [9]. Coercivity decreases with increase in Al^{3+} ion concentration. It could be due to decrease in anisotropy field which is in turn decreases the domain wall energy [10].

4. Conclusion

Al substituted nickel ferrites with the chemical formula $NiAl_yFe_{2-y}O_4$ (y = 0.5, 1.5) have been successfully synthesized by sol-gel auto combustion method. The X-ray diffraction analysis confirmed the formation of single phase spinel structure. The crystallite size was found in the range of 11nm to 18 nm. The lattice parameter decreased with increase in Al

concentration. TEM analysis confirmed the measurements of nanosize by XRD data. The incorporation of non-magnetic Al^{3+} ions in nickel ferrite resulted in decrease of saturation magnetisation and coercivity because replacement of Fe^{3+} by Al^{3+} ions weakens the sub lattice interaction and lowers the magnetic moment of the unit cell.

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लिंगभाव आणि धार्मिक आचारसंहिता
(Gender and Religious Ethics)

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सहाय्यक प्राध्यापक, समाजशास्त्र विभाग,
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सारांश

धर्म आणि संस्कृती यांच्यात मोठ्या प्रमाणात सहसबंध आहे. जेव्हा एखाद्या विशिष्ट संस्कृतीतील लोक विशिष्ट धर्म स्वीकारतात तेव्हा त्यांची संस्कृती त्या धर्मात स्वीकार्य असलेल्या आचारप्रणालीला आणि प्रथांना आत्मसात करू लागते. तसेच जेव्हा विशिष्ट धर्म एखाद्या विशिष्ट संस्कृतीमध्ये स्थापित होतो आणि रुजतो, तेव्हा त्या धर्माची आचारसंहिता,धार्मिक कार्मकांड व्यवस्था आणि नीतिमत्ता यासारख्या बाबी सामान्यतः त्या संस्कृतीच्या तत्त्वांवर आधारित असतात. अशाप्रकारे, धर्माचा त्या त्या समाजाच्या संस्कृतीवर आणि संस्कृतीचा धार्मिक अचारप्रणालीवर प्रभाव पडत असतो. पितृसत्ताक आणि पुरुषकेंद्रित संस्कृती असणाऱ्या समाजामध्ये केवळ राजकारण आणि व्यापारातच नव्हे तर धार्मिक आणि सामाजिक जीवनातही स्त्रियांपेक्षा पुरुषांना अधिक पसंती देण्यासाठी भूमिका आणि दर्जाच्या निश्चितीमध्ये स्त्री आणि पुरुष या जैविक भेदाला श्रेष्ठ आणि कानिष्ठत्वाचा आधार दिल्या गेला आहे. जगातील विविध धर्माच्या धर्मसंहितेत पुरुष आणि स्त्रियांच्या अधिकार, वागणूक ,कर्तव्ये इत्यादीबाबत भेद्भावमूलक बाबी असलेल्या स्पष्टपणे दिसतात. या संशोधन कार्याचा उद्धेश विविध धर्मांच्या अध्यात्मिक मुल्यांवर प्रकाश टाकण्याचा नसून विविध धर्मांच्या आचारसंहिता आणि व्यवहारपद्धतीवर लिंगभावाचा कसा प्रभाव पडला हे अधोरेखित करण्याचा आहे.

अतिमहत्वाचे शब्द (Keywords) : लिंगभाव, धार्मिक आचारसंहिता, धार्मिक , पितृसत्ताक, भूमिका .

प्रस्तावना (Introduction)

स्त्री आणि पुरुष या दोघांमध्ये धार्मिक बांधीलकीबाबत भेद का आहे हा शेकडो वर्षापासून वादाचा विषय आहे. आज देखील या भेदाबाबत वेगवेगळे विचारवंत आणि सामाजिक संशोधक आपापली मते मांडत असतांना दिसतात.. या मतांमधून आणि वादविवादातून एक बाब निश्चितपणे समोर येते आणि ती म्हणजे जगातील बहुतांश धर्माचे संस्थापक हे पुरुष आहेत आणि बहुतांश धर्माचे ग्रंथ आणि त्यातील संहिता या मुख्यता पुरुषांकडे झुकलेल्या किंवा स्त्रियांपेक्षा पुरुष्यांच्या वर्चस्वाला आणि श्रेष्ठत्वाला मान्यता देणाऱ्या दिसतात. त्यामुळे जगातील बहुतांश समाजात पुरुषांच्या तुलनेत स्त्रियांना जीवनाच्या प्रत्येक क्षेत्रात दुय्यम वागणूक मिळत असल्याचे दिसते. कोणत्याही समाजातील धार्मिक आचारसंहिता व पर्यायाने होणारी वर्तणूक ही जर स्त्री आणि पुरुष यांच्यात भेदभाव करणारी असेल तर त्याला धर्मातील लिंगाधिष्ठीत भेदभाव

(Discrimination in Religion) असे म्हणता येईल. धार्मिक तत्वांचा ज्याप्रमाणे समाजाच्या संस्कृतीवर प्रभाव पडतो त्याचप्रमाणे समाजाच्या संस्कृतीचा,त्यातील घटकांचा धार्मिक तत्वांवर, आचार साहिन्तेवर देखील प्रभाव पडत असतो. म्हणूनच अनेक धार्मिक तत्वांमध्ये महिलांना दुय्यम स्थान देण्यात आलेले दिसते.

लिंगभावाची संकल्पना आणि अर्थ (Concept and Meaning of Gender)

लिंग आणि लिंगभाव यामध्ये फरक आहे. लिंग ही जीवशास्त्रीय संकल्पना आहे तर लिंगभाव ही सामाजिक-सांस्कृतिक संकल्पना आहे. लिंग या संकल्पनेतून प्राणी, पक्षी , वनस्पती इत्यादीमधील नर आणि मादी , स्त्री आणि पुरुष यामधील फरक लक्षात येतो . यात श्रेष्ठत्व आणि कनिष्ठत्व अभिप्रेत नसते. परंतु लिंगभाव ही सामाजिक-सांस्कृतिक संकल्पना असल्यामुळे यातून मात्र श्रेष्ठत्व आणि कनिष्ठत्व हा भाव व्यक्त होतो.

स्त्रिया आणि पुरुष यांच्या शरीररचनांमध्ये फरक आहे, पण समाजामध्ये स्त्रिया आणि पुरुषांबाबत जे भेदभाव केले जातात, त्या भेदभावाचे कारण आपल्याला त्यांच्या शारीरिक फरकांमध्ये सापडेलच असे नाही. लिंग हे शारीरिक आहे तर लिंगभाव समाजात घडवला जातो. स्त्रिया आणि पुरुषांना विशिष्ट प्रकारे वाढवले जाते; यात स्त्रियांनी व पुरुषांनी कसे वागावे हे शिकवले जाते. ह्याच स्त्रीत्व आणि पुरुषत्व ह्या कल्पना होत. ह्या कल्पना माणसांच्या वागणुकीवर खोलवर प्रभाव टाकतात. स्त्रीत्व आणि पुरुषत्वाच्या रूढ कल्पना ह्या स्त्रिया आणि पुरुषांना साचेबद्ध करून एकमेकांविरुद्ध उभे करतात. उदा. स्त्रीने सहनशील, नम्र असावे, आज्ञाधारक असावे, सर्वांशी जुळवून घ्यावे अशी अपेक्षा असते. तर पुरुषांना आक्रमक बनायला मुभा असते. ह्या कल्पना स्त्री-पुरूषांवर अवास्तव ओझे लादतात. एखादी स्त्री जोरजोरात बोलली, हसली तर तिच्याकडे पुरुषी म्हणून बघितले जाते. घरकाम, चूल-मूल ही बाईची जबाबदारी तर घराबाहेरच्या जबाबदाऱ्या पुरुषाच्या मानल्या जातात. मुलींना लहानपणी खेळायला बाहुली, भातुकली तर मुलांना सायकल, कार, बंदूक अशी खेळणी दिली जातात. प्रौढ वयात येणाऱ्या जबाबदारीचे प्रशिक्षण लहान वयातच सुरू होते. स्त्री-पुरुषामधला शारीरिक फरक हा प्रामुख्याने त्यांच्या पुनरुत्पादनासंदर्भातील भिन्न जबाबदाऱ्या हा आहे. पुरुषाकडे रेतन तर स्त्रीकडे गर्भारपण, बाळंतपण आणि स्तनपान अशा प्राकृतिक जबाबदाऱ्या आहेत मात्र या पलीकडे कोणतीही कामे स्त्री/पुरुष कोणीही करू शकतात. उदा. स्वयंपाक, घरसफाई, शिवण-टिपण, शेतातले काम, डॉक्टर, नर्स, इंजिनिअर, शिक्षक इ.इ. मात्र घरकाम आणि बालसंगोपन ह्या आजही स्त्रीच्याच प्राथमिक जबाबदाऱ्या मानल्या जातात. इतक्या की बाहेरच्या जगातही स्त्रियांना बहुतेकदा घरकामाची विस्तारीत कामे मिळतात उदा. शिक्षिका, नर्स, स्वागतिका अशा प्रकारच्या कामात स्त्रियांचा अधिक भरणा असतो. या लिंग भावाचा उल्लेख जेंडर असाही केला जातो. थोडक्यात असे म्हणता येईल की लिंगभाव म्हणजे स्त्रियांचा वेगळा विचार नव्हे तर लिंगभाव म्हणजे एखाद्या समाजातील स्त्रिया आणि पुरुषांची सापेक्ष सामाजिक स्थिती होय.

अशा तऱ्हेने लिंगभाव हा सामाजिक -सांस्कृतिक संरचनातून घडवला जातो उदा. जात, धर्म, वय इ. वेगवेगळ्या संस्कृतींनुसार लिंगभाव बदलत राहतो. पुरुषप्रधान समाजात लिंगभावाची जडणघडण पुरुषांना झुकते माप देणारी असते आणि तुलनेने स्त्रियांना पक्षपाताला अधिक तोंड द्यावे लागते. पुरुष कुटुंबप्रमुख, पुरुषाकडे मालमत्तेची मालकी, लग्न झाल्यावर स्त्रियांनी सासरी जाणे, पितृवंशीय व्यवस्था ह्या सामाजिक प्रक्रिया आपली समाजव्यवस्था पुरुषप्रधान असल्याचे दर्शवतात. अशा समजात स्त्रीचे स्थान दुय्यम बनते. ह्याचा एक गंभीर

परिणाम म्हणजे स्त्रियांवर होणारे अत्याचार. बहुतेकदा स्त्रियांना आपल्या दुय्यम स्थानामुळे अत्याचारांना तोंड द्यावे लागते. धार्मिक बाबतीतही पुरुषांना श्रेष्ठत्व तर स्त्रियांना गौणत्व प्राप्त झालेले आहे.

धार्मिक आचारसंहिता आणि आचरण

सामान्य शब्दात, आचारसंहिता म्हणजे एखाद्या व्यक्तीला निर्देशित आणि नियंत्रित करणारी नियामनांची व्यवस्था. किंवा मानवी कृतीला योग्यतेशी किंवा अयोग्यतेशी जोडणारी नियामांची चौकट म्हणजेच आचारसंहिता होय.

डिक्शनरी नुसार, 'देवावरील श्रद्धा आणि त्यासाबंधीचे विधी किंवा कर्मकांड म्हणजेच धर्म होय.'. विशिष्ट ईश्वरावर श्रद्धा ठेवून त्यावर आधारित तत्वप्रणाली, जीवनप्रणाली असणे म्हणजे धर्म होय. आदिम काळापासून मनुष्याची नैसर्गिक प्रवृत्ती आहे, की जे काही गूढ आहे, अगम्य आहे आणि जी एक अनामिक शक्ती या विश्वात आहे, त्यावर विश्वास ठेवायचा. त्याची पूजा-अर्चना करायची. मग ती निसर्ग देवता असो, अथवा देवतेचे मूर्त स्वरूप असो किंवा देवाची आराधना करायची एखादी जागा असो, मनुष्यातील शक्ती, सृजनशीलता, नवनिर्मितीची शारीरिक आणि मानसिक क्षमता असो. कोणासमोर नतमस्तक व्हायचे याचे स्वरूप वेगवेगळे; पण उद्देश एकच, त्या शक्तीने, देवाने आपले भले करावे, आयुष्यात दु:ख कमी द्यावे किंवा देऊच नये किंवा येऊ घातलेले दु:ख हरावे आणि आपल्या सार्‌या मनोकामना पूर्ण व्हाव्यात. धर्मानुसार आचरण केल्याने मोक्ष प्राप्ती होते आणि जन्म-मरणाच्या फेर्‌यातून मनुष्याची सुटका होते, असा सार्वत्रिक समज किंवा विश्वास देवावर, धर्मावर श्रद्धा ठेवणार्‌यांमध्ये असतो. धार्मिक आचारसंहिता या त्या त्या धर्माच्या धार्मिक ग्रंथात सूचीबद्ध केलेल्या असतात उदा, बायबल, कुराण,त्रिपिटक, गुरुग्रंथ साहिब,इत्यादी तर काही वेळा त्या परंपरेने चालत आलेल्या दिसतात उदा. आदिवासींच्या धार्मिक संहिता किंवा कर्मकांड.

धार्मिक आचारसंहिता आणि व्यवहार यामध्ये लिंगभाव प्रतिमान

(Gender Pattern in Religious Ethics and Practices)

काही उपलब्ध आकडेवारीनुसार (Beit-Hallahmi and Argyle, 1997; Pew Research Center, 2014), स्त्रिया या पुरुषांपेक्षा जास्त धार्मिक असतात, विशेषता ख्रिस्चन धर्मीय स्त्रिया. हे तेव्हा घडते आहे जेव्हा बहुतांश धर्माचे संस्थापक हे दिव्य पुरुषच आहेत उदा. अब्राहम, मोझेस, गौतम बुद्ध, येशू ख्रिस्त, मोहम्मद पैगंबर इ.

'पीव रिसर्च सेंटर' ने 2008 ते 2015 दरम्यान 192 देशांमध्ये विविध धर्मीय लोकांच्या केलेल्या संशोधनामध्ये असे दिसून आले की, पुरुषांपेक्षा स्त्रियामध्ये धर्माबाबत बांधिलकी जास्त प्रमाणात असते, त्या जास्त धार्मिक वृत्तीच्या असतात. धार्मिक संशोधक असे म्हणतात की, याला कारण 'नैसर्गिकता' आणि 'संगोपन' हे दोन घटक जबाबदार आहेत. बेट-हलहामी आणि अर्जील यांनी 1997 मध्ये केलेल्या संशोधनात हे मान्य केले आहे कि, अ) स्त्रिया या पुरुषांपेक्षा अधिक भावनाशील असतात आणि म्हणून दोष ,पश्चाताप किंवा कृतज्ञतेच्या प्रसंगी धार्मिकतेकडे वळतात. ब) स्त्रियांचे सामाजीकरण हे धार्मिक मूल्यांनुसार होते तर तुलनेने पुरुषांचे फारच कमी. क) स्त्रिया या धर्माकडे सामाजिक संरचनेचा एक नैसर्गिक परिणाम म्हणून बघतात तर पुरुषमात्र फारच कमी प्रमाणात तसे बघतात.

वरील उल्लेखित काही संशोधनाचे अपवाद मान्य केले तरी धार्मिक संघटनाचे संचालन, नियंत्रण ,धार्मिक शिक्षण आणि पूजा-पाठ या सर्व गोष्टींमध्ये स्त्रियांपेक्षा पुरुषांचेच प्रभुत्व राहत आलेले आहे.

एकेश्वरवादी आणि बहुदेववादी अशा दोन्ही प्रकारच्या धर्मात लिंगभाव प्रकर्षाने दिसून येतो. एकेश्वरवादी ख्रिस्चन धर्मात 'ट्रिनीटी' तील दुसरी व्यक्ती म्हणून केवळ एकच पुरुष मसीहा अवतीर्ण झाला आणि तो म्हणजे येशू ख्रिस्त. इतर दोघे, 'फादर' आणि पवित्र आत्मा' यांना पुलिंगी ऐवजी नपुसकलिंगी मानले जाते. बायबल नुसार,पहिली महिला, 'इव्ह' हीला पहिला पुरुष आदमच्या बरगडी पासून तयार करण्यात आली. ज्यू आणि ख्रिस्चन धर्मीय लोक बरेचदा पितृसत्ताक पद्धतीचा बचाव करण्यासाठी या उदाहरणाचा दाखला देतात. दुसरीकडे, इस्लाम मध्ये मात्र आदम आणि हव्वाह(इव्ह) यांच्या उत्पत्तीबाबत स्पष्ट असे काहीही सांगितलेले नाही.

ज्यू,ख्रिस्चन आणि इस्लाम या धर्माचे संस्थापक व प्रमुख वारसदार पुरूषच आहेत, ते असे, यहुदी(ज्यू) धर्मात अब्राहम, मोझेस, डेविड ,इलीजाह इ., ख्रिस्ती धर्मात जोन बाप्तीस्त,येशू ख्रिस्त आणि त्याचे शिष्य आणि पाल , इस्लाम धर्मात मोहम्मद पैगंबर आणि त्याचे वारसदार अबू बकर,उथमानिब्न अफान, ली नीब्न अबी तालिब आणि बारा इमाम . हे सर्व पुरुषच आहेत. हे सर्व धर्म पितृसत्ताक संस्कृतीत स्थपित झाले कि ज्यामुळे त्यांची आराधना तसेच संचालन आणि नियंत्रण पुरुषांपुरतेच मर्यादित झाले, ख्रिस्चन समुदाया मध्ये चर्च फादर आहे , चर्च मदर मात्र नाही. याला अपवाद फक्त कॅथोलिक चर्चमधील महिला संतांचा. अधिपासुंन धर्मासाठी कार्य करणाऱ्या पुरुष धर्मप्रसारकांच्या तुलनेत महिला धर्म प्रसारकांच्या कामाची तेवढी दाखल घेतली जात नाही आणि त्यांना प्रसिद्धीही दिली जात नाही. आपल्या दोन हजार वर्षाच्या कालखंडात कॅथोलिक चर्चने एकही महिलेला पोप पद दिले नाही. पितृसत्ताक समाजात केवळ पुरूषच प्रबुद्ध-ज्ञानवंत होऊ शकत होते आणि महिला मात्र इतिहासही घडवू शकत नव्हत्या आणि संस्कृतीसाठी काही देऊही शकत नव्हत्या असे खेदाने म्हणावे लागते. महिलांना धर्मच काय तर सामाजिक, आर्थिक, राजकीय इ बाबतीत कोणतेही अधिकार नव्हते . स्त्रीवादी लोकांच्या दबावामुळे अगदी 19 व्या शतकापासून महिलांना काही अधिकार द्यायला सुरुवात झाली.

पारंपारिक ज्यू धर्मीय लोकांत दर्जा श्रेणीमध्ये महिलांना असणार्या संधी नाकारल्याच जात नाही तर त्यांना हीन पानाची वागणूक दिली जाते. 'लक्ष विचलित करणाऱ्या वस्तू' म्हणून प्रार्थनेच्या वेळी महिलांना पडदा किंवा भिंत याद्वारे पुरुषांच्या नजरेपासून दूर ठेवले जाते

इस्लाममध्ये महिलांना इमाम किंवा धर्मगुरू होता येत नाही. ज्यू प्रमाणेच इस्लाम धर्मीय स्त्रियांनाही लक्ष्त विचलित करणाऱ्या वस्तू समजून प्रार्थना आणि उपासनेच्या प्रसंगी त्यांना पुरुषांशी कोणत्याही प्रकारची आंतर्क्रिया करण्याची परवानगी नाही. एवढेच नव्हे तर कुराननेही त्यांना थेट असे कोणतेच अधिकार दिलेले नाहीत त्यांना इस्लामिक धर्मगुरूंच्या फतव्या नुसार, महिलांनी अत्तर लावणे, नेल पौलिश लावणे, लिपस्टिक लावणे म्हणजे पुरुषांच्या लैंगिक भावना चाळवणे होय असे म्हटले जाते. नमाज पठण हा प्रामुख्याने पुरुषांचा मक्ता मनाला जातो, महिला बुरखा घालून पुरुषांच्या मागे राहून किंवा दुसर्या खोलीमध्ये नमाज पठाण करतात. इस्लामिक संहितेद्वारे प्रार्थना आणि सामाजिक जीवन यात स्त्री आणि पुरुषांमध्ये आंतर्क्रिया किंवा संवादाच होणार नाही याची पुरेपूर काळजी घेण्यात आली आहे. अफगाणिस्तान सारख्या देशात महिलांनी एकटीने घराबाहेर पडणे, शिक्षण घेणे, नोकरी करणे, खेळ खेळणे इ. वर बंदी घातली आहे. 25 सप्टे. 2011 ला सौदी अरेबियाचे राजे अब्दुल्लार यांनी महिलांना मतदान आणि निवडणुकीत उभे राहण्याचा अधिकार देण्याची घोषणा केली तेव्हा जगणे त्या चे स्वागत केले पण अजूनही काही देशात असे अधीकार नसल्या बाबत काहींनी आश्चर्य ही व्यक्त केले. मुस्लीम धर्मात मुस्लीम व्यक्ती मुस्लीम, ज्यू आणि ख्रिस्चन धर्मीय मुलीशी विवाह करू शकतो पण मुस्लीम मुलगी मुस्लीम व्यक्तीशिवाय अन्य कोणाशी विवाह करू शकत नाही.

पतीच्या साध्या तीन तलाक म्हटल्याने मुस्लीम स्त्रीचा विवाह तुटतो. हिंदू धर्मात देखील शुद्र, पशु आणि नारी हे तदानाचे अधिकारी म्हटले आहे ,मासिक पाळीमुळे महिलांना मंदिरात जाण्याचा मज्जाव केला जातो. सतीप्रथा , केशवपन , बालहत्या, शिक्षण बंदी ,विधवा पुन:र्विवाह बंदी इ धार्मिक रूढी होत्या ज्या काळाच्या ओघात नष्ट होत व्चालाल्या आहेत. आजही महिलांना धर्मगुरू होता येत नाही.

एकंदर, धार्मिक जीवनात महिलांना पत्नी, आई आणि घर सांभाळणारी या भूमिकेतच पाहावे लागते.

निष्कर्ष

धार्मिक आचारप्रणाली आणि प्रथा ह्या समाजातील सर्व लोकांची अभिवृत्ती आणि वर्तनावर प्रभाव पाडतात. धार्मिक प्रथा संस्कृतीला आकार देतात आणि संस्कृती धार्मिक प्रथांना आकार देते.

धर्मानुसार आचरण म्हणजे मोक्षाचा राजमार्ग. पुरातन धर्मकारांच्या मतानुसार स्त्रीजातीला मोक्ष नाहीच. थोडक्यात, स्त्रीचा एक माणूस म्हणून विचार धर्मकारांनी केलेला नाही. स्त्रीचे शारीरिक वेगळेपण तिच्या मोक्ष मार्गाच्या आड येते. तिला एकतर देवी, माता अशा उच्चपदावर ठेवायचे किंवा पुरुषाला मोहात पाडणारी, म्हणून तिच्या अस्तित्वाला दुय्यम ठरवून, हीन दर्जाचे आयुष्य जगण्यास भाग पाडायचे. धर्माच्या नावाने स्त्रीविश्वाचा आवाका संकुचित करण्यास धर्मकारांनी, धर्मगुरूंनी, समाजाने आणि कुटुंबियांनी कुठलीही कसर ठेवली नाही. शतके लोटली, स्त्रिया धर्माच्या सावलीत घुसमट सहन करीत राहिल्या. ही सावली सुखावह नव्हे हे निश्चित.

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MIDGUT DIGESTIVE ENZYME ACTIVITY IN THE DRAGONFLY, *TRAMEA VIRGINIA* (RAMBUR) (ANISOPTERA: LIBELLULIDAE) AND ITS SIGNIFICANCE IN SEXUAL DIMORPHISM.

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Abstract: **The paper describes the physiocochemical properties and activity of digestive enzymes- amylase, invertase, protease and lipase in the midgut of the adult dragonfly, *Tramea virginia*(R). The maximum enzyme activity was observed at pH 6.98 for amylase, pH 6.9 for invertase, pH 7.0 for protease and pH 6.47 for lipase. The incubation period of enzyme activities was found at 40, 40, 45mins and 24 hrs for amylase, invertase, protease and lipase, respectively. The amylase, invertase and protease showed maximum activity at the enzyme concentration of 0.5 ml, while lipase showed optimal activity at 1 ml of enzyme concentration. At substrate concentration of 2% starch and sucrose,2.5% casein and 1.5%, olive oil the activity of amylase, invertase, protease and lipase was optimal. The activity of amylase and invertase was observed maximum in 0.015M buffer concentration, while the activity of protease and lipase was optimal at 0.25Mbuffer concentration. There is marked sexual dimorphism in midgut enzyme activity of this dragonfly. The midgut amylase, invertase, protease and lipase activity in the mature female was comparatively higher than that in the mature male, which seems to be in accordance with the heavy investment of reserve food material during vitellogenesis in the ovaries.**

Kyewords: **T*ramea virginia*, dragonfly, midgut, digestive enzymes, sexual dimorphism.**

Introduction

Insects exhibit a wide variation in their food and feed upon a remarkably diverse list of organic substances (WALDBAUER, 1968). Of the known insect species 361,000 are herbivorous, whereas 431,000 are blood feeders, predaceous or parasitic (STRONG *et al.*, 1984). Dragonflies are solely carnivorous, feeding on any being that moves and can be captured (CORBET, 2004). Therefore, a great variation is observed in the biochemical aspects of digestive enzymes of different insects. This aspect has been reviewed by a large number of insects and the major enzymes detected in the digestive

tract of insects are amylase, invertase, trehalase, protease and lipase (HOUSE, 1974). A comprehensive histochemical analysis of the digestive tract of insects was review by STRAMBI (1971). Investigations on the digestive enzymes was undertaken and reviewed by a large number of workers who have also studied the enzyme activities at different physico- chemical factors (ISHAAYA *et al.,* 1971; DADD, 1970; ISHAAYA *et al.,* 1971; ISHAAYA & PLAUT, 1974; AGRAWAL & BAHADUR, 1981; MANDAL *et al.,* 1981; CHRISTOPHER & MATHAVAN, 1985; INDURKAR & TEMBHARE, 2011; BHUVANESHWARI & SIVAPRASAD, 2012 b). FIGUEROA *et al.,* (2011) studied the variation in the digestive enzyme activity of two stoneflies species, Hemimelaena *flaviventris* and *Isoperl amorenica.* ZHAO *et al.,* (2017) studied the digestive enzyme activity in female adults of the cricket *Velarifictorus ornatus* and observed significant raise in amylase activity in large winged females than small winged females. Sexual dimorphism in enzyme activity has been reported in few insects (BAUMANN, 1990) mostly belonging to the Class Lepidoptera, Orthoptrea and Hemiptera (GAIKWAD & BHAWANE, 2015).

There is however, no substantial study on digestive enzymes in the order Odonata. The present work was, therefore undertaken to elucidate physico-chemical properties of the digestive enzyme and its significance in sexual dimorphism in the dragonfly *Tramea virginia.*

Material and Method:

Preparation of enzyme extract

The method of APPLEBAUM et al., (1964) with little modification was adopted for the preparation of enzyme extract. The dragonflies were dissected in live condition. The head and posterior tip of the abdomen was cut off and the entire alimentary canal was pulled out in buffer. The midgut was separated from the alimentary canal. The Malphigian Tubules and tissue attached to it were carefully removed. The gut was flushed to remove the content in the lumen. Thereafter, the midgut was weighed and homogenized for 3 minutes in ice-cold phosphate buffer (6.8 pH). A brief of the midgut was suspended in ice-cold buffer and volume was adjusted to 1 ml. The homogenate was centrifuged at 10,000 RPM for 15 minutes. The supernatant obtained was used as enzyme source to detect the activity of various digestive enzymes viz. amylase, invertase, protease and lipase.

For individual parameters, the digestive enzymes were detected keeping the other parameters constant. The parameters analyzed are substrate concentration, hydrogen-ion concentration, buffer concentration, enzyme

concentration, temperature and incubation period.

During the present study various physicochemical factors *viz.* substrate concentration, hydrogen ion concentration, buffer concentration, enzyme concentration, temperature and incubation period required for the optimum enzyme activity of the individual midgut digestive enzymes, *viz.* Amylase, Invertase, Protease and Lipase was determined by biochemical methods. To determination of maximum concentration of a particular physicochemical factor, variable concentrations of that parameter were tested but at the same time concentration of the other parameters promoting optimum enzyme activity were kept constant. The methods to estimate the activity of various enzymes and their units are described in the Table-1

Table 1: Biochemical method for the estimation of activity of various enzymes

S. N.	Enzyme	Substrate	Colour reagent	Wavelength (λ)	Unit	Reference
1.	Amylase	Starch	DNSA	540	mg glucose liberated/midgut /30 min	ISHAAYA & SWIRSKI (1970)
2.	Invertase	Sucrose	DNSA	540	mg glucose liberated/ midgut/30 min.	ISHAAYA & SWIRSKI (1970)
3.	Protease	Casein	Folin-phenol	660	mg peptide liberated/midgut /30 min.	LOWERY'S *et al.*, (1951)
4.	Lipase	Olive oil	Phenolphthalein	-	mg oleic acid liberated/midgut /24 hr.	CHERRY & CRANDAL (1932)

DNSA - Dinitrosalicyclic acid reagent.

Results

1. AMYLASE

Substrate concentration

The optimum substrate concentration (starch) for amylase activity is determined after the reaction tested with variable concentration ranging from 1 to 3.5%. Amylase activity increases from 0.18 mg glucose/midgut/30 min at 1% substrate to 0.33 mg glucose/midgut/30 min at 2% starch solution concentration. The enzyme activity beyond this concentration remains stable (Fig.1).

Hydrogen-ion concentration

Amylase activity increases rapidly from 0.04 mg glucose/midgut/30 min at pH 5.29 to 0.16 mg glucose/midgut/30 min at pH 6.98. Thereafter, the activity reduces with the increase in pH and drops to 0.13 mg glucose/midgut/30 min at 7.38 pH (Fig.2.).

Buffer concentration

The amylase activity increases moderately from 0.04 mg glucose/midgut/30 min at 0.001 M upto 0.17mg glucose/midgut/30 min at 0.015 M. With an increase in buffer concentration, the enzyme activity falls down to 0.08 mg glucose/midgut/30 min recorded at 0.02 M concentration (Fig. 3).

Enzyme concentration

The amylase activity is observed to increase from 0.09 mg glucose/midgut/30 min to 0.26 mg glucose/midgut/30 min from 0.1 to 0.5 ml enzyme concentration, respectively. The activity, thereafter, remains constant even at high enzyme concentration of 0.7 ml. (Fig. 4).

Temperature

The amylase activity gradually increases from 0.03 mg glucose/midgut/30 min at 10^{o}C to 0.19 mg glucose/midgut/30 min at 40^{o}C. The enzyme activity decreases to 0.17 mg glucose/midgut/30 min at 50^{o}C and further falls with increase in temperature at 60^{o}C (Fig. 5).

Incubation period

The amylase activity increases gradually from 0.1 mg glucose/midgut/10 min to 0.17 mg glucose/midgut/40 min since thecommencement of the reaction. There is a slow reduction in the enzyme activity with the increase in incubation period (Fig. 6).

2. INVERTASE

Substrate concentration

The amylase activity increases from 0.012 mg glucose/midgut/30 min at 0.5% substrate to 0.378 mg glucose/midgut/30 min at 2% sucrose solution concentration.

Thereafter, the activity remains constant even with an increase in the substrate concentration (Fig. 7).

Hydrogen-ion concentration

The activity increases from 0.036 mg glucose/midgut/30 min at 5.9 pH to 0.098 mg glucose/midgut/30 min at 6.9 pH. The activity slightly lowers at pH 7 and then decreases to 0.06mg glucose/midgut/30 min at 7.5 pH (Fig. 8).

Buffer concentration

The tested buffer concentration is 0.001 M to 0.03 M. The invertase activity initially increases to the maximum level at 0.015M buffer concentration with 0.22 mg glucose/midgut/30 min activity. The activity decreases to 0.15 mg glucose/midgut/30 min at 0.02M concentration, which further decreases with the increase in buffer concentration (Fig. 9).

Enzyme concentration

The invertase activity increases from 0.05 mg glucose/midgut/30 min at 0.5 ml enzyme concentration to 0.16 mg glucose/midgut/30 min at 0.5 ml enzyme solution. The enzyme activity is almost leveled above this concentration (Fig. 10).

Temperature

The invertase activity increases from 0.03 mg glucose/midgut/30 min at 10° C to 0.16 mg glucose/midgut/30 min at 40° C. The activity correspondingly diminishes to 0.08 mg glucose/midgut/30 min at 60° C (Fig. 11)

Incubation time

The invertase activity increases from 0.07 mg glucose/midgut/10 min to 0.2 mg glucose/midgut/40 min. hereafter, the activity is leveled even after the period of incubation is increased upto 100 min (Fig. 12).

3. PROTEASE

Substrate concentration

The protease activity increases from 0.01 mg peptide/midgut/30 min at 0.5% to 0.03 mg peptide/midgut/30 min at 2.5% substrate concentration. Thereafter, the activity tends to remain stable although the substrate concentration is increased to 3.5% (Fig. 13).

Hydrogen-ion concentration

The protease activity increases from 0.01 mg peptide/midgut/30 min at pH-5.9 to 0.04 mg peptide/midgut/30 min at pH 7. Thereafter, the enzyme activity decreases rapidly upto 0.02 mg peptide/midgut/30 min at pH 7.5 (Fig.14).

Buffer concentration

The protease activity increase from 0.004 mg peptide/midgut/30 min at 0.05 M to 0.036 mg peptide/midgut/30 min at 0.25 M buffer concentration.

The enzyme activity decreases to 0.019 mg peptide/midgut/30 min at 0.3 M (Fig. 15).

Enzyme concentration

The protease activity increases from 0.03 mg peptide/midgut/30 min at 0.25 ml to 0.05 mg peptide/midgut/30 min at 0.5 ml enzyme concentration. Above this concentration, the activity is almost constant (Fig.16).

Temperature

The protease activity increases from 0.023 mg peptide/midgut/30 min at 4° C to 0.038 mg peptide/midgut/30 min at 40° C. The activity decreases slightly at 50° C but at 60° C the activity suddenly decreases to 0.015mg peptide/midgut/30 min (Fig. 17).

Incubation period

The protease activity increases from 0.008 mg peptide/midgut/15 min to 0.036 mg peptide/midgut/45 min. The activity slightly decreases to 0.035 mg peptide/midgut/60 min but maintain stability with the increase in incubation time from 60 min (Fig. 18).

4 LIPASE

Substrate concentration

The lipase activity increases from 0.3 mg oleic acid/midgut/24 hr at 1 ml olive oil rapidly up to 0.6 mg oleic acid/midgut/24 hr at 3 ml substrate concentration. The activity decreases to 0.44 mg oleic acid/midgut/24 hr at 4 ml and thereafter, remains constant with the increase in substrate concentration (Fig.19).

Hydrogen-ion concentration

The lipase activity gradually increases from 0.4 mg oleic acid/midgut/24 hr at pH 5.29 to 0.9 mg oleic acid/midgut/24 hr at pH 6.4. Thereafter, the activity goes on decreasing to 0.2 mg oleic acid/midgut/24 hr at pH 7.38 (Fig. 20).

Buffer concentration

The lipase activity increases from 0.4 mg oleic acid/midgut/24 hr at 0.15 M to 0.7 mg oleic acid/midgut/24 hr at 0.25 M. Thereafter, the activity decreases to 0.54 mg oleic acid/midgut/24 hr at 0.33 M and continues to fall with the increase in the concentration of the buffer (Fig. 21).

Enzyme concentration

The lipase activity increases from 0.24 mg oleic acid/midgut/24 hr at 0.2 ml to 0.36 mg oleic acid/midgut/24 hr at 1 ml. Thereafter, although the concentration of the enzyme is increased, lipase activity remains constant (Fig. 22.).

Temperature

The lipase activity increases from 0.4 mg oleic acid/midgut/24 hr at 10° C to 0.6 mg oleic

acid/midgut/24 hr at 37° C. The activity remains same at 40° C but decreases to 0.4 mg oleic acid/midgut/24 hr at 50° C and continues to decrease further with the increase in temperature (Fig. 23).

Incubation period

The lipase activity increases from 0.2 mg oleic acid/midgut/24 hr at 6 hrs to 0.6 mg oleic acid/midgut/24 hr at 24 hr. Thereafter, the activity maintains its equilibrium even when the period of incubation is increased to 36 hrs (Fig. 24).

The physico-chemical factors promoting optimal activity of amylase, invertase, protease and lipase in the midgut of *Trameavirginia* are summarized in the Table-2.

Table-2. Physico-chemical factors promoting optimal activity of amylase, invertase, protease and lipase in the adult dragonfly *Tramea virginia*.

S.N.	Physico-chemical factors	Enzymes			
		Amylase	**Invertase**	**Protease**	**Lipase**
1.	Substrate concentration	2% Starch	2% Sucrose	2.5% Casein	1.5% Olive oil
2.	Hydrogen-ion concentration (pH)	6.98	6.9	7	6.47
3.	Buffer concentration (M)	0.015	0.015	0.25	0.25
4.	Enzyme concentration	0.5*	0.5*	0.5*	1*
5.	Temperature (°C)	40 ° C	40 ° C	40 ° C	37° C
6.	Incubation period (min)	40	40	45	24#

- hrs, ***-** ml

SEXUAL DIMORPHISM IN ENZYMATIC ACTIVITY

Amylase

The amylase activity in the immature male (IM) measures 0.05 mg glucose/midgut/30 min and it increases in the mature male (MM) to 0.08 mg glucose/midgut/30 min. The activity in the immature female (IF) measures 0.06 mg glucose/midgut/30 min and it is maximum in the mature female (MF) with 0.1 mg glucose/midgut/30 min (Fig. 25.).

Invertase

The invertase activity in the immature and the mature male measures 0.08 and 0.15 mg glucose/midgut/30 min, respectively. The activity differs in case of the immature female and measures to 0.09 mg glucose/midgut/30 min while it increases to 0.17 mg glucose/midgut/30 min in the mature female (Fig. 26.).

Protease

The protease activity in the immature male measures 0.027 mg peptide/midgut/30 min while, in the mature male it is found to be 0.033 mg peptide/midgut/30 min. The enzyme activity in the immature female measures about 0.029 mg peptide/midgut/30 min and it increases to 0.037 mg peptide/midgut/30 min in the mature female (Fig. 27.).

Lipase

The lipase activity at optimum physico-chemical conditions in the immature and mature males measures 0.5 and 0.8 mg oleic acid/midgut/24 hr respectively. The activity in the immature and mature females measures 0.6 and 0.95 mg oleic acid/midgut/24 hr, respectively (Fig.28.).

The results of midgut digestive enzyme activity in immature and mature male and female *Trameavirginia* are summarized in the Table-3.

Table-3. Sexual dimorphism in midgut digestive enzyme activity the adult dragonfly *Tramea virginia*.

Insect	Enzyme activity			
	Amylase *	**Invertase ***	**Protease ****	**Lipase *****
Immature male (IM)	0.05#	0.08#	0.027#	0.5#
Mature Male (MM)	0.08#	0.15#	0.033#	0.8#
Immature female (IF)	0.06##	0.09#	0.029##	0.6#
Mature Female (MF)	0.1#	0.17#	0.037#	0.95##

Discussion

Although the physiology of digestion in insects has been explored extensively (NATION, 2008; CHAPMAN, 2012), most of the literature is available on phytophagous rather than carnivorous insects and there is perhaps very less work on the dragonflies (CORBET, 2004) The digestive enzyme secretion is

influenced by a number of factors such as the food, sex, age, reproductive cycle and environmental parameters (GAIKWAD & BHAWANE, 2015).

The parameters required for the optimum activity of amylase, invertase, protease and lipase enzymes in the midgut differ from each other and suggest that the optimum physico-chemical characteristics are very specific to each digestive enzyme in *Tramea virginia*. Midgut digestive enzymes and factors that affect their activity have been characterized inthe dragonfly *Brachythemis contaminata* (BALASUBRAMANIAN &PALANICHAMY, 1985) and *Tramea virginia* larvae (TEMBHARE & MUTHAL, 1992). Variation in physico-chemical conditions required for the optimum activity of the midgut enzymes is directly related to the food composition and environmental factors (BHUVANE-SHWARI & SIVAPRASAD, 2012a.

In *Tramea virginia,* optimum midgut amylase activity occurs at 2% substrate concentration (starch) which differs from that *Spotoptera littoralis, Eurytoma amygdali* and mosquito larvae and *Mamestra brascicae* (ISHAAYA *et al.,* 1971; ISHAAYA & PLAUT, 1974; DADD, 1975) but similar to reports in *Catapsillacrocale* and *Othreis materna* (CHRISTOPHER & MATHAVAN, 1985; TEMBHARE & DESHMUKH, 1994). The invertase activity of *Tramea virginia* differs from that of *Chrysomphalus auridum, Aonidiella auranti, Eurytoma amygdale, Periplaneta americana, Catapsilla crocale,* and *Schizodactylus monstrosus* (ISHAAYA *et al.,* 1971; ISHAAYA & PLAUT, 1974; AGRAWAL & BAHADUR, 1981; MANDAL *et al.,* 1981; CHRISTOPHER & MATHAVAN, 1985).

In *Tramea virginia* for optimum protease activity, 2.5% substrate (casein) is required which differs in *Eurytoma amygdali*, *Bombyx mori* larvae, *Spotoptera littoralis* and *Othreis maternal* (ISHAAYA *et al.,* 1971; ISHAAYA & PLAUT, 1974; TEMBHARE & DESHMUKH, 1994). In *Tramea virginia* the optimum lipase activity is observed at the enzyme concentration of 1.5 ml olive oil which differ from that in *Schizodactylus monstrosus* and adult *Othreis materna* (MANDAL *et al.,* 1981; CHANDA & ROY, 1986; TEMBHARE & DESHMUKH, 1994).

In insects, optimum pH ranges in between 5-9.5 for amylase, 6-8 for invertase, 4-11 for protease and 5-7.2 for lipase (TEMBHARE & DESHMUKH, 1994). In *Tramea virginia*, it is observed that the midgut digestive enzymes, amylase show optimum activity at 6.98 pH, invertase at 6.9 pH, protease at 7 pH while lipase at 6.47 pH. In *Tramea virginia* the rate of substrate hydrolysis rises to a certain level with the increase in enzyme concentration and thereafter, it remains constant.

Earlier studies reveal that the incubation temperature for amylase activity varies from 25°C to 60°C in the insects depends on food source and feeding stage (TEMBHARE & DESHMUKH, 1994; KUMBHAR *et al.*, 2009, 2010). In a large number of insects 40°C is the optimum temperature for invertase activity but at 20°C, the activity is lost to about 40 percent as reported in *Chrysomphalus auridum*, *Aonidiella auranti* and fifth instar larvae of *B. mori*. (ISHAAYA & SWIRSKI, 1970; MUNIV *et al.,* 2011). For the action of the midgut protease 37°C is the optimum temperature for the action of the midgut protease in the beetles *Tenebrio molitor, Tribolium confudum*, *Tribolium castaneum* and *Othreis materna* (BIRK *et al.,* 1962; TEMBHARE & DESHMUKH, 1994). In *Tramea virginia*, temperature required for the optimum activity of amylase, invertase, protease and lipase is 40°C, 40°C, 40°C minutes and 37°C hours, respectively.

Further it is found that in *Tramea virginia*, the incubation period required for the optimum activity of amylase, invertase, protease and lipase is 40, 40, 45 minutes and 24 hours, respectively. The incubation period of enzyme activity varies in insects between 4 min (*Chrysomphalus auridum*) to 48 hours (*Phlebotomus langeroni*) (TEMBHARE & MUTHAL, 1992, 1994; DILLON & LANE, 1993). The enzyme lipase requires 24 hours of incubation period for the optimum activity in *Tramea virginia* adult supporting the observation made in *Schizodactylus monstrosus*, *Tramea virginia* larvae and *Othreis materna* (TEMBHARE & DESHMUKH, 1994).

The physio - chemical characteristics required for the optimum activity of various midgut digestive enzymes *viz.* amylase, invertase, protease and lipase, thus seem to be species-specific and differ in *Tramea virginia* from those reported in other insects.

The present study indicates that in the dragonfly *Tramea virginia,* there is marked sexual dimorphism in midgut enzyme activity. The midgut amylase, invertase, protease and lipase activity in the mature female is comparatively higher than that in the mature male which seems to be in accordance with the maturation of gonads in the opposite sexes. CORBET (2004) stated that the midgut amylase, invertase, protease and lipase activity in the mature female is comparatively higher than that in the mature male which seems to be in accordance with the maturation of gonads in the opposite sexes. LI *et al.,* (2016) examined the effect of sex, age and food source on the activity of amylase and protease which were in general higher in adult females than male. The present study also reports that in *Tramea virginia* there is marked sexual dimorphism in midgut enzyme activity.

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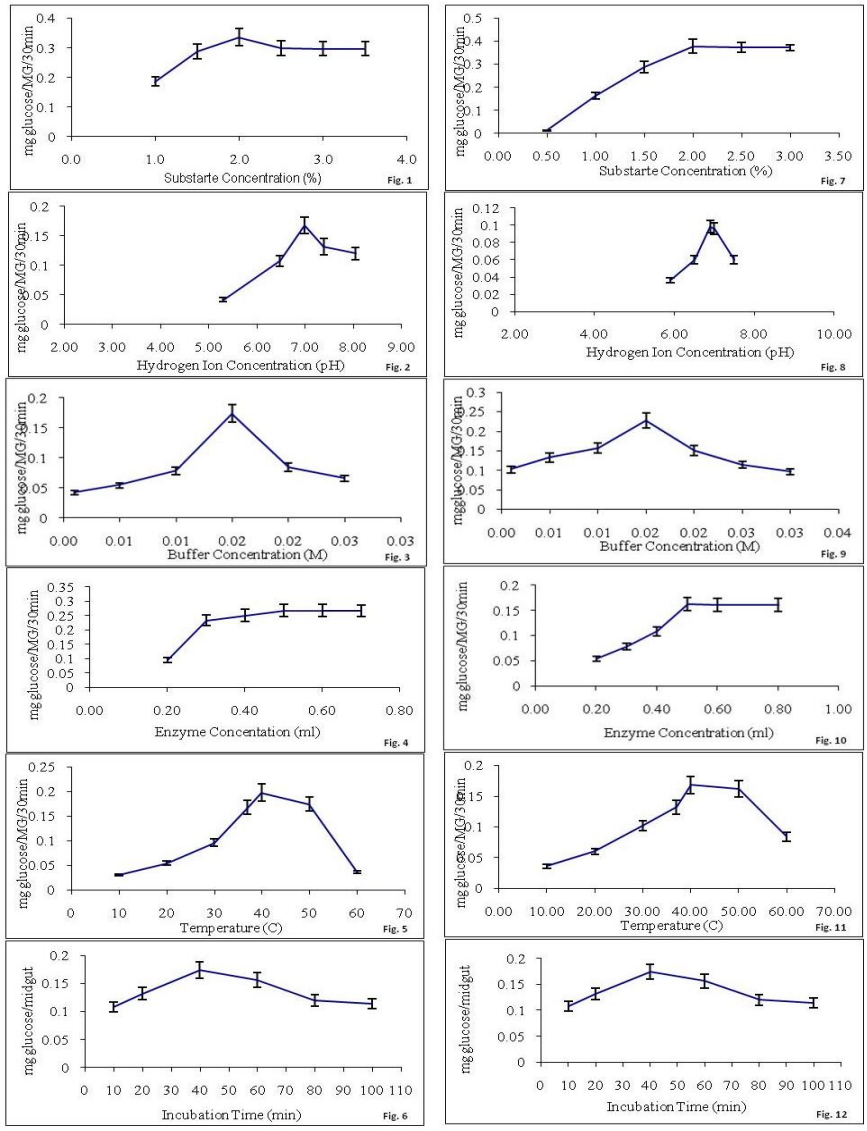
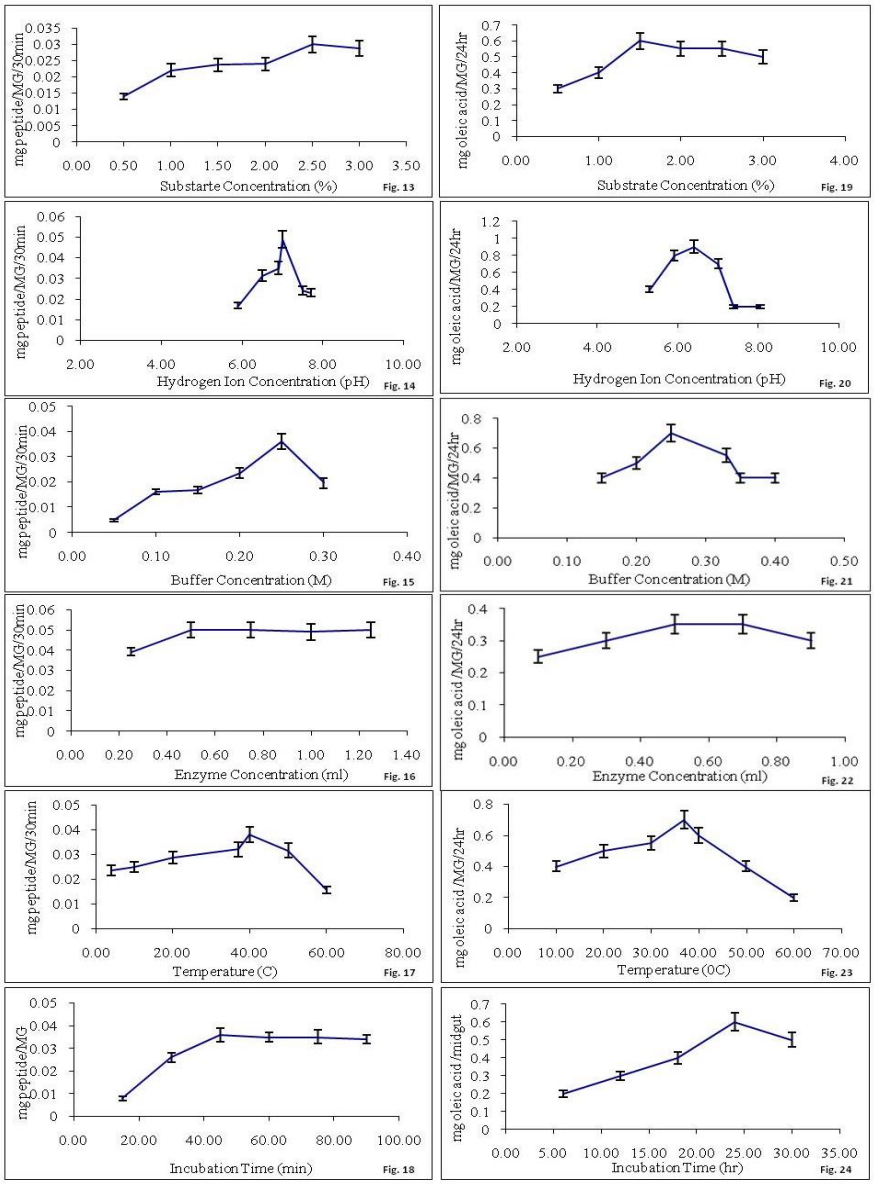


Figs. 1-12. Fig. 1- Optimum substrate concentration for amylase activity. Fig. 2- Optimal Hydrogen-ion concentration for amylase activity.Fig. 3- Optimal Buffer concentration for amylase activity.Fig. 4- Optimal Enzyme concentration for amylase activity. Fig. 5- Optimal Temperature for amylase activity. Fig. 6- Optimal Incubation period for amylase activity.Fig. 7- Optimum substrate concentration for invertase activity.Fig. 8- Optimal Hydrogen-ion concentration for invertase activity.Fig. 9- Optimal Buffer concentration for invertase activity. Fig 10- Optimal Enzyme concentration for invertase activity. Fig. 11- Optimal Temperature for invertase activity. Fig. 12- Optimal Incubation period for invertase activity.



Figs.13-24. Fig. 13- Optimum substrate concentration for protease activity.Fig. 14- Optimal Hydrogen-ion concentration for protease activity.Fig. 15- Optimal Buffer concentration for protease activity.Fig. 16- Optimal Enzyme concentration for protease activity. Fig. 17- Optimal Temperature for protease activity. Fig. 18- Optimal Incubation period for protease activity.Fig. 19- Optimum substrate concentration for lipase activity.Fig. 20- Optimal Hydrogen-ion concentration for lipase activity.Fig. 21- Optimal Buffer concentration for lipase activity.Fig. 22- Optimal Enzyme concentration for lipase activity.Fig. 23- Optimal Temperature for lipase activity. Fig. 24- Optimal Incubation period for lipase activity.

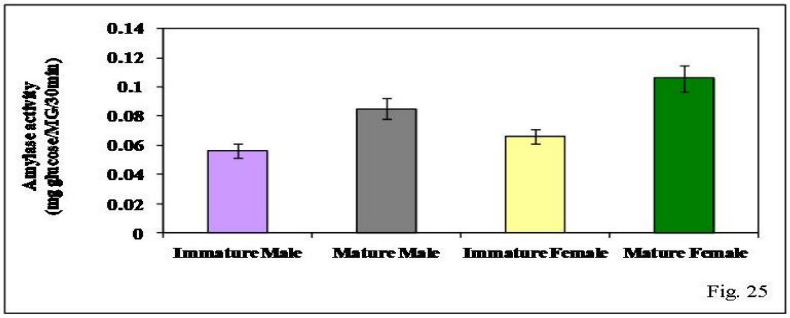


Fig. 25

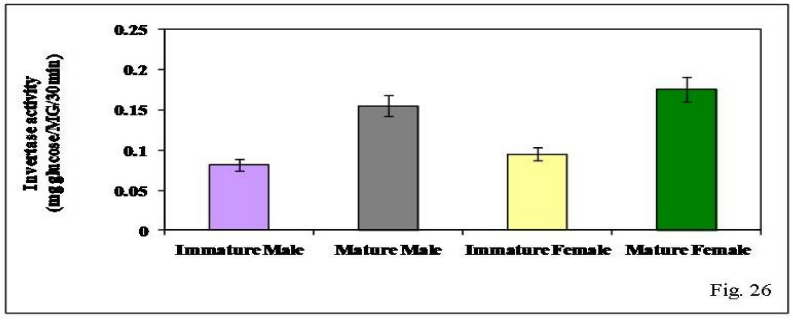


Fig. 26

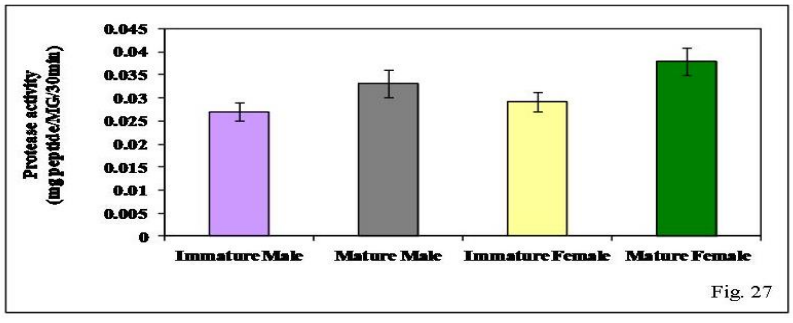


Fig. 27

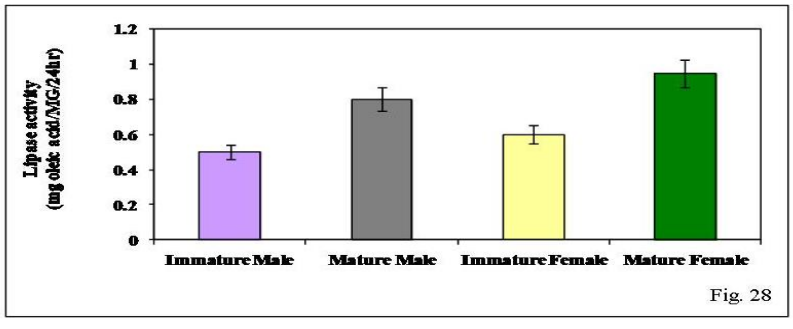


Fig. 28

Figs. 24-28. Midgut digestive enzyme activity in immature and mature male and female *Tramea virginia*.Fig. 24- Optimal Incubation period for lipase activity. Fig. 25- Optimal amylase activity. Fig. 26- Optimal invertase activity. Fig. 27- Optimal protease activity. Fig. 28- Optimal lipase activity.

ACCUMULATION AND DISTRIBUTION OF HEAVY METALS IN PORTULACA OLERACEA

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Abstract : Heavy metal contamination of water and soil is one of the major threats to human health. Phytoremediation is newer method to remediate metal pollutants from contaminated sites. A study was carried out to determine the potential of *Portulaca oleracea* as a soil heavy metal remediating plant. The metal accumulation was determined using ICPAES. To evaluate the potential of *Portulaca oleracea*, Bioconcentration Factor (BCF), Biological Accumulation Coefficient (BAC) and Translocation factor (TF) were calculated. It was found that the species *Portulaca oleracea* accumulated some metal concentration in good amount, thus making it possibly useful for phytoremediation.

Keywords: Phytoremediation, Heavy metals, Bioconcentration factor, Biological accumulation factor, Translocation factor

INTRODUCTION:

Globalization, industrialization and urbanization have all contributed to the problem of pollution including heavy metal pollution. These toxic metals pose a risk to environmental and human health. From different sources of pollution, heavy metals are accumulated as high concentrations in water, soil, sediments and plants. This poses a challenging problem to the world of science and human kind. Prevailing technologies to remove contamination from these types of polluted soil sites are isolation, mechanical separation, pyro-metallurgical separation, or chemical treatment. These are efficient but expensive, labour intensive and soil disturbing (Mulligan *et al*., 2001**)**. Soil contamination by heavy metals can cause long term problems on the biogeochemical cycle, which may affect soil functioning systems, leading to changes in soil fauna (Papa *et al*., 2010).

Metals are commonly found in Earth's crust. Heavy metals is a general collective term, which applies to the group of metals and metalloids with atomic density greater than $4g/cm^3$ or 5 time or more, greater than water. The most common heavy metals associated with the contamination of water and soil include Cr, Cd, Zn, Pb, Hg, Co, Fe, Mn, Ni, Sn and Cu. Metal ions are very easily taken up by living beings and stored faster than they are metabolized.

Phytoremediation can be defined as "the effective use of living green plants to remove, stabilize and detoxify organic and inorganic pollutants including heavy metals from air, soil and liquid substrates (Salt *et al.,* 1998). The main reason behind the development of phytoremediation technologies is the potential for low-cost remediation.

Heavy metals are non-biodegradable and have potential to accumulate. Heavy metals need to be removed physically or be transformed into less toxic forms. In view of the importance of heavy metal contamination, an attempt has been made in this study to understand to test the ability of locally growing plant for pollution control through use of the phytoremediation technique.

MATERIALS AND METHODS :

Ambazari lake which is located near the southwest border of Nagpur, Maharashtra (India) was used for the collection of plant and soil samples. *Portulaca oleracea*, an annual herb, belongs to family Portulacaceae. It has smooth, reddish, mostly prostrate stems and alternate leaves clustered at stem joints and ends.

The plant was collected in clean plastic bag. At the same time, the soil sample around the plant was collected randomly and brought to laboratory.

Plant analysis:

Plant was carefully washed using tap water to clear dust and sediment particles. The plant sample was separated into two parts i.e. shoot and root. These samples were sun dried in separate containers for two weeks. Thereafter, the dried samples were ground till fine powder was formed using mortar and pestle.

For analysis, 1.0 g of plant sample was taken in a beaker and 50 ml aquaregia along with 5% HNO_3 was added and then digested for 3-4 hours on hot plate. After digestion, the sample was left to cool and then filtered with Whatman Ashless filter paper (no. 40). The samples were then transferred to 100 ml volumetric flask and the rinsing water was added to the volumetric flask to make the volume upto 100 ml, followed by AES analysis of arsenic and nickel [Thermofischer model no. IRIS Intrepid II].

Soil analysis:

The soil sample was sun dried for 8-10 days, followed by oven drying at 110^0C for 24 hours. The dry sample was ground using mortar and pestle and sieved through a nylon sieve to obtain homogenized fine particles and stored in plastic bags.

For analysis, 1.0 g of soil sample was taken in a beaker and 50ml aquaregia was added and then digested for 3-4 hours on hot plate. After digestion, the samples were left to

cool and then filtered with Whatman Ashless filter paper (no. 40). The samples were then transferred to 100 ml volumetric flasks and the rinsing water was added to the volumetric flask to make the volume upto 100 ml, followed by AES analysis of heavy metals.

Plant ability to take up heavy metals from soil was evaluated by bioconcentration factor (BCF). BCF is the ratio of metal concentration in aerial plant part to the soil metal concentration. Plants with high BCF value (generally > 1) are suitable for phytoextraction.

The translocation factor (TF) indicates the potential of the plant to absorb and translocate the metal contaminants by plant roots into the above ground parts of the plants (Marchiol *et al.,* 2004).

Lesser TF values (generally < 1) indicates that plants stores accumulated metals in the roots and with values greater indicating metal are transferred to the above ground parts of the plant (Mellem *et al*., 2009).

RESULTS AND DISCUSSION :

The metals chosen for the study were chromium (Cr), arsenic (As), nickel (Ni), cadmium (Cd) and lead (Pb). Of these metals, Cr is an essential element that helps for metabolism. Arsenic is a non-essential element for plants. Ni is essential, in trace concentrations, for plant growth. Cadmium, considered as an environmental priority pollutant which is readily taken up by plants roots and tends to bioaccumulate. Lead is not essential for plant or animal life and consumption even at very low concentrations can be toxic.

The plant was obtained from the place nearby Ambazari Lake. The species *Portulaca oleracea* was selected since it is a local plant with good biomass and high regeneration potential.

The data showed that there was an uptake of heavy metal in the plant, which could ultimately have a risk on human health. The concentration of chromium in soil was found above the permissible limits of WHO (6) and FEPA (7). The uptake of Cr in shoot of *P. oleracea* was found highest followed by Pb and Cd. As and Ni were absorbed in very less amount in shoot. The higher uptake of Cd was found in root followed by Cr and lead. The relative higher concentration of Cr, Cd and Pb suggests that the plant have potential to absorb these metals from soil show in Figure 1.

The bioconcentration factor (BCF) is the capacity of the plant to take up heavy metals with reference to its concentration in the soil **(**Ghosh *et al*., 2005). BCF values for the different heavy metals are shown in Figure 2 and varied widely from metal to metal. The BCF value for Cr is maximum whereas for nickel is minimum. Cr and Pb shows BCF values more than one while other metals show lesser than one. The BCF value indicates that the plant shows good accumulation capacity for chromium and lead. The BCF value for the plant *P. oleracea* decreases in the order Cr > Pb > As = Cd > Pb during the study. Therefore, the plant *P. oleracea* can be a capable plant to eradicate the heavy metals.

Bioaccumulation factor was calculated as ratio of concentration of heavy metal in plant roots to that of soil **(**Yoon *et al*., 2006). BAF values for different heavy metals are shown in Figure 3 and varied widely from metal to metal. The BAF values are less than one for all metals.

Translocation factor was described as the ratio of heavy metal concentration in plant shoot to that in plant root **(**Zu et al., 2005). The translocation factor (TF) for the plant *P. oleracea* are exposed in Figure 4. The highest peak ratio of shoot/root (TF) concentrations was recorded for Cr (3.17) and the lowest was for Ni (0.88). The orders of the intensity of bioaccumulation of the examined metals in the shoot and root were different. In general TF decreases in the order- Cr > Pb > As > Cd > Ni. The values more than one for BCF and TF is an indication of a promising accumulator plant (Gonzaga *et al*., 2006). Therefore, the plant *Portulaca oleracea* can be a capable plant to eradicate the heavy metals.

CONCLUSION :

The study found that there are potential health risks because of the increased contamination of heavy metals in soil and uptake of these toxic metals by the *Portulaca oleracea*. The levels of studied heavy metals in nearby soil of Ambazari lake poses concern. The bioconcentration factor values revealed that the plant is a heavy metal accumulator. The TF value showed that it has ability to translocate Cr and Pb effectively to aerial part. So, the study employ that the plant can be used to remediate heavy metal contaminated sites.

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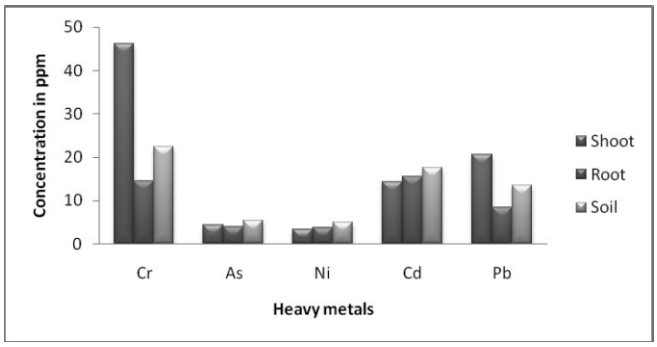

Figure 1: Heavy metal concentration in soil and plant parts

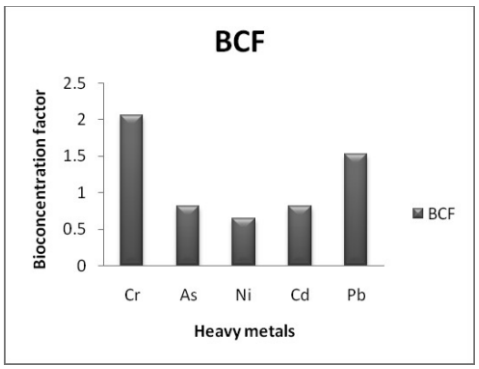

Figure 2: Bioconcentration factor for heavy metals

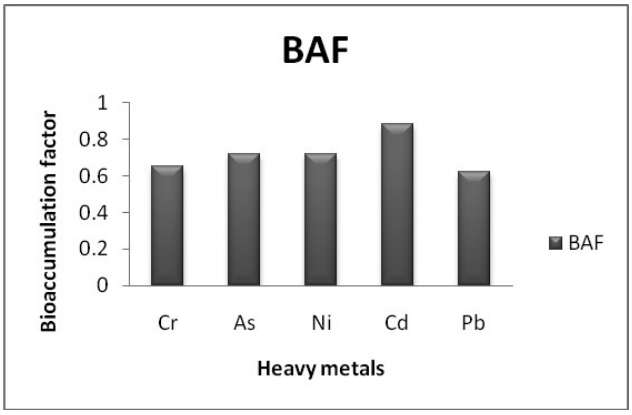

Figure 3: Bioaccumulation factor for heavy metals

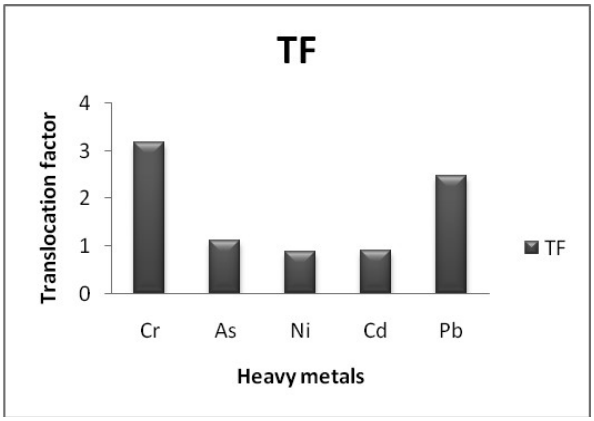

Figure 4: Translocation factor for heavy metals

Copper(II) Salt Catalyzed Coupling Strategy Towards Synthesis of Substituted Dibenzopyranones

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Copper(II) Salt Catalyzed Coupling Strategy Towards Synthesis of Substituted Dibenzopyranones

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Copper salts are environmentally friendly and less expensive as compared to other transition metal salts. These salts have historically been used for carbon-carbon cross-coupling reactions. In present work, we adopted $CuSO_4$ catalyzed C-C coupling reactions in presence of base to obtain series of substituted dibenzopyranone derivatives.

Keywords: Copper(II), Catalysis, Coupling, Synthesis, Dibenzopyranones.

INTRODUCTION

Coupling reactions particularly catalyzed by transition metal have received massive interest by virtue of its applicability [1-6]. Before 150 years, one of the first copper-mediated coupling reaction was developed by Glaser [7] featuring the dimerization of terminal acetylenes. Ullmann and Bielecki [8] paved the way for the copper-mediated synthesis of biaryls starting from aryl bromides in roughly year 1901. Copper-based catalysts for various coupling reactions are found to be more attractive due the lower cost and environmental factors associated with it [9-12]. In fact, acetylenes and halides as partners in Sonogashira reaction [13] employs catalytic amount of Pd(0) and Cu(I). Towards advancing catalysis as a science, Buchwald *et al.* contributed on Cu-catalyzed cross-coupling reactions by amalgmating chelating ligands [14-16]. Mechanistically, use of ligands in such processes lower the activation energy of the metal catalyst and moderates the coupling reaction in a much faster pace. It has recently been reported that, in the presence of light and a copper(I) catalyst, nitrogen nucleophiles undergo C–N coupling with alkyl halides under mild conditions. Moreover, it has also been established that photo induced, copper-catalyzed alkylation can also be applied to C–C bond formation [17a]. Shi *et al*. [17b] have accomplished a synthesis of dibenzopyranones but by using Pd(II) and Cu(II) dual catalytic system. Shi's group has also enlisted several other ways of synthesizing this scafold. In present work, we used a substrate that does not require in ligand yet extremely effective in coupling reaction towards the synthesis of dibenzopyranones. The dibenzopyranone is found in many natural products *e.g.* fruits, herbs and vegetables. Myriad of methods reported towards synthesis of dibenzopyranones, notably, in 2002, Abbott Laboratories manage to synthesize glucocorticoid receptor A-224817.0 through Negishi cross coupling but the disadvantages associated of these methods include poor process efficiency, multistep sequence and intensive purification of the intermediates. Here we report $CuSO_4$ catalyzed C-C coupling reactions in presence of base to obtain series of substituted dibenzopyranone derivatives with mechanistic understanding as shown in Fig. 1.

EXPERIMENTAL

Typical procedure for the synthesis of the targeted compounds **3**(**a**-**e**) is described. Uncorrected open capillaries Toshniwal melting point apparatus has been used to record the melting points. Brucker Avans DRX 300 (300 MHz, FT NMR) spectrometer using TMS as internal standard has been used to record the ^{1}H NMR and the chemical shift are reported in δ (ppm) scale and the coupling constants are reported in Hz. JEOL-JMSD 300 instruments fitted with a direct inlet system were employed to run electron impact (EIMS) mass spectra. Elemental analyzer EA-1108 was used in elemental analysis and results were within ± 4 % of theoretical values. The purity of the products was checked on Precoated silica gel 60 F_{254} or aluminium oxide 60 F_{254} TLC plates were used to check the purity and the iodine vapours spray were used to visualize the spots.

3,8-Dihydroxy-9-methoxy-6*H*-benzo[c]chromen-6-one (3a): Resorcinol (550 mg, 5 mM) was added to a solution of

methyl 2-bromovanillic acid (598 mg; 2.42 mM) in aqueous sodium hydroxide (8 %, 2.5 mL). After refluxing the reaction mixture at 120 °C by using in an oil bath for 45 min aqueous copper sulfate solution (5 %, 1 mL) was added and the reaction mixture was refluxed for another 15 min. Precipitated product was filtered off after cooling and washed with water (1 mL × 3), dried. Crystallization of product was achieved by using acetic acid (2 mL)- methanol (5 mL) to obtain157 mg brown amorphous solid. Yield, 61 %, m.p., 288 °C, ^{1}H NMR ($CDCl_3$, δ ppm): 3.91 (s, 3H, OCH_3), 6.73 (d, 1H, H^4, J = 3.0 Hz), 6.82 (dd, 1H, H^2, J = 12.0, 6.0 Hz), 7.40 (s, 1H, H^{10}), 7.50 (s, 1H, H^7), 7.90 (d, 1H, H^1, J = 12.0 Hz). Mass: $C_{14}H_{10}O_5$; 258 (M^+) 243, 219, 215, 187, 131, 91, 69.

3-Hydroxy-8,9-dimethoxy-6*H*-benzo[c]chromen-6-one (3b): Compound **3b** was prepared by similar procedure as described for **3a**. In this particular synthesis, 4,5-dimethoxy-2-bromobenzoic acid (568.98, 2.18 mM) and resorcinol (550 mg; 5 mM) were used. Weight: 142 mg, Yield: 52 % m.p. > 280 °C, ^{1}H NMR ($CDCl_3$, δ ppm): 3.85 (s, 3H, 8-OCH_3), 3.98 (s, 3H, 9-OCH_3), 6.71 (d, 1H, H^4, J = 3.0 Hz), 6.80 (dd, 1H, H^2, J = 9.0, 3.0 Hz), 7.5 (s, 1H, H^{10}), 7.6 (s, 1H, H^7), 8.16 (d, 1H, H^1, J = 15.0 Hz), Mass: $C_{15}H_{12}O_5$; 272 (M^+), 258, 228, 214, 158, 121.

8-(Benzyloxy)-3-hydroxy-9-methoxy-6*H*-benzo[c]-chromen-6-one (3c): Compound **3c** was prepared by similar procedure as described for **3a**. In this particular synthesis, 4-benzyloxy 3-hydroxy 8-methoxy 2-bromobenzoic acid (630 mg; 2.18 mM) and resorcinol (550 mg; 5 mM) were used. Weight: 41 mg; Yield, 52 %. ^{1}H NMR ($CDCl_3$, δ ppm): 3.91 (s, 3H, OCH_3), 5.49 (s, 2H, OCH_2), 6.87 (d, 1H, H^4, J = 3.0 Hz), 6.95 (dd, 1H, H^2, J = 4.5, 1.5 Hz), 7.49-7.69 (m, 7H, H^7, H^{10} and Ar-H), 7.93 (s, 1H, H^7), 8.28 (d, 1H, H^1, J = 12.0 Hz), Mass: 272 (M^+), 258, 228, 214, 158, 121.

3-Hydroxy-9-methoxy-8-[2-(pyrrolidin-1-yl)ethoxy]-6*H*-benzo[c]chromen-6-one (3d): Compound **3d** was prepared by similar procedure as described for **3a**. In this particular synthesis, 2-bromo 5-methoxy 4-pyrrolidinoethoxy benzoic acid (826 mg; 2.12 mM) and resorcinol (550 mg; 5 mM) were used. The product was crystallized by using methanol (2 mL)-water (0.5 mL). Weight: 170 mg; Yield, 47.8 %; m.p., 196 °C. ^{1}H NMR ($CDCl_3$, δ ppm): 1.70-1.80 (m, 4H, $(CH_2)_2$ of pyrrolidine), 2.50-2.57 (m, 4H, $N(CH_2)_2$ of pyrrolidine), 2.98 (t, 2H, NCH_2, J = 9.0 Hz), 3.98 (s, 1H, OCH_3), 4.33 (t, 2H, OCH_2, J = 3.0 Hz), 6.76 (d, 1H, H^4, J = 15.0 Hz), 6.85 (dd, 1H, H^2, J = 4.5, 1.5 Hz), 7.53 (s, 1H, H^7), 7.64 (s, 1H, H^{10}), 8.18-8.22 (m, 1H, H^1), 9.13 (s, 1H, OH), Mass: $C_{20}H_{21}O_5N$; 355 (M^+), 307, 289, 242, 154, 136.

3-Hydroxy-8-methoxy-9-piperidinoethoxy dibenzo-[b,d]pyran-6-one (3e): Compound **3e** was prepared by similar procedure as described for **3a**. In this particular synthesis, 1 g (830 mg; 2.18 mM) 2-bromo 5-methoxy 4-piperidinoethoxy benzoic acid and resorcinol (550 mg, 5 mM) were used. The product was crystallized by using methanol (2 mL) water (0.5 mL). Weight: 184 mg; Yield, 49.8 %; m.p., 205 °C. ^{1}H NMR ($CDCl_3$, δ ppm): 1.4-1.5 (m, 6, $(CH_2)_3$ of piperidine ring), 2.4-2.7 (m, 4H, $N(CH_2)_2$ of piperidine ring), 2.74 (t, 2H, NCH_2, J = 6.0 Hz), 3.77 (s, 3H, OCH_3), 4.33 (t, 2H, OCH_2, J = 6.0 Hz), 6.73 (d, 1H, H^4, J = 6.0 Hz), 6.82 (dd, 1H, H^2, J = 12, 9.0 Hz), 7.5 (s, 1H, H^7), 7.71 (s, 1H, H^{10}), 8.21 (dd, 1H, H^2, J = 12, 9.0 Hz), Mass: $C_{21}H_{23}O_5N$; 369 (M^+), 149, 121, 91, 55.

RESULTS AND DISCUSSION

The C-H activation is one of the most fascinating areas in transition metal catalyzed syntheses. Here in our efforts, aryl C-H activation is being effective due to the fact that phenolic hydroxy functionality is present at *para* position to the C-C bond forming carbon in one of the aromatic rings. Eventually, compounds **3**(**a**-**e**) have been synthesized by reacting substituted *ortho*-bromobenzoic acids [**1**(**a-e**)], with resorcinol (**2**) in aqueous alkaline medium in presence of copper(II) sulfate. Substrates **1**(**a**-**c**) are substituted with relatively less bulky protecting groups whereas substrates **1d** and **1e** are fully decorated with ethyl pyrrolidine and ethyl piperidine. As shown in Fig. 1, the proposed mechanism operates through Cu(III) species [18], resulted after oxidative insertion of Cu(II) across aryl halide carbon halogen bond in **2a**. Strategically placed phenolic hydroxy group helped in metalation thereafter reductive elimination afforded the desired product. As a result, Cu(I) species possibly gets oxidized in presence of aerial oxygen to Cu(II) to maintain the catalytic cycle as shown in Fig. 1.

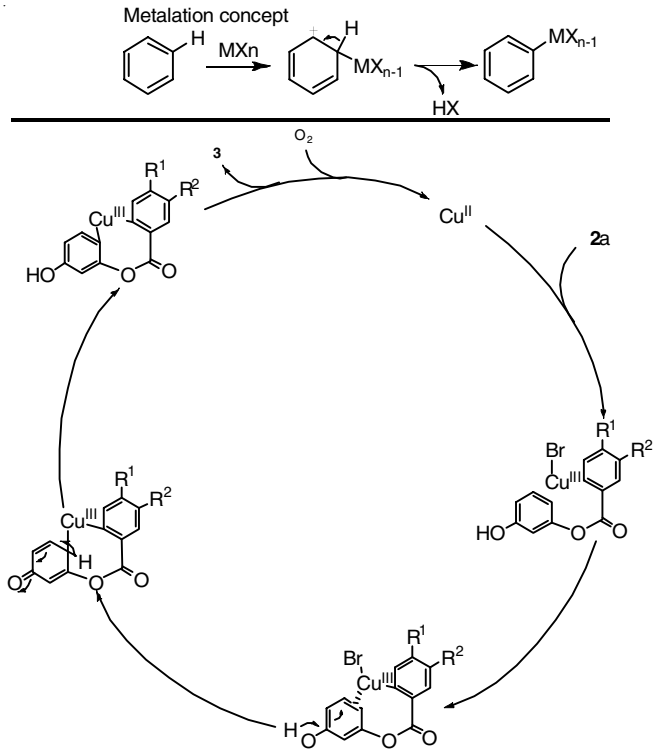
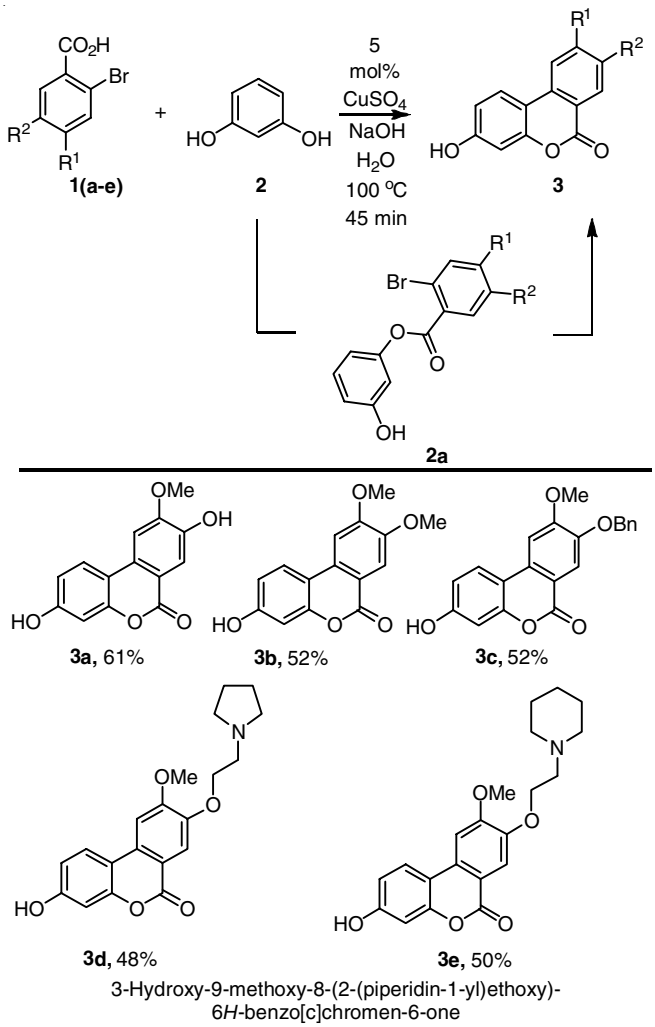


Fig. 1. Proposed mechanism for Cu(II) catalyzed synthesis of substituted dibenzopyranone derivatives

There were number of compounds **3**(**a**-**e**), substituted dibenzopyranone derivatives synthesized. Synthetic strategy involved 2-bromovanillic acid derivatives and resorcinol in presence of sodium hydroxide solution in water under refluxing conditions. The substrate variation is maintained along with R^2 substituents in 2-bromovanillic acid derivatives. Substrate **1a** has only phenolic hydroxyl functionality that would have helped C-Br bond present at *para* position to take

part in oxidative insertion event quite effectively due to inductive effective leading to offer higher yield of the product (61 % **3a**). Other two substrates **1b** and **1c** have similar substituents (*e.g.* –OMe and –OBn) would have followed similar course of C-C bond forming events as substrate **1a** would have gone through. The yields for corresponding products [**3b** and **3c** (52 and 52 %)] are slightly lower than that of **3a**. Last two substrates are fully functionalized with side chains containing pyrrolidine and piperidine bases. Non-bonding lone pair of electrons at nitrogen of these bases would have mortgaged the reactivity up of Cu(II) to certain extent during oxidative insertion as a crucial event leading to formation of the products with lesser yields [**3d** and **3e** (48 % and 50 %)] than the other products (**3a**, **3b** and **3c**). In order to believe that this reaction is being progressed in a catalytic fashion, the role of dissolved can't be ruled out. Mechanistically, we reasoned that dissolved oxygen in water acts as oxidant in order to establish the catalytic cycle. This process affords product with yield ranging from 48 to 61 %.

Various *ortho*-bromobenzoic acids, used in the **Scheme-I** were in turn prepared by known literature methods starting from simple starting materials [19a-c].



Scheme-I: Synthesis of substituted dibenzopyranone derivatives

Conclusion

A series of series of substituted dibenzopyranone derivatives have been synthesized by using Cu(II) salt which is environmentally friendly and less expensive as compared to other transition metal salts. Further expansions of this strategy to make medicinally relevant molecules are under progress.

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Therapeutic Potential of Chromones

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Abstract

Chromones are found to be natural or natural origin. Several studies have been performed on the types of reagents utilized for the cyclization of chalcones to chromene-4-ones. Chromones are recognized as pharmacophores having a number of biological activities such as anticancer, antiviral, antifungal, antimicrobial, antioxidant, antidepressant and antiobesity etc. There are various synthetic methods reported. Therapeutic potential and brief discussion on synthesis of chromones are reviewed.

***Keywords:* Chromones; Anticancer; Antibacterial; Anti-HIV; Chalcones**

Introduction

Chromone moiety forms the important component of pharmacophores of a number of biologically active molecules having synthetic or natural origin and many of them have useful medicinal applications. Chromones are the hetrocyclic compounds with benzopyron network with substituted keto group on pyron ring. Chromone is an isomer of coumarin. Chromone derivatives have a number of biological activities such as anticancer, antihypertensive, antiviral, antifungal, antimicrobial, antioxidant, antidepressant, anti-obesity. These derivatives also possess enzymetic inhibition properties towards different systems such as oxidoreductase, kinase, lipoxygenase and cycloxygenase.

Chemistry

The most conventional and common method for the cyclization is through an oxidative ring closure with bromine and a base or by refluxing with SeO_2 in dioxane [1]. In the reaction of chalcone with bromine, besides bromine addition to the olefinic bond, nuclear bromination at position 5 also occurs resulting in the bromoflavone [2] Chalcone dibromide is converted into chromone by the action of pyridine [3]. Ray and Dutta converted chalcone dibromide into the corresponding chromone by heating above the melting point [4]. Rao et al. studied the cyclization of chalcones with DDQ and found that even a slight variation in reaction conditions led to the formation of a mixture of chromone and chroman-4-one [5].

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Yao et al. synthesized nitro chromones through regioselective nitration of chalcones followed by cyclization catalyzed by I2-DMSO [6]. Huang et al. improved the total synthesis of baicalein, wogonin, and oroxylin from chalcones using I2-DMSO as the cyclizing agent [7] and Lokhande et al. also cyclized 2-allyloxychalcones to chromones using I2-DMSO [8]. Alam studied the conversion of methylenedioxy chalcones utilizing diphenyl sulphide, I2-DMSO or DDQ and found that cyclization with I2-DMSO improve the yields, while diphenyl sulphide gave the lowest yields [9].

Kumar and Perumal demonstrated the use of ferric chloride in the oxidative cyclization of o-hydroxychalcones to chromones [10]. Kumazawa et al. prepared a naturally occurring 6-C-glucosylated derivative and the 8-C-glucosylated compound via the cyclization of chalcones [11,12].

Ganguly et al. prepared 3-acylchromones through a modified Baker-Venkataraman rearrangement using DBU and pyridine via a triketo intermediate [13] these 3-acylflavones were then converted into chromones by refluxing with aqueous K_2CO_3. Similarly, Pinto et al. used K_2CO_3-pyridine under microwave assisted conditions to prepare β-diketone intermediates, which were cyclized to give 3-aroylchromones [14].

A synthesis of flavones from ortho-methoxy acetophenones via a two-step process, which utilizes only 1 equiv of LDA to form the lithium enolate has also been reported. The enolate is reacted with benzoyl cyanide to give β-diketone, which on treatment with HI yields the chromones [15]. Creuzet et al. conventionally prepared 3-Hydroxychromones from a methoxy- or benzyloxy-o-hydroxyacetophenone via Baker-Venkataraman rearrangement forming the b-diketones, which undergo cyclization [16,17].

Hageman et al. synthesized 3-Hydroxychromones from chalcones. In this method, o-hydroxychalcone was subjected to base catalyzed epoxidation of the conjugated double bond [Algar-Flynn-Oyamada (AFO)] oxidation followed by ring closure and aromatization to yield hydroxyl chromones [18].

Auwers et al. reported the synthesis of 3-hydroxychromones from aurone via a series of reactions commonly known as the Auwers synthesis [19]. Bromination of the alkene yields a dibromo adduct, which rearranges to hydroxychromone by treatment with KOH via various intermediates. The 4-O-alkyl-derivatives of 5, 7-dihydroxy-chromones were prepared by cyclization of the corresponding chalcones with sodium acetate followed by oxidation of the crude intermediates (chroman-4-ones) with a catalytic amount of iodine in pyridine [20].

7-O-alkyl derivatives of chromones have been prepared by various workers. Babu et al. prepared 7-O-alkylated derivatives of chrysin, (5, 7-dihydroxychromones) having antibacterial activity using alkyl halides and K_2CO_3 [21]. Shin et al. also attempted to synthesize regioselective 7-O-alkyl derivatives of chrysin using K_2CO_3 or $KHCO_3$, but obtained a mixture of mono- and di-O-alkylated products [22]. They successfully tried to form 7-O-esters using DCC and DMAP. It was concluded that esterification occured primarily at C7 because of the shielding of the 5-hydroxy by the 4-keto group.

Jain et al. also attempted nuclear iso-prenylation of chrysin by refluxing it with prenyl bromide, but the results were not satisfactory due to poor yields [23] Comte et al. prepared C-prenylated chromones in low yields by microwave irradiation on a solution of chrysin and tetramethyl ammonium hydroxide in methanol containing tetraethylammonium iodide [24].

Marta Perro Neves et al. successfully synthesized dihydropyranochromones by one-pot synthesis, using Montmorillonite K10 clay as catalyst under microwave irradiation [25]. Ramesh Kamboj et al. synthesized 3-alkoxy-6-chloro-2-(3-methylthiophen-2-yl)-4H-chromen-4-ones in methanol [26] with pyrex filtered UV-light led to the formation of tetracyclic compounds.

A series of bromo-substituted 3-aroyl flavanones and flavones have been synthesized [27]. The identities of the new compounds synthesized have been developed on the basis of usual chemical transformation and IR, NMR spectral studies. The diisochromenochromen-4-one has been prepared from the photocyclization reaction of bischromen-4-one. The later compounds are obtained from the O-alkylation of the suitable 3-hydroxy-2-aryl-4H-chromen-4-one with bischloromethyl-diphenyl in dry acetone, anhydrous K_2CO_3, and PTC (Bu4N+I−) under refluxing conditions [28].

Liu Xin-Hua et al. synthesized ten novel 3-(2-(3-methyl-5-substituted-phenyl-4,5-dihydropyrazol-1-yl)-2-oxo-ethoxy)-2-substituted-phenyl-4H-chromen-4-one derivatives [29]. Eeda Venkateswararao et al, a series of (E)-5-alkoxy-3-(3-phenyl-3-oxoprop-1-enyl)-4H-chromen-4-ones and (E)-5-alkoxy-3-(3-hydroxy-3-phenylprop-1-enyl)-4H-chromen-4-ones were synthesized [30]. Qiao Ren et al. synthesized 6, 7-Dimethyl-3-[(methyl-2-(methyl-(1-3-trifluromethyl-phenyl)-1H- indol-3-yl-methyl)- amino)- ethyl)-chromen-4-one drug that prevent TNF-α binding to its receptor [31].

Biological activities of chromene-4-ones

Antibacterial and antifungal activities

Bingi et al. synthesized a number of 3-hydroxy-6-(hydroxymethyl)-2-(2-phenyl-4H-chromen-4-yl)-4H-pyran-4-ones in a one pot catalyst free reaction of 2-hydroxy chalcone with kojic acid in toluene at reflux temperature and studied their biological activities. The compounds showed potent antimicrobial activity against various strains of bacteria [32].

Hatzade et al. attempted a convenient route to synthesis 7-O-β-D-glucopyranosyloxy-3-(3-oxo-3-arylprop-1-enyl)-4H-chromene-4-ones. These compounds were evaluated for antibacterial and antifungal activities [33].

Javed Sheikh et al. reported computational evaluation and experimental verification of 7-hydroxy-3-(1-phenyl-3-aryl-1H-pyrazol-5-yl)-4H-chromen-4-ones and their O-β-D-glucopyranosides for their antimicrobial and antioxidant activity [34]. Palakuri Kavitha et al. synthesized tridentate 3-formyl chromone Schiff bases of Ni(II) and Zn(II) such as 3-((2-hydroxyphenylimino)methyl)-4H-chromen-4-one, 3-((3-hydroxypyridin-2-ylimino)methyl)-4H-chromen-4-one and 3-((2-mercaptophenylimino)methyl)-4H-chromen-4-one which exhibited pronounced activity against tested bacteria and fungi strains compared to the ligands [35].

Kale et al. synthesized and characterized some of the chromone derivatives as antimicrobial agents (FIG. 1) [36].

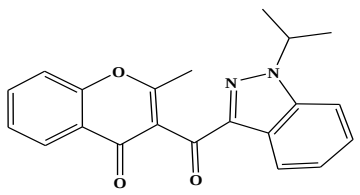
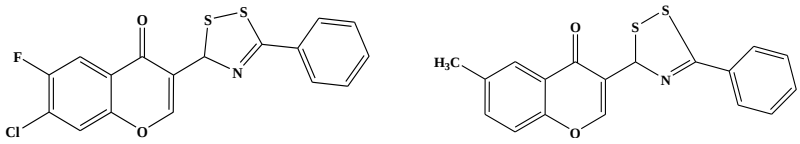


FIG. 1. **Chromone derivatives.**

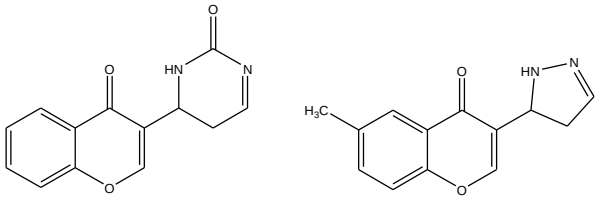
Chromone conjugated dithiazoles and 4-oxo-4H-chromene-3- carbothioic-N-phenylamides were synthesized and screened for antibacterial and antifungal by disk-diffusion assay. The dithiazole derivative (FIG. 2a) bearing electron withdrawing (-F, -Cl) groups at C6 and C7 positions shows high antifungal activity in comparison to fluconazole. For Gram Positive bacteria *S. aureus*, maximum growth inhibition of 92.72% was observed for in FIG. 2b [37].



2a 2b

FIG. 2. **4-oxo-4H-chromene-3-carbothioic-N-phenylamides.**

Musthafa et al. developed chromone fused pyrazolines, pyrazoles, dibromo derivatives and dihydropyrimidines, under microwave irradiation, and evaluated for *in vitro* antibacterial activity against an assortment of two Gram-positive bacteria, *S. aureus*, *B. subtilis*, and two Gram-negative bacteria, *E. coli*, *Salmonella typhimurium*, *in vitro* antifungal activity was tested against three fungal strains, *C. albicans*, *A. niger* and *Aspergillus fumigatus*. The antimicrobial activity of compounds indicates that various compounds are potent antimicrobial agents (FIG. 3a and 3b) [38].



3a 3b

FIG. 3. **The antimicrobial activity of compounds indicate that various compounds are potent antimicrobial agents.**

Nawrot-Modranka et al. synthesized chromone derivatives and studied there *in vitro* antibacterial activity (FIG. 4) [39].

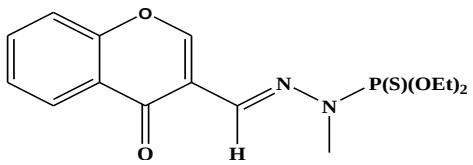
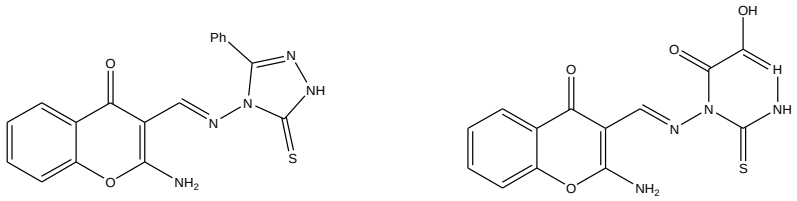


FIG. 4. **3-tetrazolylmethyl-4H-chromen-4-ones.**

Pedro et al. synthesized novel 3-tetrazolylmethyl-4H-chromen-4-ones via multicomponent reaction and studied their biological evaluation against Entamoeba histolytica, *Giardia lamblia* and *Trichomona vaginalis* [40].

Ibrahima coworkers synthesized new nitrogen heterocyclic systems combining chromone moiety with 1,2,4-triazole or 1,2,4 triazine in one molecular frame through an azomethine linkage and evaluated *in vitro* for their antimicrobial activities, using the disc-agar diffusion method, against *S. aureus* and *Streptococcus pyogenes* as Gram positive bacteria, *Pseudomonas fluorescens* and *Pseudomonas phaseolicola* as Gram-negative bacteria, and the fungi *F. oxysporum* and *A. fumigatus* [41]. Compounds showed high activity toward the tested fungi. (FIG. 5a and 5b).



5a 5b

FIG. 5. **Nitrogen heterocyclic systems combining chromone moiety with 1,2,4-triazole or 1,2,4 triazine.**

Anti-cancer activity

Liu T et al. synthesized chromone analogues bearing heterocyclic thioether moiety and were assayed for their antitumor activity. Out of these, IC50 of 3- (benzothiazole-2-ylsulfanyl)-chromen-4-one against MDA-MB-435S was found out to be 17.2 μM. They concluded that the presence of heterocyclic thioether or cyclic tertiary amine will benefit the antitumor activities of chromones [42].

Three methylated quercetins and a series of O-3-substituted, tetra-O-methylated quercetin derivatives have been synthesized by Jian Yuan et al. and studied their anticancer activity [43]. He Huang et al. successfully prepared a new type of quercetin derivatives, the novel compounds show higher selectivity as inhibitors against Src tyrosine kinase. (IC50 values ranging from 3.2 mM to 9.9 mM) than against EGFR tyrosine kinase. Molecular docking revealed that both hydrophobic and hydrogen bonding interactions are important to the selectivity [44]. Guo-Biao Liu et al. synthesized (5, 7-dihydroxy-4-oxo-4H-chromen-3-yl) methyl esters and evaluated LPS-activated murine macrophages cell culture systems and cytotoxicity of these compounds was checked using MTT assay [45]. Liu Xin-Hua et al. synthesized ten novel 3-(2-(3-methyl-5-substituted-phenyl-4,5-dihydropyrazol-1-yl)-2-oxo-ethoxy)-2-substituted-phenyl-4H-chromen-4-one derivatives and screened for their anticancer activity (FIG. 6). The bioassay tests show that compounds exhibited potentially high activity against human gastric cancer cell SGC-7901 [46]. Ishar et al. Synthesized and evaluated novel 6-chloro-/fluorochromone derivatives as potential topoisomerase inhibitor anticancer agents [47].

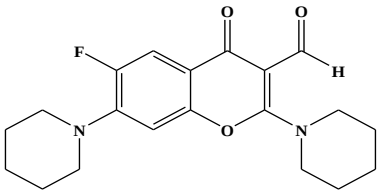


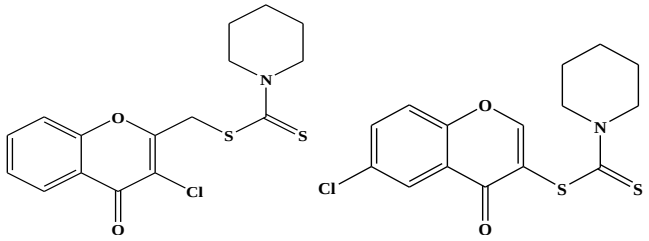
FIG. 6. **6-chloro/fluorochromone derivatives.**

The compounds (3-chloro-4-oxo-4H-chromen-2-yl)methyl piperidine-1-carbodithioate (FIG. 7a) and (6-chloro-4-oxo-4H-chromen-3-yl)methyl piperidine-1-carbodithioate (FIG. 7b), showed the most promising antitumor activity against SW-480 cells and MDA-MB-435 cells [48]. Compound exhibited cytotoxicity against human neuroblastoma cell line compared to the standard drug Doxorubicin (FIG. 8) [49].

Anti-inflammatory activity

Hasan and researcher synthesized 6-Aminomethyl-2-aryl-1-benzopyran-4-one derivatives and tested for anti-inflammatory, analgesic, ulcerogenic, and lipid peroxidation actions. Among the tested compounds, two compounds showed higher degree

of anti-inflammatory activity [50]. Khan et al. effectively synthesized and characterized 3-formylchromone and its derivatives. Anti-inflammatory activities were studied of these compounds [51].



7a 7b

FIG. 7. **(3-chloro-4-oxo-4H-chromen-2-yl)methyl piperidine-1- carbodithioate and (6-chloro-4-oxo-4H-chromen-3-yl)methyl piperidine-1-carbodithioate.**

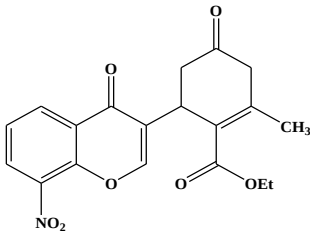
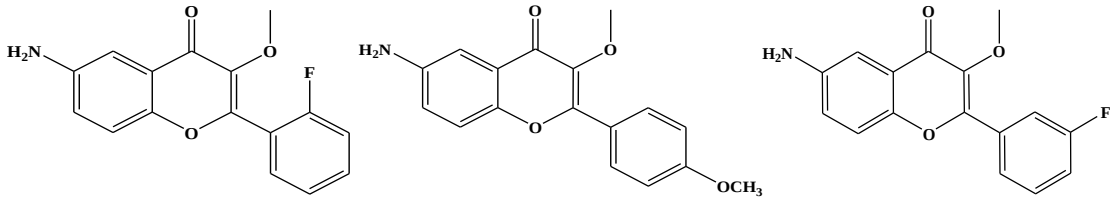


FIG. 8. **Doxorubicin.**

Anti-HIV activity

Casano et al. developed and synthesized a series of methoxy flavones and studied their antiproliferative activity on Plasmodium falciparum parasites and anti-HIV activity. Methoxyflavone (FIG. 9a) was active in both *P. Falciparum* and HIV-1 whereas compounds (FIG. 9b) and (FIG. 9c) were specific inhibitors of the HIV-2 multiplication. Author suggested that para substitution on the B ring is needed to promote antiplasmodial activity and increase HIV-2 potency [52].



9a 9b 9c

FIG. 9. **Methoxyflavone.**

Among a series of benzopyran-4-one scaffolds synthesized by Ungwitayatorn et al. via one pot cyclization reaction, 7,8-dihydroxy-2-(30-trifluoromethylphenyl)-3-(300-trifluoromethylbenzoyl) chromone (FIG. 10) showed HIV-1 protease inhibition *in vitro* [53].

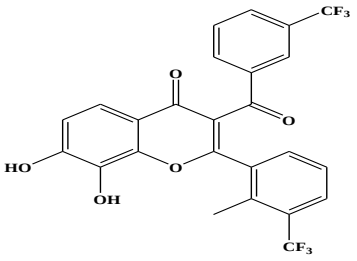


FIG. 10. **7,8-dihydroxy-2-(30-trifluoromethylphenyl)-3-(300-trifluoromethylbenzoyl) chromone.**

Antioxidant activity

Yasar et al. synthesized azaflavone (FIG. 11) and evaluated their antioxidant activities and antimicrobial activities [54].

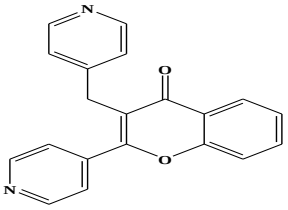


FIG. 11. **Azaflavone.**

Anti-malarial activity

A new chromone derivative (FIG. 12) was isolated from the wood-decay fungus Rhizina species by Isaka et al. and evaluated for antimalarial activity against *P. falciparum* K1. This derivative exhibited antimalarial activity with an IC50 of 5.1 mg/mL.

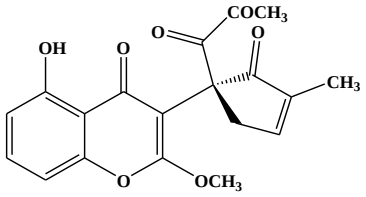
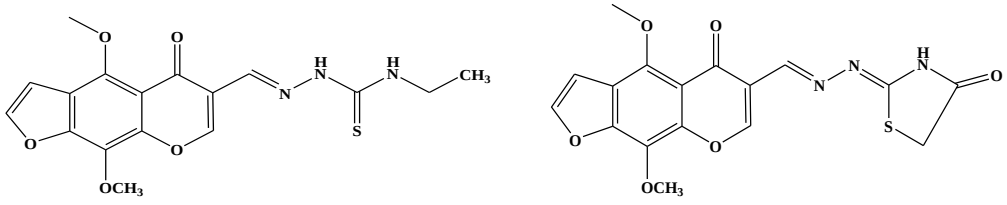


FIG. 12. **New chromone derivative isolated from the wood-decay fungus Rhizina species.**

Anti-convulsant activity

Following FIG. 13a and 13b chromone showed 100% protection of 300 mg/kg in scPTZ test. In the MES test, all the tested compounds were inactive showing no protection against the seizures induced even up to a dose of 300 mg/kg body weight.



13a 13b

FIG. 13. **Chromone derivatives.**

Anti-platelet activity

Highest activity was found, when the 2-amino substituent of tested chromones (FIG. 14) was a diethylamino group Activity was increased, when the presence of electron releasing substituents (-OH, -OCH_3, -CH_3) was at position 7, whereas a decrease occurred when an electron withdrawing substituent was present in position (3-NO_2) or (6-NO_2, 6-Cl).

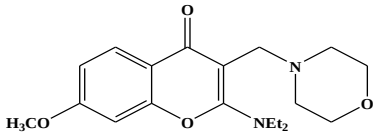


FIG. 14. **Diethylamino group.**

Gastroprotective activity

9-and 6-Alkylaminomethyl furochromones (FIG. 15) synthesized from the naturally occurring chromones visnagin and khellin were screened for gastroprotective activity in the rat ethanol-induced damage model. The presence of methoxy group (either in 4, 9 or 7-position as methoxyphenyl) and through the appropriate substitution in 6-position with alkylaminomethyl group, furochromones exhibited good gastroprotective activity in the ethanol damage model.

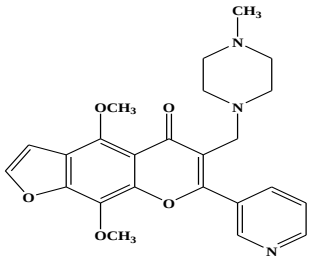


FIG. 15. **9-and 6-Alkylaminomethyl furochromones.**

H1 Anti-histaminic activity

2-phenyl-4H-chromen-4-one (FIG. 16) analogs were evaluated for the H1 antihistaminic activity computational method, the compounds showed highest antihistaminic activity.

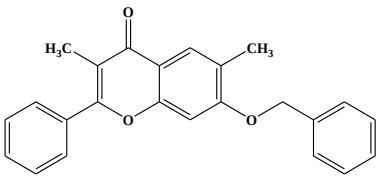


FIG. 16. **2-phenyl-4H-chromen-4-one.**

Antihypertensive activity

Wu et al. synthesized 3-Phenylflavonoxy propanolamines (FIG. 17a and 17b) and evaluated for potential antihypertensive activity in spontaneously hypertensive rats as well as for *in vivo* and *in vitro* evidence of β-adrenoceptor antagonism. Compounds were active in lowering blood pressure at 8 mg/kg.

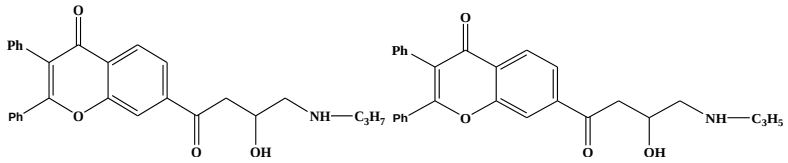


FIG. 17. **3-Phenylflavonoxy propanolamines.**

m-calpain inhibition activity

Lee et al. prepared chromone carboxamide derivatives and evaluated for m-calpain inhibition using a casein-coomassie blue microplate assay. Compound (FIG. 18c), was the most potent calpain inhibitor of this series (IC50¼ 0.24 mM), exhibited 14.4% and 22.4% inhibition, demonstrating high selectivity of chromone derivatives for m-calpain. The introduction of dioxane ring in the chromone ring generally resulted in the decreased inhibitory activity of the parent compound, irrespective of amide; however, amide substituents were also important in the activity.

The compounds (FIG. 18) possessing benzyl and phenethyl amide showed good inhibition of m-calpain, while the potencies were decreased about 10-fold when these substituents were replaced by 2-(morpholin-4-yl) ethyl or isopropyl amide.

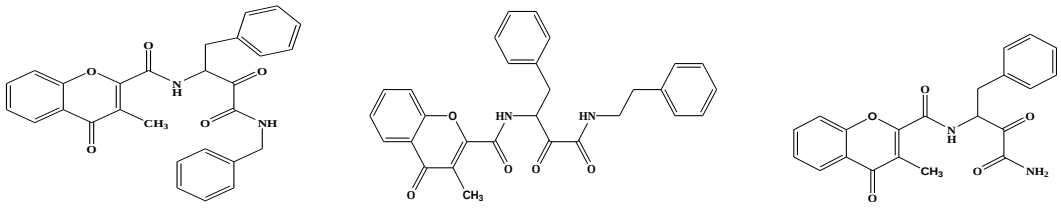
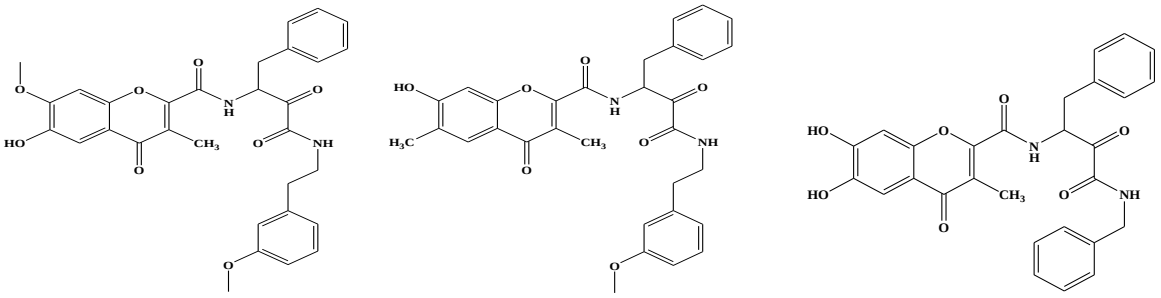


FIG. 18. **Benzyl and phenethyl amide combined with m-calpain forms 2-(morpholin-4-yl) ethyl or isopropyl amide.**

New chromone carboxamide derivatives were synthesized and evaluated using human calpain I isolated from erythrocytes. Compounds with 4-methoxyphenethyl group at the keto-amide position, i.e., (FIG. 19a) and (FIG. 19b) exhibited the most potent m-calpain inhibitory activities (IC50¼ 0.09e0.10 mM), and compound (FIG. 19c) showed both potent m-calpain inhibitory activity (IC50¼ 0.28 mM) and antioxidant activities in DPPH scavenging and lipid peroxidation inhibition assay reported by Kim et al. [54].

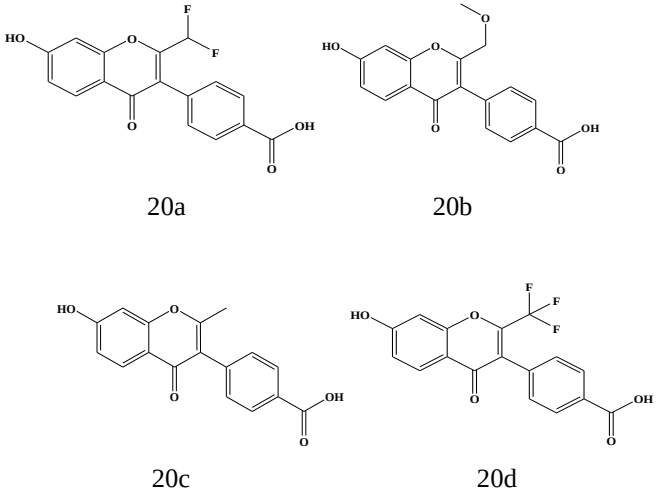


19a 19b 19c

FIG. 19. **Keto-amide position exhibited the most potent m-calpain inhibitory activities.**

Glutathione reductase activity

A series of chromone compounds (FIG. 20a-20d) were synthesized as S-nitrosoglutathione reductase (GSNOR) inhibitors by Sun et al. These GSNOR inhibitors can be utilized in any pharmaceutically acceptable dosage form, including but not limited to injectable. Some of the compounds (FIG. 20a to 20c) have showed IC50 less than 0.5 mM and compound (20d) showed IC50 less than 0.1 mM against the GSNOR inhibitors [55].



20a 20b

20c 20d

FIG. 20. **S-nitrosoglutathione reductase (GSNOR) inhibitors.**

Anti-allergic activity

Abram et al. [56] synthesized 2,3,7-Substituted chromone salts (FIG. 21) and screened for their antiallergic activity. All compounds tested exhibited oral antiallergic activity when ad ministered at a concentration of 30 mg/kg.

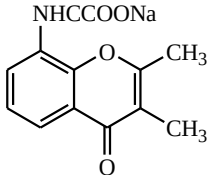


FIG. 21. **2,3,7-Substituted chromone salts.**

Conclusion

Therapeutic potential and synthetic brief of chromones are reviewed. There have been several synthetic methods developed. Noticeably, cyclization of chalcones to chromene-4-ones is one of the most utilized synthetic tools used in the synthesis of chromones. These moieties are recognized as pharmacophores having a number of biological activities such as anticancer, antiviral, antifungal, antimicrobial, antioxidant, antidepressant, anti-HIV and antiobesity etc.

Acknowledgement

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REVIEW Article

A BRIEF REVIEW ON RECENT ADVANCES OF CITRUS MAXIMA (CHAKOTA)

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ABSTRACT

A great number of epidemiological studies have shown that Citrus fruit consumption is protective in a variety of human cancers and many more diseases and Citrus maxima being the largest citrus fruit also has these medicinal properties. The present review is aimed to evaluate the cytoprotective action of *Citrus maxima* for various diseases especially cancer and it has been reported to have a broad range of therapeutic effects, including antibacterial, antiviral, antifungal, antitumor, antihelmin, analgesic, hypotensive, anti-inflammatory, and immune enhancing effects. This article summarizes external morphology of the plant including leaves, fruit and seeds. Also captured is the chemical analysis in which various chemical constituents present in the different parts of the plants. Also captured are the medicinal properties which have been used from centuries and the recent developments.

INTRODUCTION

India is well known for its Ayurvedic medicines from centuries. Ayurveda has given many herbal medicines which are very useful against Cancer, Heart diseases and many more but there are number of plants, which are not studied totally. From such plants, one of these is *Citrus maxima*. As citrus is important part of our diet including oranges, lemons, limes and grapefruits and are a principal source of important nutrients, which are suggested to be responsible for the prevention of degenerative disease. These include vitamins C, folic acid, carotenoids, dietary fibres, potassium, selenium and a wide range of phytochemicals. A great number of epidemiological studies have shown that Citrus fruit consumption is protective in a variety of human cancers and many more diseases. It is native to Asia and cultivated for utilization of its medicinal properties in many countries like Japan, Vietnam, Malaysia, Indonesia and Thailand. The fruits are a rich source of vitamin C, B1, B2, B12, protein and calcium. Decoctions of the leaves, flowers, fruits and seeds are used to treat convulsive cough, fever and gastric disorders and are also given for their sedative effects in cases of epilepsy. Citrus peels exhibit prominent antioxidant and anti-inflammatory effects. Leaves and peels contain numerous bioactive compounds such as phenolic acids, flavonoids and limonoids. Some of the compounds like limonene, citral, aldehydes, geraniol, cadinene and linalool are skin irritants which may cause dermatitis on excessive contact. [1]

Citrus maxima, the pomelo (also called pummelo or shaddock) in the Rutaceae (citrus family). Its scientific name is *Citrus maxima* because it is the largest citrus fruit. The closest in size to this king of citrus fruits is a grapefruit. *C. maxima* is considered as an easily recognized species due to a number of notable morphological characteristics, such as huge leaves borne on broadly winged petioles, very large and fragrance flowers and big fruits with a single embryo, while most of other Citrus species are polyembryonic (Uzun and Yesiloglu, 2012) [2]. Pomelos are primarily found in Southeast Asia, which is their native region, and primarily found there. It has not become widely popular in other parts of the world, because it typically takes 8 years before the seeds can begin to flower and bear fruit. Also, much of the weight and volume of pomelos is tough and inedible, while only the inner flesh is palatable. It is a medium sized tree but the largest of all Citrus species, with large leaves, flowers, and fruits. The species is native to southern China and Malaysia (and possibly other parts of Southeast Asia), and is now cultivated in many tropical and semitropical countries for its large fruits. This species was a progenitor of the grapefruit (C. X paradisi) and the tangelo (C. reticulata), among other modern citrus hybrids. Pomelos are often confused with grapefruits, from which they can generally be distinguished by their larger size, thicker rinds, milder-even sweet-flavor, and tough bitter membranes that are often considered inedible. *Citrus maxima* was originally called "shaddock" in English, after the captain of an East India Company ship who introduced it to Jamaica in 1696. Recently

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the word "pomelo" has become the more common name, although "pomelo" has historically been used for grapefruit.

Like other citrus fruits, pomelos are high in vitamin C. They are generally eaten as a fresh fruit, and they store well. They have long been popular in Asia, especially China, Indonesia, and Thailand, but are increasingly found in specialty markets in the U.S. as well. The juice is also used in various beverages (both alcoholic and non alcoholic) and the peel may be candied. Traditional medicinal uses of the fruit include treatment of coughs, fevers, and gastrointestinal disorders. The aromatic flowers are picked and processed into perfume in Vietnam, and the wood, which is heavy and hard grained, used for making tool handles.

Several recent studies have demonstrated that the cytoprotective action of citrus fruits is enhanced by the presence of antioxidants including vitamin C, phenolics, carotenoids and flavonoid. Additionally, epidemiological studies reveal a strong correlation between high levels of citrus fruit consumption and CVD risk reduction, but the mechanisms of action, particularly on endothelial cells and cardiac cells, have not been fully explored. [2]

About *Citrus maxima* plant:

Local Names [4]

Pomelo, Pommelo, Pummelo, Pompelmous, Shaddock

Common Names [4]

Burmese - Shouk-ton-oh, Kywegaw
Dutch - Pompelmoes
English - Shaddock, Pummelo, Pumelo, Chinese grapefruit, Pompelmous
Sanskrit - Madhukarkati
Hindi - Mahanimbu
Marathi - Panis, Papanas
Bengali - Betabi lebu
Assamese Robab teng
Manipuri Nobbab
Malayalam Kambili narnga
French Pamplemousse
German - Pampelmus, Pompelmus
Indonesian - Jeruk besar, Jeruk Bali
Khmer - Krôoch thlông
Lao - Sino-Tibetan
Malay - Bali lemon, Pomelo
Thai - Som-o,ma-o
Vietnamese - Bu'o'i
Transcribed Chinese - You, zhu luan
Portuguese - Jamboa

Classification [5]

Citrus maxima (Burm. f.) Merr.
Kingdom: Plantae-Plants
Subkingdom: Tracheobionta - Vascular plants
Superdivision: Spermatophyta - Seed plants
Division: Magnoliophyta - Flowering plants
Class: Magnoliopsida - Dicotyledons
Subclass: Rosidae
Order: Sapindales
Family: Rutaceae Rue family
Genus: Citrus L.Citrus
Species: *Citrus maxima* (Burm. f.) Merr.Shaddock

Biology

Pummelos may flower 2-4 times a year. In the prime-growing region in southern Thailand, fruiting is heaviest in May-October and scant in January-March and November-December. In Nepal, pummelo trees starts fruiting from September-February. In Florida, the fruits ripen from November to February and there may be a small crop in the spring. Pummelo is largely self-incompatible, and unlike other Citrus species, does not produce nucellar seedlings. Cross pollination and fertilization occur between pummelo and other species of the genus, giving it a greater range of genetic variability relative to other Citrus species. In most cases, the quality and quantity of production of pummelo is very low in farmers' fields due to inferior trees grown from seeds. The citrus species are famous for the source of essential oils. *Citrus maxima* is same as other citrus species that contain essential oil glands in their fruit peel and flower petals. [6]

Geographic Distribution

The Pomelo is native to south eastern Asia and all of Malaysia and grows wild on river banks in the Fiji and Friendly Islands. It may have been introduced into China around 100 B.C. It is much cultivated in southern China (Kwangtung, Kwangsi and Fukien Provinces) and especially in southern Thailand on the banks to the Tha Chine River. In Taiwan and southernmost Japan, southern India, Malaya, Indonesia, New Guinea and Tahiti, Pomelos are like unexpected guests that appear, say a quick hello, and then run off. In India these fruits grow from November through December, during which they come and go from the markets. Because these fruits do not grow on a large-scale commercially, those who live more than 30 miles from the nearest pummelo grove are out of luck. On occasion, pomelos are imported from overseas and thus appear in specialty grocery stores. Their appearance shouldn't be credited to local demand, but rather the growing number of Asian expats living in India. [5], [7]

Distribution: 2

The Pummelo is tropical or near-tropical and flourishes naturally at low altitudes close to the sea. On the salty mud flats, farmers dig ditches and create elevated beds of soil for planting the trees. The salt content of the water varies throughout the year but may be as high as 2.11 % at times. In Malaysia, the tree grows well on the tailings of tin mines.

Documented Species Distribution

The map below shows countries where the species has been planted. It does neither suggest that the species can be planted in every ecological zone within that country, nor that the species cannot be planted in other countries than those depicted. Since some tree species are invasive, you need to follow biosafety procedures that apply to your planting site.

Exotic range-Not found
Native range-Bangladesh, Cambodia, Chile, India, Indonesia, Japan, Laos, Malaysia, Philippines, Thailand, Vietnam. [6]

Life history and behavior

Altitude - 01300
Habit - Tree
Fruit Details - Fruit Is Modified berry known as hesperidium
Habitat - Saline mud flats and mostly cultivated
Flowering Period - April June
Fruiting Period - Oct Dec
Fruit Type - Berry
Bark Type - Rugged
Bark Details - Bark grayish brown and lenticellate
Leaf Type - Compound
Leaf Arrangement - Alternate (leaves born singly along stem)
Mean annual temperature - 25 30ºC
Mean annual rainfall - 1,500 1,800 mm
Flower Colour - White
Drought Tolerance - Low
Salinity Tolerance - Medium
Sun Tolerance - High
Wind Tolerance - High
Water-Log Tolerance - Low
pH Level - Basic
Pest Tolerance - Medium
Disease Tolerance - High
Growth Rate - Medium
Fragrance - Yes
Growth Habit - Upright/Spreading
Soil type - From its coastal habitat, it prefers the rich silt and sand overlying the organically enriched clay loam of the flood plain and highly tolerant to brackish water pushed inland by high tides. Although it tolerates a wide range of soils from coarse sand to heavy clay, pummelo prefers deep, medium-textured fertile soils free from salt. In southern Florida and the Bahamas, the trees grow and fruit modestly on oolitic limestone. [8]

Plant Description

The Pomelo tree may be 16 to 50 ft (515 m) tall, with a somewhat crooked trunk 4 to 12 in (1030 cm) thick, and low, irregular branches. The young branchlets are angular and often densely hairy, and there are usually spines on the branchlets, old limbs and the trunk. The leaves are alternate, ovate, ovate oblong, or elliptic, 2 to 8 in (520 cm) long, 3/4 to 43/4 in (212 cm) wide, leathery, dull green, glossy above, dull and minutely hairy beneath. The flowers are fragrant, borne singly or in clusters of 2 to 10 in the leaf axils, or sometimes 10 to 15 in terminal racemes 4 to 12 in (1030 cm) long with 4 to 5 petals, yellowish white, 3/5 to 1 1/3 in (1.53.5 cm) long, somewhat hairy on the outside and dotted with yellow green glands. Stamens are white, prominent, in bundles of 4 to 5, anthers orange. The fruit ranges from nearly round to oblate or ear shaped, 4 to 12 in (1030 cm) wide. The peel, clinging or more or less easily removed, may be greenish yellow or pale yellow, minutely hairy, dotted with tiny green glands, 1/2 to 3/4 in (1.252 cm). The pulp varies from greenish yellow or pale yellow to pink or red and it is divided into 11 to 18 segments, very juicy to fairly dry. The segments are easily skinned and the sacs may adhere to each other or be loosely joined.

Fig 1 Tree of *Citrus maxima*.

The flavor of the pulp varies from mildly sweet and bland to subacid or rather acid, sometimes with a faint touch of bitterness. Generally, there are only a few, large, yellowish white seeds, white inside, though some fruits may be quite seedy.

A Pomelo cross pollinated by another pummelo is apt to have numerous seeds. If it is cross-pollinated by sweet orange or mandarin orange, the progeny will not be seedy. [5]

The citrus species are famous for the source of essential oils. The *Citrus maxima* is the same as other species of citrus that contains essential oil glands in their fruit peels and flower petals. The citrus oil have strong aroma with refreshing effect. They have been used as flavouring in food, beverages and pharmaceutical products. They also have been used as fragrance in perfumes, cosmetics and aromatherapy. The citrus flower oil have relaxing and hormone balancing effect which has been used in Aromatherapy and perfumery.

In Thailand, after peeling the citrus fruit for juice and fruit pulp, the metric ton of peeled part is used for its oil as a by-product. Nowadays, there are no *Citrus maxima* essential oil available. Because the extraction of flower essential oil needs modern methodology for reducing solvent residue, impurities

and chemical transformation and increasing yield. This factors only influences on the oil quality. Therefore supercritical carbon dioxide extraction is considerable advantage over the other extraction method.

It is true that gardeners or cultivators grow *Citrus maxima* trees for their fruits and not for flowers. However after the fertilization of *Citrus maxima* flower, their petals fall down and they are allowed to wither with and no use. Then the development of *Citrus maxima* flower oil extraction is profitable for the gardener. Because the *Citrus maxima* is unique in Southeast Asia and its flower oil could generally substitute neroli that import from western countries.

Soil and Climatic Adaptation

The pummelo thrives in the lowland tropics. For commercial production, elevation not exceeding 400 masl is preferred with optimum temperature of 2530 C. It can tolerate a wide range of soils from coarse sand to heavy clay. However, it prefers deep, medium textured, fertile soils free from injurious salts; Optimum pH from 5.5 to 6.5; Annual rainfall requirement 15001800 mm. In the 3 major pummelo provinces of Thailand, the best orchards are situated on the banks of current and former river courses.

Cultural Practices

Plant Propagation

Pummelo can be propagated sexually by seed or asexually by air layering (marcotting), budding, grafting and stem cuttings. In Southeast Asia, the most common propagation method is air layering. However, when there are certified disease free mother plants, grafting and budding are recommended. In the Philippines, shield budding is the standard budding method using calamandarin rootstocks. Calamandarin is believed to be a hybrid of the calamondin (x*Citrofortunella microcarpa*) and mandarin (*Citrus reticulata*).

Land Preparation and Planting

In sloping lands and in staggered planting, the farm can be prepared by slashing of the vegetation and clearing of the immediate peripheries of the hills. Otherwise, the land should be prepared thoroughly by ploughing and harrowing. If the soil is too acidic, lime should be applied. Holes or pits are then dug about 0.5 m deep and wide.

The plant to plant spacing is 810 m x 68 m, depending on the terrain and soil fertility. This is equivalent to a population density ranging from about 125 to 208 plants per hectare. To ensure supply of nutrients, compost is applied at the bottom of the hole or mixed at about 1/3 proportion with the topsoil which will be used to refill the hole after planting. In general, planting is delayed for at least 15 days if raw manure will be used. Planting is better done during the onset of the rainy season. But it can be done anytime if rainfall is well distributed throughout the year or where there is irrigation. In Thailand, pummelos are grown on raised beds with ditches in between beds.

Watering

Watering should be done immediately after planting to ensure contact of the soil and roots and to prevent wilting. The regular supply of water is especially important before flowering and until after harvest. To force early flowering, irrigation is delayed during the dry season until the trees show signs of wilting. The wilting trees are then irrigated. To sustain new shoot growth and the development of flowers and fruits, regular supply of water is needed. A mature pummelo tree may need 100 to 200 litres water daily during dry periods.

Intercropping

Planting of intercrops like banana and areca palm on the strips between the rows of pummelo has been practiced to maximize utilization of vacant farm spaces, provide shade and protection from wind, and serve as cash crops during the juvenile stage of the main crop. Annual intercrops will also serve as cover crop.

Weeding

Just like other crops, pummelo needs regular weeding to eliminate competition for soil moisture and nutrients. The uprooted weeds can be piled around the base of the trees to serve as mulch.

Pruning

At 46 months after planting, the trees are pruned to induce branching. This is done by top pruning about 30-40 cm from the ground. 3 branches which are evenly distributed in separate horizontal directions are retained and allowed to develop.

Genetics and improvement

There has been practically no genetic improvement of pomelos. All existing cultivars were obtained from selection of chance seedlings and somatic mutations.

Fertilizing

Proper fertilization is a standard cultural practice in fruit production, especially in association with floral induction. A practice in Nakhon Prathom, Thailand is to apply 5 kg complete fertilizer per tree per year split into 6 applications or every two months. Foliar fertilizer is also applied every new flushes. In the last application before harvest, NPK combination of 131321 is used to improve fruit taste. In other parts of the country, 2 split applications are recommended, the first before flowering and the second 46 months later.

Pests and Diseases Control*:* All pests of citrus also attack the pummelo plant. These include the common leafminers (*Phyllocnistis citrella*), leaf eating caterpillars, fruit boring caterpillar (*Citripestis* sp.), scales, red mites, fruit flies, nematodes and rats. The major disease of pummelo is the bacterial canker caused by *Xanthomonas citri*. Symptoms are characterized by oily spots on the leaves and fruits which later turn brown and corky.

Control methods: include defoliation and, in severely infected plants, burning to prevent spread. Other diseases are the root rot, gummosis on the trunk and brown rot of the fruit, all of which are caused by the Phytophthora fungi. Both fruits and leaves are also infected by scab caused by *Elsinoe fawcetti*. To control fungal diseases, repeated spray of chemical fungicides is recommended. The leaves, fruits and sometimes the branches are likewise prone to sooty mold which is caused by *Capnodium citri* or *Miliola citricola*. Sooty mold can be prevented by proper insect pest control. A recent innovation to

prevent serious damage due to insect pests and diseases is the bagging of fruits.

Harvesting

The pummelos are picked at maturity which occurs about 140 to 160 days from fruit set. The dull skin of the fruit brightens upon ripening as the oil glands become more prominent and shiny. This change starts near the tip of the fruit and progresses towards the stalk.

Postharvest operations

At maturity, the color of the rind changes as the oil glands become more prominent and shiny. The fruit should be harvested immediately in order to obtain the highest quality and longest shelf life, which may be as long as several months. Having a rather thick rind, little postharvest treatment is considered necessary.

Fruiting season

The fruiting season of *Citrus maxima* is different in different regions of the world. If we talk about Vietnam, in the South, September to February (peak season November to January). In the North, August to November (peak season in October). There is some difference in cultivars with respect to fruit maturation, for example Phuc Trach (a popular cultivar of Ha Tinh province in the North), matures in August to September. And in India, These fruits grow from November through December and sometimes mid in the year.

Yield

Pomelos are potentially heavy bearers because they do not have a severe problem with pests and diseases. Normally about 70 to 100 fruits per year are expected from a five year old or older tree. This is equivalent to about 20 t/ha. [9]

Review

Leaves of Citrus maxima

Leaves, compound, appearing simple, having one leaflet, alternate, glandular, dotted, ovate to elliptical, 5-20 cm long, 2-12 cm wide and leathery. Petiole broadly winged to occasionally nearly wingless, up to 7 cm wide. [6]

Fig 2 *Citrus maxima* Leaves

Macroscopic Study of Citrus maxima Leaf: 10 to 12 matured leaves were taken for macroscopic study. Size measured is mean of ten readings (Figure 2). Leaves were evenly distributed on branches of tree.

Leaf- 15-16cm long and 5.5-6.5cm width.

1. Petiole 4-4.5 cm long (Winged) and 2.5-2.8cm width.
2. 2. Shape: Ovoid.
3. Apex: Acute.
4. Base: Asymmetrical.
5. Margin: Entire.
6. Color: Greenish.
7. Surface: Glarus.
8. Midrib: Prominent on both surfaces of leaf.
9. Odour: Characteristic.
10. Taste: Acrid

Leaf preparation for microscopy [10]: Fresh leaves were taken & boiled with chloral hydrate solution for clearing the section. Transverse section of leaf through midrib was taken & then photographs of section were taken (**Figure 3 & 4)** Following are some of the microscopic characters observed in sections;

Lamina: Leaf showed dorsiventral characteristics.

Epidermis: Lower and upper epidermis showed abundant Anisocytic stomata and uniserate, multicellular, thin walled, covering trichomes on lower epidermis. It showed single layer of palisade cells on upper epidermis.

Mesophyll: It is middle part between lower & upper epidermis of leaf. It shows the sclerenchymatous cells covering to vascular bundle. Parenchymatous cells contain calcium oxalate crystals. Collechyma cells were present in mesophyll under the vascular bundle & lower epidermis.

Starch grain and yellow colored oil globules were present.

Midrib: Vascular bundle: Vascular bundle present & showing xylem and phloem arrangement at middle of midrib.

In their research Ratna Susandarini and coworkers from Indonesia for assessment of Taxonomic Affinity for Indonesian Pummelo on the basis of Morphological characters, a total of 60 accessions were collected, including 17 accessions representing 11 commercial cultivars and 43 accessions representing landraces.

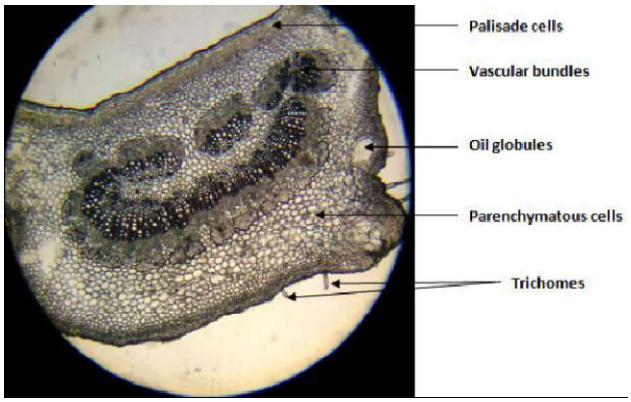

Fig 3 T. S. of *Citrus maxima* leaf without stain.

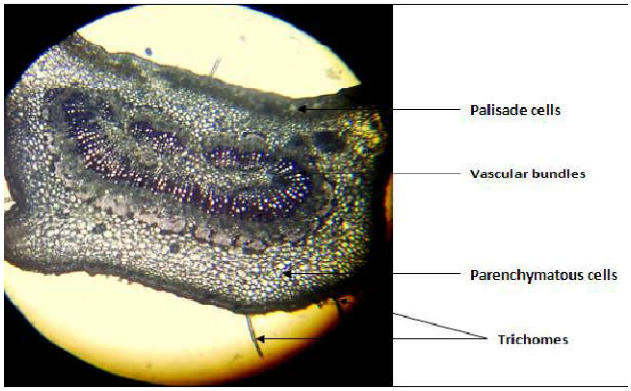

Fig 4 T.S. of *Citrus maxima* leaf with Phloroglucinol staining.

Observation on leaves morphology revealed a number of variability among accessions, including shape of leaf blade, leaf base, leaf apex, leaf margin, length of petiole, shape of petiole wing, ratio of leaf blade to petiole wing and the nature of connection between leaf blade and petiole wing. Flowers morphology varied only on their size and relative position of stamens to pistil. Fruits showed variability in their shape, apex, base, peel texture, appearance of oil glands on the peel, mesocarp color, number and arrangement of fruit segments, fruit flesh color and texture and number of seeds. Since flowers were not always available in all samples, thus the data used for subsequent analysis was consisted of morphological characters from leaves and fruits. The dendrogram constructed using UPGMA method showed that two main clusters commonly known as "Sour and Bitter Pummelo", whereas the second cluster (group B) was comprised of accessions known as "Sweet Pummelo".

Table 1 Morphological characteristics of two pummelo groups

Morphological character	Group A: Sour and Bitter Pummelo	Group B: Sweet Pummelo
Shape of petiole wing	Obcordate or obdeltate	Obovate or linear
Leaf length to petiole wing length ratio	Big (wide petiole wing)	Small (narrow petiole wing)
The nature of connection between leaf blade and petiole wing	Imbricate or valvate	Separate
Leaf margin	Crenate	Entire
Rind texture	Medium rough or rough	Smooth or medium rough
Number of seeds in fruit	Numerous	Few or medium

Each group could be recognized by combination of characters with consistently clustered accessions belonging to the corresponding group and thus combination of these characters was regarded as distinguishing characters for the group were formed. The first cluster (labeled as group A) consisted of Pummelo accessions.

The grouping of accessions resulted from cluster analysis which represented considerable degree of phenotypic variability did not show any correlation pattern to geographical origin of the samples. Members of a particular cluster were consisted of accessions from various sampling areas and thus indicated that phenotypic variability was not influenced by their habitat or other environmental factors. It was reasonable to affirm that this phenotypic variability had a genetic basis. Results of this study also suggested that leaves and fruit morphological characters provided a practical approach in distinguishing cultivar groups within pummelo and thus applicable for common people and breeders in selecting favourable cultivars. [11]

Table 2 Phytochemical screening of leaves of chakota [12]

Phytoconstituent	Test	Result
Alkaloids	Dragendorff's test	+ve
	Hager's test	+ve
	Wagner's test	+ve
Flavonoids	Shinoda test	-ve
	Lead acetate test	-ve
Phenolics	Ferric chloride test	-ve
	Folin ciocalteu test	-ve
Sterols and triterpenoids	Salkowski test	-ve
	Libermann-Buchardt test	-ve
Cardiac glycosides	Legal test	-ve
	Baljet test	-ve
Saponin glycosides	Foam test	+ve
	Lead acetate test	+ve
Anthraquinone glycosides	Borntrager test	-ve
	Modified Borntrager test	-ve
Carbohydrates	Fehling's test	+ve
	Molisch test	+ve

Phytochemical analysis showed the presence of important classes of phytoconstituents like alkaloids, saponins and carbohydrates. This indicates that this plant can be useful for treating different diseases because the therapeutic activity of a plant is due to the presence of particular class of compounds. Development of such a monograph would help in isolation of phytoconstituents, therapeutic investigations and standardization of formulations containing its leaf material. [12]

Flower Description

Flowers fragrant, borne singly or in clusters of 2-10 in the leaf axils, or sometimes 10-15 in terminal racemes, 10-30 cm long; rachis and calyx hairy; 4-5 petals, yellowish-white, 1.5-3.5 cm long, somewhat hairy on the outside and dotted with yellow-green glands. Stamens 20 25, white, prominent, in bundles of 4-5, anthers orange. Flowers are highly aromatic and used for making perfumes in Vietnam.

Fig 3 Flowers of *Citrus maxima*.

Fruit Description

This fruit is biggest among citrus family. Fruit ranges from nearly round to oblate or pear-shaped; 10-30 cm wide; the peel, clinging or more or less easily removed, may be greenish-yellow or pale-yellow, minutely hairy, dotted with tiny green glands; 1.25-2 cm thick, the albedo soft, white or pink; pulp varies from greenish-yellow or pale-yellow to pink or red; is divided into 11-18 segments, very juicy to fairly dry; the segments are easily skinned and the sacs may adhere to each other or be loosely joined; the flavour varies from mildly sweet and bland to sub-acid or rather acid, sometimes with a faint touch of bitterness. Seeds few, large, yellowish-white and white inside; though some fruits may be quite seedy. [6]

Fig 4 Unripen fruit.

Fig 5 Ripen Fruit

Its flesh is juicy, soft in texture and rich in nutrients. However, the pomelo cannot be picked immature for after-ripening because it contains little starch and is non-limacteric. The rind of the pomelo consists of the flavedo, which is green with oil glands spotted all over the fruit peel, and the albedo, which is white and has a spongy texture (Fig. 6). There are eight to nine segments containing juice sacs (flesh) which are covered with a tough skin called the lamella. At the center of each lamella, there is a core which is hollow when the fruit is ripe. Close to the core in the juice sac segments are the seeds. These parts of the fruit change texturally and physicochemically during maturation. The ripening occurs in the final phase of fruit development, and involves deep metabolic changes in the biochemistry, physiology and gene expression of the fruit in the form of chlorophyll degradation and pigment (carotenoids and anthocyanins) biosynthesis, conversion of starch to simple sugars, accumulation of flavor and cell wall softening, ethylene receptor degradation, simple sugar and organic acid accumulation, volatile oil production and flesh softening. Many of the changes have been primarily characterized in climacteric fruits, but are poorly understood in non-climacteric fruits.

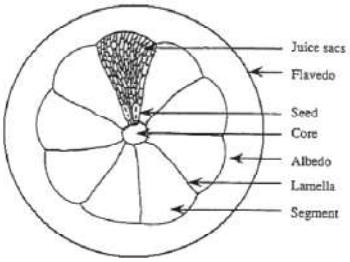

Fig 6 Schematic diagram of pomelo fruit [13]

Semi-quantitative analyses of thin sections of pummelo peel revealed a gradual transition in density between exocarp and mesocarp. Thus, structurally, the dense exocarp cannot be separated clearly from the spongy mesocarp. We hypothesize that due to this lack of an abrupt change in tissue composition and therefore in structural and mechanical properties the risk of delamination of the tissues during impact is reduced. The impact force acting on the pummelo depends on the velocity of the fruit before impact and its weight, but also on the consistency of the ground. Under natural conditions, part of the total energy is dissipated by the relatively pliable ground, as typically existing in the regions where pummelos grow naturally. In the tests presented, mechanical loads acting on the fruits were increased by dropping the fruits onto a hard ground. Thus all kinetic energy must have been dissipated by the fruits themselves. The mesocarp with its air filled intercellular spaces represents a compressible foam. As the Young's modulus of this spongy part of the peel is rather low, we conclude that its ability to dissipate large amounts of energy must result from the structural composition of the peel. [14]

Checking for Ripeness in Pomelo

Many delicious pummelos have green skin while others have a burnt yellow appearance. The range of the fruit's colorful exteriors means that the skin color should not be used as a

baseline. Pick pummelos that feel heavy for their size, are firm, smooth and shiny. Avoid fruit with marks, coarse or wrinkly skin, and soft spots. The thinner rind fruits often contain the most flesh, especially those practically emitting citrus oil while in the hand. A good chakota is also aromatic near the stem.

Pomelos have the taste of grapefruit without the bitterness and acidity, coupled with gorgeous floral overtones and a clean taste. The texture is fleshy and has more membrane than many other types of citrus; A bad pummelo is marked by dry, desiccated flesh with little juice.

There are actually three types of the pomelo;

White Pomelo: Belonging to the Citrus Grand family; the Israeli variety of the Pomelo is actually an exclusively huge fruit, described as huge juice saccules, extremely thicker peel, sweet pulp as well as exclusive odour. White pomelo is usually offered as treat which will help in the digestion of food. The Pomelo is collected in between mid-October as well as mid-May

Fig 7 White Pomelo

Red Pomelo: Red pomelo has got softer as well as thinner-skinned variety.

Fig 8 Red Pomelo.

The Red Pomelo is good, tangy, as well as sour, compact along with pink pulp with a little more compacted design. This massive citrus fruit, abundant with vitamin C as well as potassium, is really an indigenous of Malaysia and is also thought to be the ancestor of the grape fruit. The Israeli-grown Red Pomelo ripens in between September as well as January.

Pink Pomelo: Pink pomelo consists of numerous seeds and is also sweet as well as juicy. The pink pomelo can also be regarded as the remedy for stomach or even the intestinal worms.

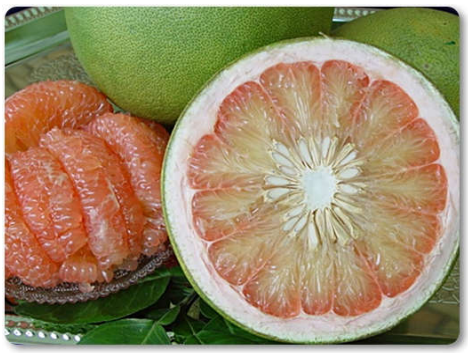

Fig 9 Pink Pomelo.

Nutritional values of C.maxima

Malnutrition problem is a matter of great concern in developing countries. Health profile of a community is greatly influenced by its nutritional status and life style. India is one of the developing countries of the world, where aforesaid problem is very common, especially in villages. Nutritionist have raised concern on the nutritive value of cooking food because density of the most nutrients like protein, carbohydrates, vitamins and mineral are very poor. Fruits have been included in the human diet since prehistoric time and now in the western and developing countries, there is a habit to take fresh fruits after meal. Fruits are major source of above mentioned food supplements. *Citrus* is primarily valued for the fruits, which is either eaten alone as fresh fruit, processed into juice, or added to dishes and beverages. All species have traditional medicinal value.

The *Citrus* is rich source of Vitamin C. Its juice also contains carbohydrates, proteins, amino acids, phenolic compounds and minerals etc. Sometimes, after starvation of serious diseases, doctors suggest to take some *Citrus* fruits for vitamins, minerals and other necessary food supplements, which recover weak health condition by improving appetite quickly. Fruits and vegetables are rich source of secondary metabolites such as phenolics which are now identified as natural antioxidant agents. Phenolic compounds have been shown to possess an antioxidant activity based on their (hydroxyl group) donation to free radicals.

Table 3 Various nutritional constituents present in fruit juice of *Citrus maxima* [15]

S. No.	Constituent	*Citrus maxima* (mg/100 ml)
1.	Total Soluble Sugar	4.87 ± 0.09
2.	Total RNA & Pentose Sugar	59.60 ± 6.33
3.	Total Free Amino Acids	5.30 ± 0.07
4.	Total Soluble Proteins	60.51 ± 3.42
5.	Total Phenolic compounds	16.08 ± 0.65
6.	Total Vitamin C	55.25 ± 4.71

Table 4 Nutritional value of fruit juice of *Citrus maxima* [16]

Nutritional value per 100 g (3.5 oz)		
Energy	159 kJ (38 kcal)	
Carbohydrates	9.62 g	
Dietary fiber	1 g	
Fat	0.04 g	
Protein	0.76 g	
Vitamins		
Thiamine (B1)	0.034 mg	(3%)
Riboflavin (B2)	0.027 mg	(2%)
Niacin (B3)	0.22 mg	(1%)
Vitamin B6	0.036 mg	(3%)
Vitamin C	61 mg	(73%)
Trace metals		
Iron	0.11 mg	(1%)
Magnesium	6 mg	(2%)
Manganese	0.017 mg	(1%)
Phosphorus	17 mg	(2%)
Potassium	216 mg	(5%)
Sodium	1 mg	0.00
Zinc	0.08 mg	(1%)

Peel of *Citrus maxima*

Peels were separated from fruits and dried in tray drier. Peel powder was stored in air tight container at room temperature. 25 g of powdered peel was extracted with methanol using soxhlet extractor till complete exhaustion. Extract was concentrated using rotary vacuum evaporator at 40 °C and stored in the vacuum desiccator.

Fig 10 Peel of Pomelo

Pharmacognostic studies

In their study, Aruna Jadhav and her coworkers from Navi Mumbai of Microscopical, Physicochemical and Phytochemical screening of *Citrus maxima* peel made detailed analysis of *C.maxima* fruit peel. [17]

Macroscopic and Microscopic characteristics *Citrus maxima* fruit is mature hesperidium fleshy indehiscent approximately 7.9 cm in diameter, spherical in shape. Outer surface of fresh peel is greenish yellow in color and turns to brownish yellow when dried. Inner surface of fresh peel is white and turns to brownish when dried. Fresh peel has strong aromatic odour while dried peel is less aromatic. Taste is sour and bitter. T.S. of peel shows layer of small epidermis with characteristic stomata (Figure 11 and 12). Next is a zone of parenchyma, composed of loosely packed thin-walled cells. These cells contain prismatic crystals of calcium oxalate (Figure 13). Scattered in parenchyma are large oil glands and xylem vessels with spiral thickening (Figure 14 and 15)

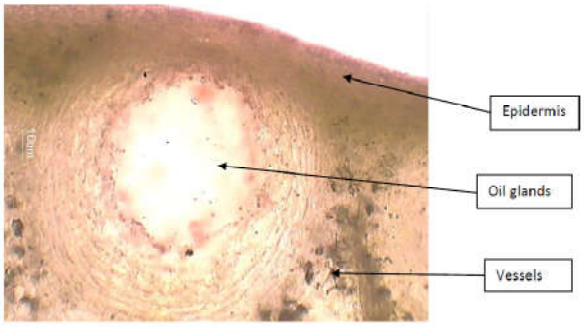

Fig 11 T.S. of *Citrus maxima* peel stained with solution of sudan red.

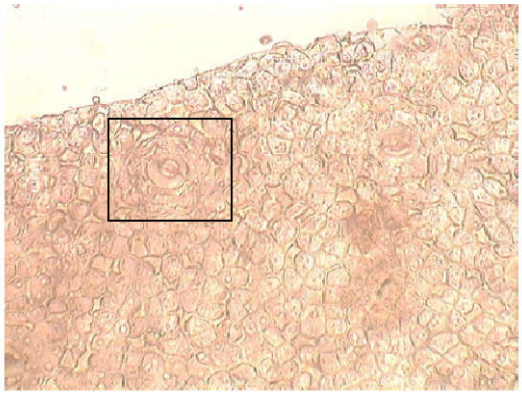

Fig 12 Stomata

Fig 13 Calcium Oxalate Crystal

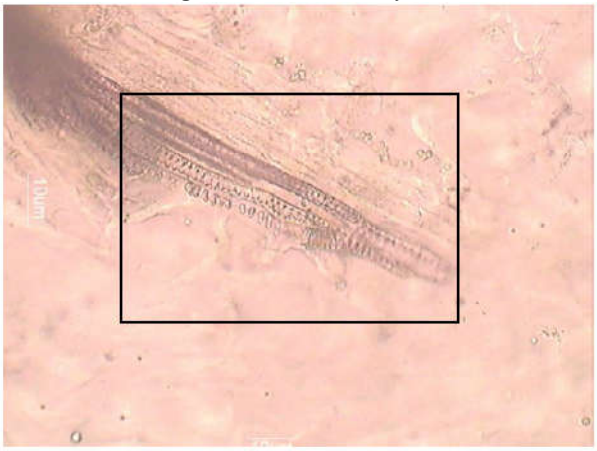

Fig 14 Spiral Vessels

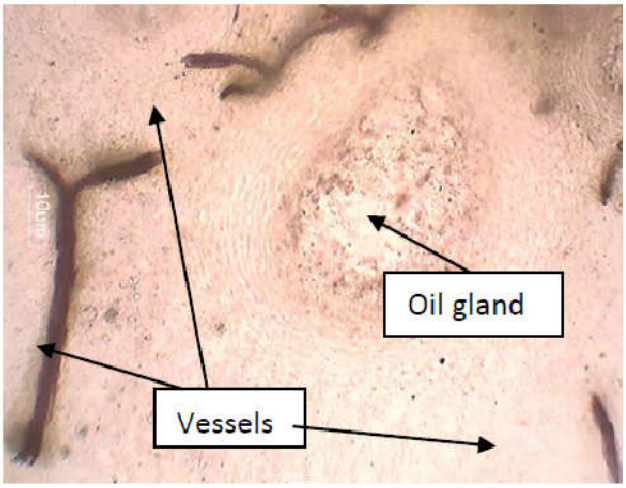

Fig 15 T.S. of *Citrus maxima* peel.

Powdered peel shows presence of epidermis with stomata, xylem vessels and calcium oxalate prisms.

Physicochemical analysis The physical constant evaluation of the drugs is an important parameter in detecting adulteration or improper handling of drugs. Physicochemical characterization of peel powder of *Citrus maxima* is shown in Table 5

Table 5 Physicochemical parameters of *Citrus maxima* peels [17]

Parameters	Values
Total ash	3.17 % w/w
Acid insoluble ash	0.83 % w/w
Water soluble ash	0.67 % w/w
Alcohol soluble extractive	29.24 % w/w
Water soluble extractive	10.25 % w/w

Preliminary Phytochemical analysis The results of qualitative phytochemical analysis of the methanolic extract of pomelo peel are shown in Table 6. Peel had maximum flavonoids and steroids while saponins and tannis were in less amount.

Table 6 Qualitative phytochemical analysis of *Citrus maxima* peel [17]

Phytochemical	Methanolic extract
Flavonoids	+ ve
Alkaloids	+ ve
Steroids	+ ve
Tannins and Phenolic compounds	+ ve
Saponins	+ ve
Anthraquinones glycosides	+ ve
Cardiac glycosides	+ ve
Coumarin and Coumarin glycosides	+ ve
Proteins	- ve
Amino acids	- ve
Carbohydrates	+ ve
Fats and Oils	+ ve

The preliminary phytochemical screening of *Citrus maxima* peels indicated that the plant possesses medicinally important phytochemicals hence can be employed as herbal medicine for primary health care needs as the conventional chemical drugs have many side effects. This study could be useful to establish the authenticity of this medicinally useful plant.

Chemical Constitution of Citrus maxima [18]

There are plenty of reports about the constituents in the different parts of C. maxima including alkaloids, amino acids, benzenoids, carbohydrates, carotenoids, coumairns, flavonoids, mooterpenes, sesquiterpenes and steroids.

Fig 16 Products of Pomelo.

Class	Compound	Plant part
Alkaloids		
	5-hydroxyacronycine	root bark, stem bark
	acriginine A	root
	atalafoline	stem bark
	baiyumine A	root bark
	baiyumine B	root bark
	Buntanbismine	stem bark
	Buntanine	root bark, stem bark
	Buntanmine	stem bark
	citbismine A	root
	citbismine B	root
	citbismine C	root
	citbismine E	root
	citpressine I	root bark, stem bark
	citracridone I	root bark, stem bark
	citracridone II	root bark
	citropone A	root bark
	citropone B	root bark
	citrusinine	root bark
	Geibalansine	stem bark
	glycocitrine I	root bark
	grandisine I	root bark
	grandisine II	root bark
	grandisine III	root
	Grandisinine	root bark, stem bark
	Honyumine	root bark, stem bark
	natsucitrine II	root bark
	Prenylcitpressine	root bark
	Preskimmianine	root bark
	Pumiline	root bark
	Caffeine	flower
Amino acids		
	Alanine	leaf
	Asparagine	leaf
	aspartic acid	leaf
	Coline	leaf
	glutamic acid	leaf
	Glycine	leaf
	Proline	leaf
Benzenoids		
	Crenulatin	root bark, stem bark
	Diphenylamine	fruit juice, flavedo
	n-methylanthranilate	leaf
	p-hydroquinone	root bark
Carbohydrates		
	phytol	leaf
	synephrine	peel
	methyl antranilate	flower (essential oil)
	fructose	leaf
	glucose	leaf, fruit peel
	pectin	peel
Carotenoids		
	carotene	peel
	roseoside	peel
Coumarins		
	5-geranoxy-7-methoxy-coumarin	peel
	5-methoxy seselin	root bark, stem bark
	5-methyltoddanol	stem bark
	6-hydroxy-methylherniarin	stem bark
	aurapten	peel
	auraptene	peel
	bergamottin	peel
	bergapten	peel
	buntansin A	stem bark
	buntansin B	stem bark
	buntansin C	stem bark
	cedrelopsin	root bark
	(Z)-isokhellactone	stem bark
	citrubuntin	root bark, stem bark
	clausarin	root bark
	honyudisin	root bark
	isoimperatorin	peel

Class	Compound	Plant part
	isomeranzin	peel
	meranzin	flavedo
	meranzin hydrate	flavedo
	nordentatin	root bark
	osthole	root bark
	pranferin	peel
	scopoletin	root bark, stem bark
	suberenone	stem bark
	suberosin	root bark
	thamnosin	root bark
	thamnosmonin	stem bark
	umbelliferone	root and stem bark, peel
	xanthotoxol	peel
	xanthoxyletin	root bark, stem bark
	xanthyletin	root bark, stem bark
Class	Compound	Plant part
Flavonoids		
	4'-5-7-8-tetramehoxy flavone	peel
	acacetin	leaf
	apigenin trimethyl ether	peel
	cosmosiin	leaf
	diosmetin	flavedo
	diosmin	flavedo, fruit juice
	eriocitrin	albedo
	hespeidin	peel, fruit juice
	honyucitrin	root bark
	isosinensetin	peel
	luteolin	fruit juice, peel, leaf
	naringenin	peel, leaf
	naringin	fruit juice, peel, leaf
	naringin glucoside	flavedo, albedo
	narirutin	fruit juice, peel, leaf
	neodiosmin	fruit juice, peel
	neoeriocitrin	fruit juice, peel, leaf
	neohesperidin	fruit juice, peel, leaf
	neoponcirin	fruit juice, peel
	nobiletin	peel
	poncirin	albedo, leaf
	quercetin	fruit juice
	rhoifolin	fruit juice, peel, leaf
	rutin	peel, leaf
	sinensetin	fruit juice, peel
	tangeretin	peel
Monoterpenes		
	α-pinene	peel, flower, leaf
	α-terpineol	peel
	anethole	peel
	β-pinene	peel, leaf
	camphene	peel, flower
	camphor	flower
	citral	peel, flower, leaf
	citronellal	leaf
	citronellol	peel
	farnesol	peel, flower
	geraniol	peel
	geraniol acetate	peel, leaf
	limonene	peel, flower, leaf
	linalool	peel, flower, leaf
	linalyl acetate	leaf
	myrcene	leaf
	neral	peel, flower, leaf
	perilla aldehyde	peel
	terpinene	peel
Class	Compound	Plant part
Sesquiterpenes		
	α-bisabolol	peel
	α-cadinene	peel
	α-copaene	peel
	α-cubebene	peel
	β-caryophyllene	peel, flower, leaf
	β-copaene	peel
	β-cubenene	peel
	β-elemene	peel
	δ-cadinene	peel

	elemol	peel
	α-humelene	peel
	nerolidol	peel, flower
	nootkatone	peel
	valencene	peel
Triterpenes		
	deacetynomilin	seed
	deoxylimonin	seed, fruit pulp
	limonin	peel, leaf, seed, fruit pulp and juice
	nomilin	peel, leaf, seed, fruit pulp
	nomilin glucoside	peel
	nomilinic acid	seed
	obacunone	leaf, seed, fruit pulp
	obacunone glucoside	seed
Steroids		
	β-sitosterol	peel, root
	campesterol	peel
	daucosterol	peel
	stigmasterol	root
Miscellaneous		
	α -tocopheral	peel
	ascorbic acid	fruit juice
	chlorophylls	peel
	decan-1-al	peel
	decyl acetate	peel
	dodecyl acetate	peel
	fumaric acid	leaf
	malonic acid	leaf
	nonan-1-al	peel
	nonyl acetate	peel
	octan-1-al	peel
	octyl acetate	peel
	oxalic acid	leaf
	succinic acid	leaf
	tartaric acid	leaf
	2-dodecenal	peel
	citric acid	fruit juice, peel
	decanoic acid	peel
	heptyl acetate	peel

Biological activities of C. maxima

As they are the secondary metabolites, essential oils have been known as the protective compound of plants. They have lots of bioactivities, especially antioxidant and antimicrobial activites. Thus, they are used in skin care products for perfuming and aromatherapy purposes. There have been a plenty of researches on biological activities, since the anti-microbial has been the common activity found in essential oils from plants.

Aimee Sheree A. Barrion and her coworkers from Philippines had tested the antioxidant and antibacterial activities of the phytochemical constituents of the pericarp, mesocarp and segment membrane. Crude ethanolic extracts of Pummelo (*Citrus maxima* (*Burm.*)) fruit were tested against *Escherichia coli* and *Salmonella typhimurium*. Preliminary phytochemical test revealed the presence of phenols, tannins, saponins expressed as catechine equivalent (CE)/100ml and flavonoid expressed as gallic acid equivalent (GAE)/100ml. The order of which was as follows pericarp > segment membrane > mesocarp. The strongest antioxidant activity was obtained by the pericarp extract (29.64 expressed as % lipid peroxidation). The differences in the measured amount of phytochemicals and antioxidant activity among the three sample extracts were found to be significant. In terms of antimicrobial activity, the pericarp, mesocarp and segment membrane extracts generated zone of inhibitions measuring 17.10, 18.00 and 17.03 mm for *S. typhimurium*, respectively at 100% concentration. *E. coli* was noted to be inactive in all three sample extracts at 100% concentration. The capacity of *E. coli* to counteract the inhibitory effect of the phytochemicals contained in the pummelo extracts may be attributed to its rough corrugated cell

Table 8 Biological activities of C. maxima [18]

Acitvity	Part	Sample	Methods	Concentration	Result
Antibacterial	Peel	Essential Oil *Staphylococcus aureus* *Pseudomonas aeruginosa*	Agar plates	20.0 µl/agar disc	Active
	Peel	Essential Oil *Esherichia coli* *Shigella dysenteriae* *Vibrio cholera*	Agar plates	20.0 µl/agar disc	Inactive
	Peel	EtOH extract *Esherichia coli* *Pseudomonas aeruginosa* *Staphylococcus aureus*	Agar plates	20.0 µl/agar disc	Inactive
Antifungal	Peel	Essential Oil *Trichophyton mentagrophytes* *Microsporum audounil*	Agar plates	MIC 500.0 ppm	Active
	Peel	Essential Oil *Alternaria solan* *Curvularia luna* *Fusarium equiseti* *Macrophomina phaseolina*	Agar plates	N/S	Inactive
Antiyeast	Peel	EtOH extract Candida albicans	Agar plates	30.0 µl/agar disc	Inactive
Antioxidant	Peel	Essential Oil	DPPH	N/S	Active
	Peel	70% EtOH extract	Inhibition of lipid peroxidase	N/S	Active
Larvicidal	Peel	Essential Oil mosquito larvae. Culex quinquefasciatus Culex tritaeniorhynchus Aedes aegypti	Against	0.02 ml/L	Active
Smooth muscle relaxation	Peel	50% EtOH extract	Cell culture of intestine	250.0 µg/ml	Active
Uterine relaxation	Peel	50% EtOH extract	Cell culture of uterus (non-pregnant)	250.0 µg/ml	Active
Capillary Permeability	Peel	50% EtOH extract	Cell culture	5.0 µg/ml	Increase
Inotropic effect	Peel	50% EtOH extract	Cell culture of uterus (non-pregnant)	1.0 µg/ml	Active
Platelet aggregation inhibition	Peel	50% EtOH extract	Cell culture	5.0 µg/ml	Increase

N/S : Not Stated
EtOH : ethanol
MIC : minimum inhibitory concentration
DPPH : 2,2-diphenyl-1-picrylhydrazyl

wall and thick periplasmic space as opposed to the smooth curved and barely seen periplasmic space of *S. typhimurium*. [19]

Terpene hydrocarbons (monoterpenes and sesquiterpenes) are the hydrocarbons derived from isoprene unit (2-methyl butadiene) having molecular formular of $(C_5H_8)_n$

Table 9 Phytochemical composition and antioxidant activity of Citrus maxima (Burm.) Merr. fruit portion extracts.[19]

Extract Sample	Total Phenol mg CE/100ml	Tannins mg CE/100ml	Flavonoids mg GAE/100ml	Saponins mg CE/100ml	Anti-oxidant activity % LP	Alka-Loids	Terpe-Noids
Pericarp	25.71[a]	40.47[a]	31.48[a]	345.39[a]	29.64[c]	Positive	Positive
Mesocarp	13.94[c]	7.94[c]	11.65[c]	79.03[c]	75.95[a]	Negative	Positive
Segment Membrane	18.46[b]	21.02[b]	20.17[b]	147.93[b]	71.54[b]	Positive	Positive

Table 10 Zone of inhibition (diameter in mm) of Citrus maxima (Burm.) Merr. fruit portion extracts against E. coli and S. typhimurium.[19]

Conc. (%)	E. coli					S. typhimurium				
	Different Pummelo Extracts			Control		Different Pummelo Extracts			Control	
	Pericarp	Mesocarp	Segment Membrane	+*	−**	Pericarp	Mesocarp	Segment Membrane	+*	−**
10	0	0	0	26.70	0	8.10ac	8.13b	8.10c	28.06	0
30	0	0	0			8.17a	8.16ab	7.95b		
50	0	0	0			8.23a	8.23ab	8.17c		
100	0	0	0			17.10ac	18.00b	17.03c		

Essential oil from Citrus spp

Natural flavors and fragrances are the odoriferous principles found in various parts of the plant including the seeds, roots, wood, bark, leaves, flower, fruits, balsam and resin. They are called essential oils because they represent the characteristics essence of the origin. The responsible chemical for the flavour or aroma are organoleptic compounds, which affect the sense organs. They are present in their sources at various concentration levels ranging from part per billion to part per hundred. These compounds have molecular weights normally below 300 amu and are relatively volatile.

Essential oils or aroma chemicals differ in their chemical constitutions, but they have some common characteristic physical properties, such as refractive index, optical activity, immiscibility with water, and sufficient solubility to impart aroma to water. They are soluble in ether, alcohol, organic solvents, as well as supercritical carbon dioxide.

Essential oils are volatile oils that differ from nonvolatile fixed oils, i.e., glycerides of fatty acids. These essential oils can be classified into:

1. Acyclic monoterpene hydrocarbons such as myrcene and ocimene.
2. Cyclic monoterpene hydrocarbons such as p-cymene, pinene and sabinene.
3. Acyclic oxygenated monoterpenes such as farnesol, linalool and neral.
4. Cyclic oxygenated monoterpenes such as terpineol and geraniol.
5. Acyclic sesquiterpene hydrocarbons such as farnesene
6. Cyclic sesquiterpene hydrocarbons such as copaene and humulene.
7. Acyclic oxygenated sesquiterpenes such as nerolidol.
8. Cyclic oxygenated sesquiterpenes such as nootkatone and spathulenol.
9. Aromatic compounds such as indole.
10. Long chain hydrocarbons such as tetradecanal and dodecanal.

(monoterpene hydrocarbons contain n = 2 and sesquiterpene hydrocarbon contain n=3). They are the unsaturated compounds that can decompose by hydrolysis or photolysis and change to the other compounds. The odour and taste of essential oils are mainly determined by these oxygenated constituents, which to some extent are soluble in water, and most of them are soluble in alcohol.

The essential oils from *Citrus* spp. (fruit peel, leaf and flower) are well known as the perfumery and flavouring agent from natural source and have been produced in metric tons per year. The quality of Citrus essential oils obviously depends on a large extent of factors deriving from the nature itself (provenance, type of soil, climate, Citrus variety), but the processing of raw material also has a significant effect. Since the fragrance of an essential oil is directly related to the content of aldehydes and esters, then extraction technique is very important. In order to produce Citrus oil with a high aldehyde content, the amount of water used in the procedures should be reduced to the minimum as necessary. The chemical transformations of Citrus oil which may occur during the distillation method, by subject to high temperatures (95-105 °C) for long periods of time (6-12 hours) in a very acidic environment (pH 2.2-2.4) can modify the Citrus oil in its composition:

aldehyde content (neral, geranial) and sabinene almost disappear, otherwise, 1,4- and 1,8-cineole, terpinolene, α-terpineol and *p*-cymene are formed.

Physical and chemical characteristics

Physical values and Infrared spectra (IR spectra) of SCP, CP, VP, SC-f and neroli were shown in Table. The density and refractive index of *C. maxima* peel and flower oils and neroli were close to each other. Their density was around 0.8433-0.9445 g/ml and their refractive index was about 1.4622-1.4685. Their optical rotation vary from +6.975 to +9.369. From the values of density, optical rotation and refractive index and the IR spectrums of all kind of oils that were very close to each other meant that the chemical components in the oils might be nearly the same, but different in proportion.

Table 11 Physical properties of essential oils from C. maxima peel and flower, and neroli [18]

Properties	SCP	CP	VP	SC-f	Neroli
Density (gm/ml)	0.8803	0.8881	0.8433	0.85	0.9445
Optical rotation [α]D	6.975	7.821	9.369	6.975	0.875
Refractive index [n]D	1.4667	1.4622	1.4685	1.4632	1.4647
Appearance	clear solution	clear solution	clear solution	clear solution	clear solution
Color	dark-green	dark-green	no color	yellow	Yellow

Table 12 Classification of the chemical compositions of C. maxima peel and flower essential oils and neroli [18]

Compounds group	Compounds name
Acyclic monoterpene hydrocarbons	(Z)-β-ocimene
	(E)-β-ocimene myrcene
Cyclic monoterpene hydrocarbons	p-cymene
	α -(-)-pinene
	β-(+)-pinene
	α -phellandrene
	Terpinolene
	α –thujene
	Camphene
	γ-terpinene
	R-(+)-limonene sabinene
Acyclic oxygenated monoterpenes	(E,E)-farnesol
	(E,Z)-farnesol
	(Z, E)-farnesol
	(Z,Z)-farnesol
	citronellol
	Linalool
	Nerol
	Citronellal
	Geranial
	Neral
	dihydrolinalyl acetate
	neryl acetate
	geranyl acetate
	geranyl formate
	linalyl acetate
Cyclic oxygenated monoterpenes	α -terpineol
	(Z)-(+)-carveol
	(E)-(+)-carveol
	γ -terpineol
	Geraniol
	terpinen-4-ol
	perilla aldehyde
	α -terpinyl acetate
	(Z)-limonene oxide
	(E)-limonene oxide
	(Z)-(-)-linalool oxide
	(E)-(+)-linalool oxide
	(E)-sabinene hydrate
Acyclic sesquiterpene hydrocarbons	(E,E)- α –farnesene
Cyclic sesquiterpene hydrocarbons	α -copaene
	β-copaene
	α -(-)-cubebene
	β-(-)-cubebene
	α -humulene
	α -(-)-selinene
	β-(+)-selinene
	δ-(+)-cadinene
	β-(-)-elemene
	δ-elemene
	γ -(+)-elemene
	bicyclogermacrene
	germacrene B
	germacrene D
	β-caryophyllene
Acyclic oxygenated sesquiterpenes	(E)-nerolidol
Cyclic oxygenated sesquiterpenes	germacrene D-4-ol
	(+)-spathulenol
	(+)-nootkatone
	caryophyllene oxide
Aromatic compounds	phenyl ethyl alcohol
	methyl anthanilate
	methyl benzoate
	2-(formylamino)-bezoate
	Indole
Long chain hydrocarbons	3,7-dimethyl-1,5-octadien-3,7-diol
	3,7-dimethyl-2,6-octadien-1-ol
	dodecanal
	n-decanal
	tetradecanal
Miscellaneous	unknowns

Hybrids of Citrus

This is a summary picture of the current hypotheses of the relationships of the most common species and hybrids of *Citrus*:

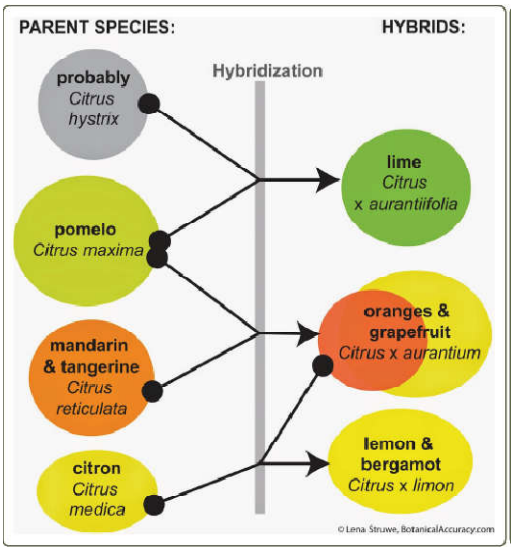

Fig 17 Origins and scientific names for the most commonly cultivated citrus fruits [20]

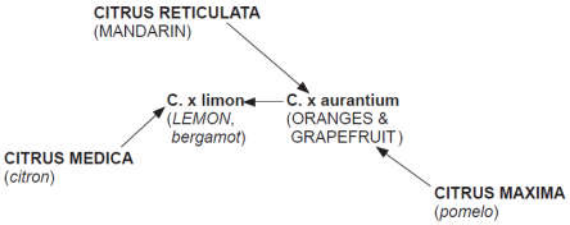

Fig 18 The origins of oranges, grapefruit, lemons and bergamot [20]

Medicinal Properties of Citrus maxima

Medicine: Medicinally, decoctions of the leaves, flowers, fruits and seeds have properties, which can treat coughs, fevers and gastric disorders in the Philippines and Southeast Asia. Fruit has alkalizing effect on blood, is a purgative, antibacterial and cleansing agent.

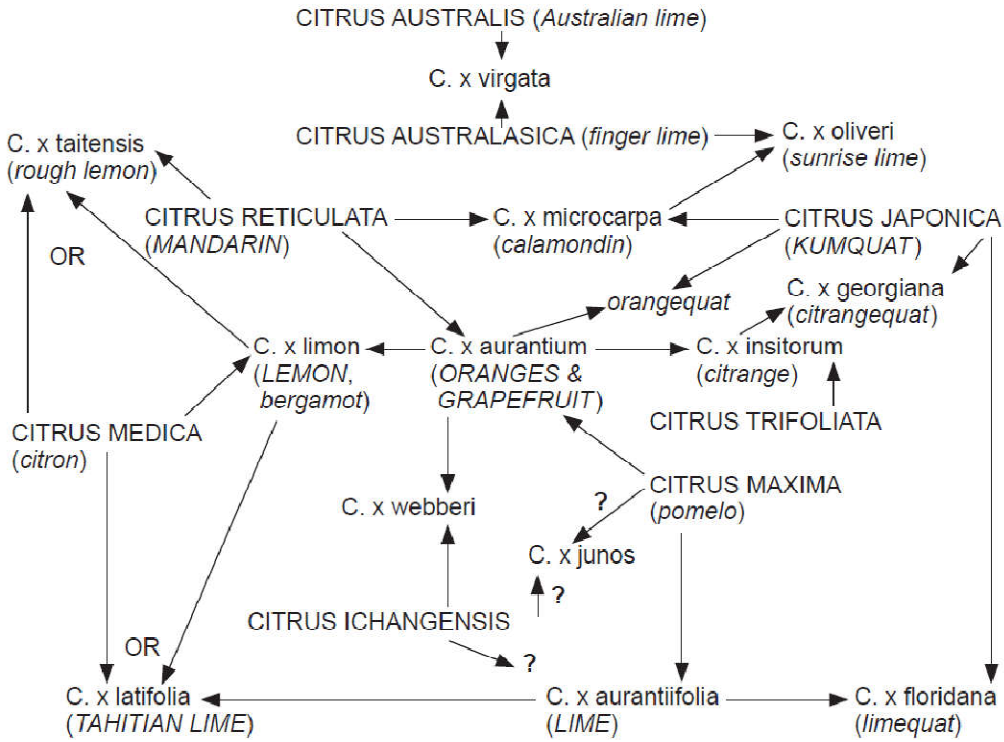

Fig 19 The relationship of commercially significant fruits and their wild allies as revealed through hybridisation and molecular analysis. Name of the parental, apparently, truly wild species in roman block capitals, those of significant crop plants in italic block capitals. [21]

The leaves are used for medicinal infusions. Decoctions of leaves, flowers and rind are given for their sedative effects in cases of epilepsy, chorea and convulsive coughing. The hot leaf decoction is administered on swellings and ulcers and fruit juice as febrifuge. The seeds are used against coughs, dyspepsia and lumbago while gum exudes remedies for cough in Brazil. The rind has pectin used in ointments/paste for burns. [6]

Prevent Cancer

The rind of pomelo is rich in bioflavonoid. Studies have shown that bioflavonoid in the fruit eliminates extra estrogen in the body and halts breast cancer cells from spreading. Pomelo rind is commonly used in Chinese cooking to add flavor to dishes. And the anticancer property of plant extracts were analysed using HeLa cell line. The results of leaf and fruit peel extracts of *C.maxima* may be helpful to develop nutraceutical product for cancer prevention. [22]

Fight Cold and Flu

Pummelo is an excellent source of vitamin C, supplying 193% of RDA. This potent antioxidant vitamin helps improve the body's immune system to protect it from common cold and influenza.

Assist in Weight Loss

Pommelo contains loads of dietary fibre. Foods high in dietary fibre make you feel full longer and require more chewing time, thereby able to reduce the intake of food. The fat burning enzyme in the fruit also promotes food absorption and lowers the starch and sugar in the body.

Reduce Blood Pressure Levels

Like banana, avocado and guava, pomelo has a good amount of potassium. This essential mineral plays an important role to regulate blood pressure levels and therefore beneficial to people with hypertension.

Get Rid of Arterial Deposits

Abundant with pectin, pummel juice is capable of clearing the arterial deposits accumulated in the body, thereby reducing the impurities.

Constipation Aids

Pommelo is full of dietary fibre, a vital compound that is useful to promote regular bowel movements, effectively protect you against hemorrhoids and lower the risk of colon cancer.

Alkalize the Body

Research has shown that an alkaline body is less prone to getting various common diseases. Like lemon, pomelo juice has an alkaline effect after digested, thereby having therapeutic value to your body.

Anitumor Activity

Citrus maxima leaves possesses potent anticancer activity which can be attributed to the flavonoids present in it which can therefore serve as a stepping stone for the discovery of a new anticancer agent. [23]

Antidepressant like activity

The aqueous extract of leaves of this plant showed that it has antidepressant activity. Extract was found to be safe as no mortality was observed following treatment with doses as high as 2000 mg/kg. [24]

Analgesic and Anti-Inflammatory Activities

The extracted compounds from *C.maxima* exhibited analgesic activity against chemical and thermal noxious stimuli on both early and late phases of pain by the *Citrus maxima* extracts (300 mg/kg). And it possesses anti-inflammatory activity in formalin induced paw edema models in comparison to control. [25]

Antibacterial Activity

The plant extract of *Citrus maxima* (Burm.) Merr showed significant antibacterial activity against Escherichia coli and Pseudomonas aeruginosa. [26]

Antihyperglycemic effect

The methanol extract of *C. maxima* leaves exert a marked antihyperglycemic effect in STZ induced diabetic Wistar rats as well as hypoglycemic activity in normoglycemic rats. [27]

Antioxidant effect

The consumption of *Citrus maxima* juice can be linked to improved antioxidant status and reduction in the risk of oxidative stress. [28]

Anti-diabetic, cholinesterase and tyrosinase inhibitory potential

C.maxima not only possesses antioxidant and radical scavenging activities but also exhibits excellent inhibitory potential against α-amylase, α-glucosidase, acetylcholinesterase, tyrosinase and β- glucuronidase in vitro. [29]

Effect of C.maxima fruit juice on Human Endothelial Cells: Enhancing Cell Migration and Delaying Cellular Aging

The pummelo (*Citrus maxima* Merr. var. Tubtim Siam, CM) fruit extract on human umbilical vein endothelial cell (HUVECs) migration and aging shows positive effect in vitro. [30]

Treatment of anxiety disorders

The potentiality of *C. maxima* will be an alternative source for psychiatric and neurological disorders which are proven on depressant, anxiolytic, convulsant, hypnotic and muscle relaxant experimental animals. [31]

CONCLUSIONS

Citrus maxima being the largest citrus fruit offers significantly greater medicinal benefits as compared to the other fruits. Apart from its various medicinal properties, bio flavonoids play an important role in prevention of cancer. Also the traditional usage of various parts of *Citrus maxima* have shown a broad spectrum of cures in treatment of various diseases. *Citrus maxima* thus is a multi-faceted plant which has larger use in human life as large its fruit is in size. As reviewed in this paper, extracts of leaves, fruit, peel and stem have been studied for secondary metabolites and their properties, however these secondary metabolites are yet to be isolated, identified and evaluated for their medicinal properties.

Author's Contribution

Trupti Sawant was involved in preparing manuscript. Dr. Deepa Panhekar participated in discussions of views represented in the paper. Both authors have read and approved the final manuscript.

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Heavy Metals Uptake, Translocation and Bioaccumulation Properties by Ipomoea Aquatica

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Abstract
Heavy metal pollution of lake water is of great environmental and health concern and needs attention. This study was carried out to assess the content of heavy metals in *I. aquatica* plant and associated sediment and water in different seasons. The concentrations of the metals followed the trend: sediment > *I. aquatica* root > *I. aquatica* shoot > water. There were differences in the sequences of the metal content in the plant compared to the sequences of their bioaccumulation ability. These differences suggest a different capacity of the plant for different metals. The present study revealed that *I. aquatica* can tolerate heavy metals and may be used as a biological agent in phytoremediation.
Keywords: Heavy metals, bioaccumulation, translocation

Introduction

Heavy metals are defined as metallic elements with atomic number higher than 20. Heavy metals are always present in trace amounts in most natural water bodies, concentration being less than one µg/l but when present beyond permissible limits act as pollutants because, firstly they cannot be destroyed through biological degradation as in case with most organic pollutants and secondly metals tend to accumulate in the environment [1-3].

Therefore, the way in which metals act in response to sediment and their acquisition by the plant is certainly of considerable importance for research in the environment. There is not a single type of theoretical model to be used to predict the metal content of plants from its content in a nearby sediment or water. In the same way, no device existed by which plants obtained metals and transported them through their tissues.

The application of plant organisms for research of heavy metal pollution in a lake environment has a number of advantages over standard methods for the detection of metals in water by chemical analysis. Thus, metal concentrations in water are often below the detection limit of the employed instrument whereas the concentrations of metals in plants are much higher and allow for the determination of the available biological and cellular metals in aqueous medium [4-6].

There are a small number of studies on the trace metal concentrations in Gorewada Lake, Nagpur. However, the data presented provides insufficient information on their concentration in different parts of *Ipomoea aquatica* and their seasonal variations.

In the present study, the content of heavy metals (Cd, Cr, Ni, Pb, and As) in sediment, water and different organs of *I. aquatica* collected from Gorewada lake, Nagpur was investigated during different seasons.

The aim of this study was to determine the ways and means of metal adoption within *I. aquatica* tissue, as well as the differences and degree of bioaccumulation in dependence on the metal, plant part, location and season.

Material and methods

Sample collection

Samples of *I. aquatica* were collected at three seasons from Gorewada Lake. *Ipomoea aquatica* is a twining wine growing on riverbanks, lakeshores and roadsides. The plant material was packed in polyethylene bags and transferred to laboratory. Water and sediment samples were also taken from the same place as the plant material. Stones and coarse plant material were mechanically removed. The sediment samples were placed in plastic boxes, carefully labelled and transferred to the laboratory for further analysis. Water samples were collected from the depth of 0.5–1 m using 1.5 L PET bottles.

Sample analyses

The sampled plant material was first washed with tap water, and then twice with deionised water to clear dust particles and gently dried with a paper towel. The samples of the *I. aquatica* plants were separated into shoot and root to determine bioaccumulation diversity of the plant organs. The plant material was then sundried. The samples were ground into a fine powder using mortar and pestle.

1 g of prepared plant samples was taken in a beaker and 50ml aquaregia was added along with 5% HNO_3 and then digested for 3-4 hours on hot plate. After digestion, the samples were left to cool and then filtered with Whatman Ashless filter paper (no. 40). The samples were then transferred to 100ml volumetric flasks and the rinsing water was added to the volumetric flask to make the volume up to 100ml, followed by ICPAES analysis [Thermofischer model no. IRIS Intrepid II].

The sediment samples were dried in air and then in an oven at 110 ° C for 24 h. The dried sediment samples were ground in mortar and pestle and sieved through a 1.5 mm sieve to obtain homogenized fine particles. Approximately, 1g of sediment sample was taken in a beaker and 50ml aquaregia was added and then digested for 3-4 hours on hot plate. After digestion, the samples were left to cool and then filtered with Whatman Ashless filter paper (no. 40). The samples were then transferred to 100ml volumetric flasks and the volume was made up to the mark with 5% HNO3. The plant samples were ready for analysis by ICPAES.

Water samples were collected from Gorewada lake in the clean plastic bottle during all seasons and directly subjected to chemical analysis by ICPAES for heavy metal contents.

The ability of plants to absorb and accumulate metals from sediment was evaluated using Enrichment coefficients. Enrichment coefficient is calculated as the concentrations of metals in the plant part and the associated sediment. Higher enrichment factor values imply greater phyto-accumulation ability of the plant.

Enrichment coefficient = $[Metal]_{part\ of\ plant}$ / $[Metal]_{sediment}$

The possibility of plants to transport metals from the root to the shoot was estimated using translocation factor. Translocation ability was calculated as the ratio of concentration of metals in shoot and root.

Translocation factor = $[metal]_{shoot}$ / $[Metal]_{root}$

The TF of more than 1 indicates a very efficient ability to translocate metals from root to shoot, most likely due to efficient metal transport systems [7].

Results and Discussion

Variation of heavy metals in all matrixes

Table 1: Concentration of heavy metals in water (mg/l) in different seasons

Season	Chromium	Arsenic	Nickel	Cadmium	Lead
Winter	0.003	0.0061	0.004	0.003	0.003
Summer	0.027	0.0398	0.041	0.007	0.314
Rainy	0.029	0.0346	0.03	0.003	0.03

Table 2: Concentration of heavy metals in sediment (ppm) in different seasons

Season	Chromium	Arsenic	Nickel	Cadmium	Lead
Winter	17.15	7.764	19.836	3.56	3.9
Summer	40.74	2.338	24.472	4.33	4.2
Rainy	38.97	2.694	22.856	4.978	3.41

The concentrations of heavy metals from Gorewada lake water were determined seasonally. Chromium and arsenic concentrations were detected in traces. The highest concentrations of heavy metals were observed during summer and rainy season while lower in winter season. This trend could be attributed to the evaporation of water from lake during summer and subsequent dilution due to precipitation and run off from catchment area during rainy season [8]. The chromium and arsenic content indicated that it remained below toxic limits in all seasons. The concentrations of nickel, cadmium and lead during summer were found above permissible level.

Table 3: Concentration of heavy metals in different plant parts in different seasons

Seasons	Chromium		Arsenic		Nickel		Cadmium		Lead	
	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot	Root
Winter	7.214	3.448	0.255	0.836	2.702	3.4	0.26	0.206	0.84	1.032
Summer	6.632	7.108	0.662	1.216	9.87	10.6	0.308	1.294	3.032	4.13
Rainy	1.416	217.6	1.262	2.58	9.168	133.3	0.428	0.494	2.74	5.072

The concentrations of metals in the individual parts of *I. aquatica* were significantly different from their concentrations in water and sediment and followed the trend: sediment > root > shoot > water. Concentrations of the metals in the shoot and root of I. aquatica followed the trend: Cr > Ni > Pb > As > Cd. Significantly higher values of the concentration of Cr and Ni were recorded during rainy season compared to other seasons.

The enrichment coefficient value of *I. aquatica* was shown through the enrichment factors. Differences in the sequences of the metal contents in the plant, the sequences of their bioaccumulation capacity and their numerical relationships could be seen to a certain extent. These differences suggest a different bioaccumulation capacity of *I. aquatica* for different metals. The plant accumulates certain metals irrespective of their concentrations in water and sediment, which is obviously a characteristic provided by its capacity for each individual element.

The orders of the intensity of bioaccumulation of the examined metals in the shoot and root were different. These differences cannot be interpreted solely by differences in metal translocation through the plant because, most probably, the bioaccumulation capacities of the shoot for individual metals directly from the water are different.

Table 4: Enrichment factors and Translocation factor for heavy metals at different seasons

Heavy Metals	EFS			EFR			TF		
	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
Cr	0.42	0.16	0.036	0.2	0.17	5.58	2.09	0.93	0.0065
As	0.0328	0.2831	0.4684	0.1077	0.52	0.95	0.305	0.54	0.4891
Ni	0.13	0.403	0.401	0.79	0.85	5.83	0.7947	0.47	0.068
Cd	0.073	0.071	0.086	0.0579	0.0679	0.0992	1.26	1.04	0.86
Pb	0.216	0.712	0.8047	0.2637	0.97	1.4874	0.82	0.73	0.541

Table 5: Enrichment factor (shoot) for heavy metals at different seasons

Enrichment factor (shoot)	Winter	Summer	Rainy
Chromium	0.42	0.16	0.036
Arsenic	0.0328	0.2831	0.4684
Nickel	0.13	0.403	0.401
Cadmium	0.073	0.071	0.086
Lead	0.216	0.712	0.8047

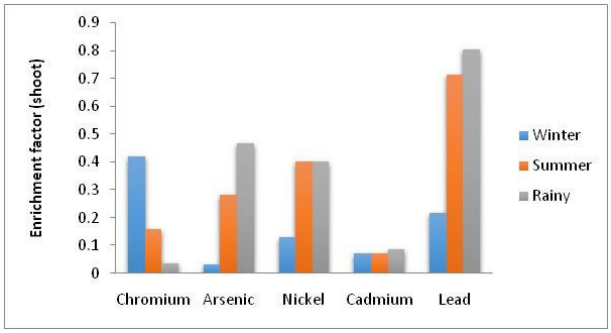

Figure 1: Enrichment factor (shoot) for heavy metals at different seasons

The enrichment coefficient value of *I. aquatica* shoot was below 1 for all studied metals indicating that shoot does not have the special ability to absorb and transport metals from sediment and then store them in their above-ground part.

Table 6: Enrichment factor (root) for heavy metals at different seasons

Enrichment factor root	Winter	Summer	Rainy
Chromium	0.2	0.17	5.58
Arsenic	0.1077	0.52	0.95
Nickel	0.79	0.85	5.83
Cadmium	0.0579	0.0679	0.0992
Lead	0.2637	0.97	1.4874

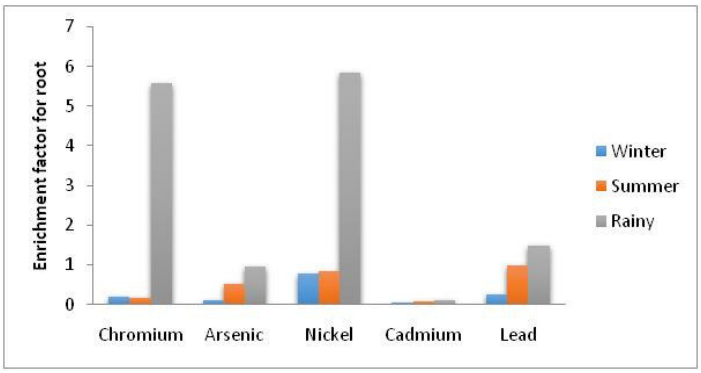

Figure 2: Enrichment factor (root) for heavy metals at different seasons

The enrichment coefficient value of *I. aquatica* (root) for Pb was higher than 1 during summer and rainy. The enrichment coefficient value of chromium, arsenic and nickel were higher than one during rainy season indicating that the roots have the property to accumulate heavy metals.

Table 7: Translocation factor for heavy metals at different seasons

Translocation factor	Winter	Summer	Rainy
Chromium	2.09	0.93	0.0065
Arsenic	0.305	0.54	0.4891
Nickel	0.7947	0.47	0.068
Cadmium	1.26	1.04	0.86
Lead	0.82	0.73	0.541

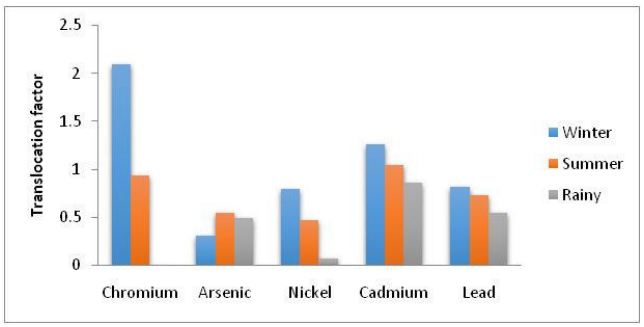

Figure 3: Translocation factor for heavy metals at different seasons

The seasonal values of the translocation ability are given in table 7. The translocation factor for Cr and Cd were found to be greater than 1 indicating that the plant can effectively translocate these metals from roots to shoots.

Chromium

Significant seasonal variations in concentrations of Cr have been observed. Cr content ranges from 1.416 ppm to 7.214 ppm in the shoot while in the root it ranges from 3.448 ppm to 217.6 ppm. The chromium content in the shoot declined from winter to rainy while that of root increased from

winter reaching a maximum at the rainy season. Enrichment factor (root) of Cr in relation to sediment in *I. aquatica* is greater than 1 during rainy season. However, there is a noticeable translocation of the average ratio shoot/root during winter and summer.

Arsenic

The concentration of arsenic in the shoot ranged from 0.255 ppm to 1.262 ppm whereas in the root it was 0.836 ppm to 2.58 ppm. The arsenic content in the shoot and root were significantly increased from winter to rainy. Enrichment factor (shoot) was found to be less than one whereas enrichment factor (root) during rainy season was considerable. Translocation factor revealed that *I. aquatica* do not have ability to accumulate As in its tissues.

Nickel

The Ni concentrations ranged from 2.702 ppm to 9.87 ppm in the shoot and in the root the Ni content ranged from 3.4 to 133.3 ppm. The content of nickel in the root was higher than shoot in all seasons. Nickel does not exhibit the bioaccumulation as well as translocation ability showing that *I. aquatica* do not have ability to accumulate Ni in its tissues.

Cadmium

Of the studied metals, cadmium was present in the lowest amount in the tissues of *I. aquatica* in the shoot from 0.26 ppm to 0.428 ppm and from 0.206 ppm to 1.29 ppm in the root. The concentration of Cd in the shoot increased from winter to rainy. Enrichment factor (root) for Cd was the lowest. However, there is a noticeable translocation of the average ratio shoot/root during winter and summer. Enrichment coefficients for shoot and root were found to be less than one.

Lead

The Pb concentrations ranged from 0.84 ppm to 3.03 ppm in the shoot and in the root the Pb content ranged from 1.032 ppm to 5.07 ppm. The enrichment factor for shoot and root shows that these values increased from winter to rainy. Compared to enrichment factor (shoot), the value of enrichment factor (root) was found to be 1 during summer and rainy seasons. Therefore, *I. aquatica* shows ability to tolerate lead in its root.

Conclusion

Concentrations of metals in different parts of *I. aquatica* were significantly different from their concentration in water and sediment following the trend: sediment > root > shoot > water. The enrichment factor for root shows that *I. aquatica* can tolerate Cr, Ni and Pb in root. Similarly, TF values for Cd and Cr indicated that *I. aquatica* can effectively translocate Cr and Cd to the aboveground portion. The results of the present study indicated that *I. aquatica* is a promising plant for metal accumulation. So, it may be used to ameliorate polluted water.

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RESEARCH ARTICLE

Crystal Structure, Thermal Behavior and UV Spectroscopy of 6-Chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl Acetate

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Abstract: 6-Chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate consist of acetylated 2-furan substituted chromene molecule was prepared. The single crystal of compound was obtained by the slow evaporation technique. Thermal studies were carried out by thermogravimetric (TGA) and differential calorimetric analysis (DSC). The crystal structure was obtained by single crystal x-ray diffraction which crystallizes in the monoclinic space group $P2_1/n$ with cell parameter a= 5.0656(3) Å, b= 4.4661(10) Å, c= 18.4123(14) Å and Z = 4.

Keywords: Single crystal-hydrogen bonding, Intermolecular packing, Thermal study, Chromene

Introduction

Chromones constitute one of the major class of naturally occurring compounds whose carbon skeleton is widely distributed throughout plant kingdom and it exist in wide range of structural and biological diversity and also as flavonoids (2-phenyl chromone derivatives)[1,2]. Flavonoids are well known for their antioxidant properties which protect organism from oxidative stress by destroying reactive species that would otherwise destroy cell[3,4].

Foods containing flavonoids lower the risk of cancer, heart disease and rheumatoid arthritis[5]. Flavonoids are also recognized moiety for antifungal, cytotoxic, neuroprotective and HIV-inhibitory antimicrobial and antifungal properties[6-13]. The synthesis, spectral study and biological activity significance for flavone molecule 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate was reported[14-16]. In this work, we report the crystallographic studies to have more insight view of molecular structure and physical property of title compound. Additionally, UV-Visible and thermal studies of furan substituted acetyl chromene were carried out.

Experimental

0.5 g of 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate was dissolved in chloroform: ethanol mixture (25:50 mL) in 200 mL beaker. The beaker was wrapped with aluminum foil and small holes were made in order to evaporate the solvent. The beaker was kept for 18 hours at room temperature. Crystals appeared on walls of beaker were carefully collected and analyzed under microscope. The crystals with uniform dimension were sending for single crystal analysis.

Method and materials

All the chemicals and solvents were obtained from Merck (LR grade) and were used without further purification. UV-Visible spectra was recorded on Perkin Elmer lambda 35 instruments and scanned over entire region of 200-800 nm and the data processed with UV Win Lab software. DSC thermogram was recorded on a Q-100 instrument (TA Instrument, New Castle, USA). Sample weighing 2-3 mg was heated in crimped aluminium pan with pierced lead from 30 to 210 °C at a rate of 10 °C/min. Nitrogen was used as purging gas under ambient flow rate.

The mass loss of the sample as a function of temperature was determined using a TGA Q-500 instrument (TA Instruments, New Castle, USA). The sample was placed in open platinum crucible and heated at the rate of 25 °C/min in the range of 30-300 °C under a nitrogen purge (20 mL/min). The DSC and TGA data was processed using universal analysis 2000 software (version 4.3 A).

Single crystal data were collected on an oxford Xcalibur Mova diffractometer[17] equipped with Eos CCD detector utilizing MoKα radiation (λ = 0.71073 Å). The structure was solved by direct methods and refined with full matrix least-squares technique by using ShelX[18]. All non-hydrogen atoms were refined anisotropically whereas the positions were geometrically fixed and refined isotropically for all the hydrogen atoms. All calculations were performed using PLATON[19] in the WinGX software package[20].

Results and Discussion

The compound 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate crystallizes in a monoclinic system, space group $P2_1/n$ with Z=4. The crystallographic and refinement details are given in Table 1. The molecule of 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate adopts a nearly planar conformation as shown in Figure 1. Intermolecular packing is mainly guided through various C–H···O hydrogen bonds (Figure 2 and Table 2). Type-I Cl···Cl contacts[21]{d(Cl···Cl)= 3.42 Å)}observed across the centre of inversion as shown in Figure 2 is a noteworthy aspect of the crystal packing. Additionally, the π···π [d(Cg1···Cg2) =3.8950(16) Å and d(Cg2···Cg3)=3.6724(13) Å] and C–Cl···π [d(Cl···Cg3) =3.6697(13) Å] interactions further interconnect the molecules generating a three-dimensional network. [The ring centroid are defined as Cg1: O(3)-C(10)-C(11)-C(12)-C(13); Cg2: O(1)-C(1)-C(2)-C(3)-C(4)-C(9) and Cg3: C(4)-C(5)-C(6)-C(7)-C(8)-C(9)].

UV-Visible study

Band at 203.19 and 253.25 are characteristic peak of furan while 256.17 nm is overlapped band of benzenoid and heteroaromatic furan moiety (Figure 3). The broad and intense band at 361.65 nm corresponds to π-π* transition of enone which on acetylation causes hypsochromic effect in title compound due to its electron withdrawing effect causes λ_{max} shifts to 328 nm. The spectra also resemble the spectrum of flavonoids predicted through semi empirical and *ab initio* method. Both the compounds are transparent to visible region.

Table 1. Crystal data and structure refinement

Crystal Data	
Formula	$C_{15}H_9ClO_5$
Formula weight	304.67
Color	Colorless
Crystal morphology	Block
Temperature/K	295(1)
Radiation	Mo Kα
Wavelength/Å	0.71073
Crystal system	Monoclinic
Crystal dimension, mm	0.30×0.20×0.20
Space group	$P2_1/n$
a (Å)	5.0656(3)
b (Å)	14.4661(10)
c (Å)	18.4123(14)
β (°)	93.376(7)
Volume (Å^3)	1346.89(5)
Z	4
Index range	$-6 \le h \le 6, -17 \le k \le 17, -22 \le l \le 22$
Absorption correction (multi-scan)	$T_{min} = 0.9147$, $T_{max} = 0.9420$
Density, g/mL	1.50
μ, 1/mm	0.302
F (000)	623.9
θ (min, max)	2.6, 26.0
No. Unique Refln	2644
reflection with $I > 2\sigma(I)$	1428
R_{int}	0.046
No. of parameters	191
*R*_obs, wR_2_obs	0.046, 0.108
$\Delta\rho_{min}$, $\Delta\rho_{max}$ (eÅ^{-3})	-0.269, 0.237
Goodness of fit on F^2	0.898
CCDC No	846821

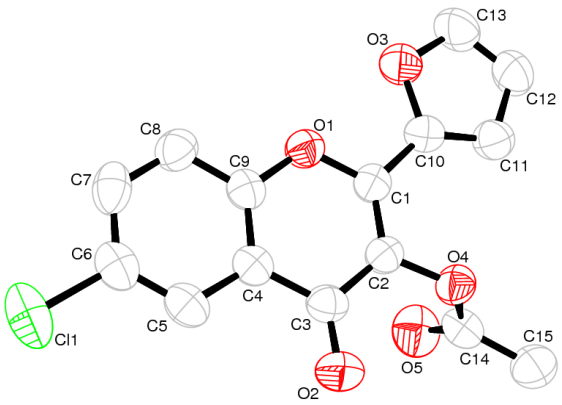

Figure 1. ORTEP diagram of 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate drawn at 50% ellipsoidal probability. Hydrogen atoms are omitted for clarity

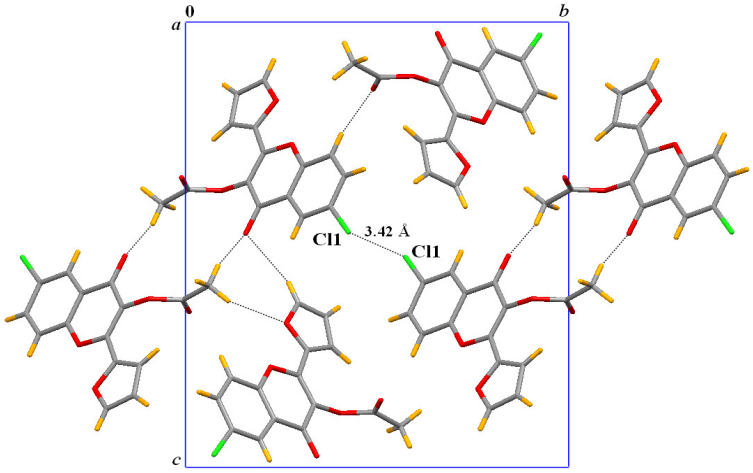

Figure 2. Packing diagram of 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate viewed down the *a*-axis, type-I Cl···Cl contact and C–H···O intermolecular hydrogen bonds are shown by the dotted lines

Table 2. Intermolecular hydrogen bonds in 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate

D–H···A	r(D–H)/Å	r(D–A)/Å	r(H···A)/Å	∠ D– H···A /º	Symmetry
C8–H8···O5	0.93	3.240(4)	2.401(2)	150.0(1)	-x-1/2,+y+1/2,-z+1/2
C11–H11···O5	0.93	3.770(4)	2.959(2)	146.5(1)	x+1,+y,+z
C15–H15B···O5	0.96	3.324(4)	2.570(2)	135.5(2)	x+1,+y,+z
C15–H15A···O2	0.96	3.396(4)	2.518(2)	152.0(2)	-x,-y,-z+1
C15–H15C···O3	0.96	3.503(4)	2.716(2)	139.5(2)	-x+1/2,+y-1/2,-z+1/2
C13–H13···O2	0.93	3.500(4)	2.617(2)	158.7(2)	x+1/2,-y+1/2,+z-1/2

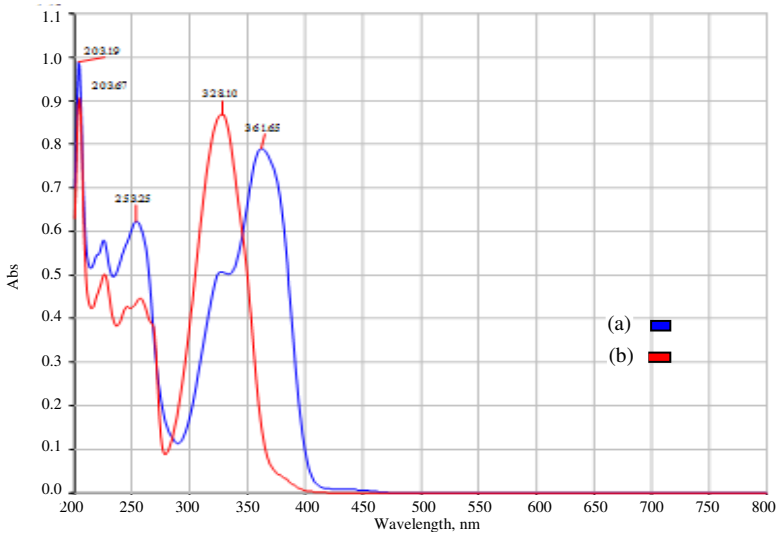

Figure 3. UV spectra of (a) 6-chloro-2-(furan-2-yl)-3-hydroxy-4*H* –chrome-4-one and (b) 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate

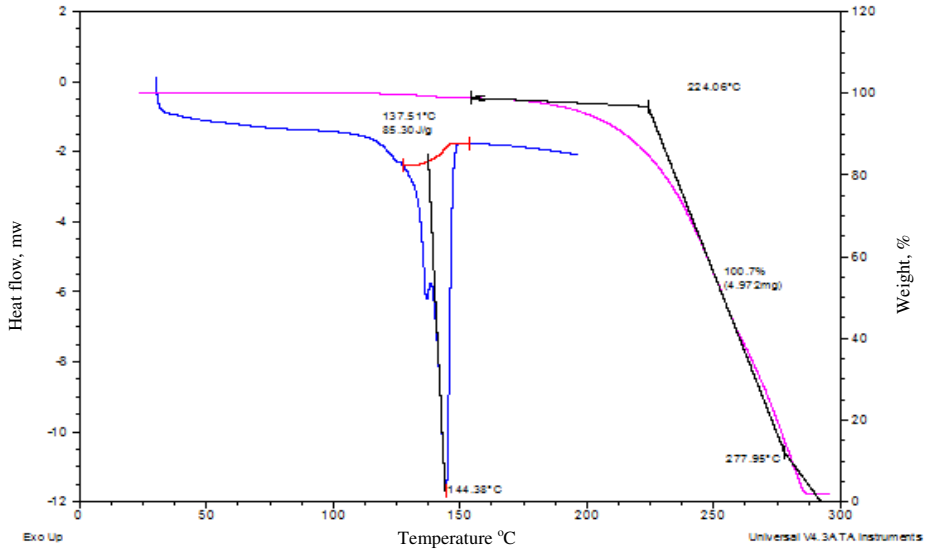

Figure 4. TGA-DSC of 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate

Thermal behavior (DSC and TGA)

TGA-DSC graph shown in Figure 4 represents thermogravimetric analyses of 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl acetate under N_2. Molecule is stable up to 137 °C and undergoes decomposition on further heating; the event shows a weight loss of 100% in the temperature range of 137-299 °C.

Conclusion

Crystallographic study of 6-chloro-2-(furan-2-yl)-4-oxo-4*H*-chromen-3-yl gave deep insight to the intermolecular and intramolecular interactions within the molecule, which is helpful in determination of stability of molecule. Moreover, type-I Cl···Cl weaker interaction in molecule was identified which will be helpful to study pharmacodynamic properties of biological active molecules in future.

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Supplementary data

Crystallographic data for the structure reported in this work including anisotropic displacement parameters, full bond lengths, bond angles and dihedral angles have been deposited with the Cambridge Crystallographic Data Center with CCDC No 846821. Available free of charge via www.ccdc.cam.ac.uk/data_request/cif or by contacting The Cambridge Crystallographic Data

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