



Crossian Center for R&D

# **Proceedings of the International Conference on “Integrating Innovative Pedagogies and Multidisciplinary Research for Successful Research Grants”**

**25th & 26th July, 2024**

Organized by

**CROSSIAN CENTRE FOR RESEARCH AND  
DEVELOPMENT  
Holy Cross College (Autonomous),  
Nagercoil,  
Tamil Nadu, India**

An ISO 9001: 2015 Certified Institution &  
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## **Editors**

*Dr. S. Sonia  
Dr. S. Thenmozhi  
Dr. E. Jebamalar*



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**BOOK TITLE: Proceedings of Two Day International Conference on Integrating Innovative Pedagogies and Multidisciplinary Approaches for Successful Research Grants**

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## **From the Editors' desk...**

The Crossian Centre for Research and Development has over the years organized annual conferences on themes of contemporary relevance. This year too we are glad that our conference call, 'Integrating Innovative Pedagogies and Multidisciplinary Research for Successful Research Grants' was received with an overwhelming response from institutions near and far.

We believe that the full-length papers released as part of this conference will further conversations, build and strengthen ties between researchers, promote deep engagements, initiate new beginnings and deepen the scope of fundamental/basic research.

We take this opportunity to thank our patron, chairperson, the conveners and the organizing team members whose motivation, support and partnership has been invaluable in releasing this proceedings on the day of the conference itself.

It is our wish and desire that the participants, authors and researchers benefit from the think-tank of ideas that originate from this collection of original research.

The Editors

## **Secretary's Message**

The two day International Conference on Integrating Innovative Pedagogies and Multidisciplinary Research for Successful Research Grants is a great opportunity for the faculty and Scholars to unlock the future of Education and Research. My special appreciation to the members of Crossian Centre for Research and Development for the initiative taken to showcase all concrete avenues available to bring research to the reach of the society and to bridge the challenges that confront research grants. This groundbreaking event aims to catalyze new approaches to securing successful research grants by fostering collaborative environments that transcend traditional academic boundaries.

Whether you're an educator, researcher or grant administrator, this conference promises invaluable opportunities to network, learn and collaborate with peers from around the globe. Together, let's redefine the future of education and research. Let us join for a transformative exploration into the synergy of innovative pedagogies and multidisciplinary research at our upcoming International Conference. Wishing you God's guidance, blessings and success to the organisers.

I wish this International Conference a grand success!

**Dr. Sr. M. Mary Gilda,**  
Secretary  
Holy Cross College (Autonomous),  
Nagercoil

## ***Principal's Message***

It is indeed my pleasure to greet the Crossian Centre for Research and Development for organizing a two day International Conference on “Integrating Innovative Pedagogies and Multidisciplinary Approaches for Research Grant Success” on 25<sup>th</sup>& 26<sup>th</sup> July, 2024.

Innovative pedagogies and multidisciplinary approaches are essential in today's educational and research environments. The integration of these strategies not only enhances learning but also significantly boosts the potential for securing research grants. I expect, this conference explores the synergy between innovative methods and multidisciplinary collaboration, illustrating how this integration can lead to successful research funding. I appreciate the effort of the Crossian Centre for Research and Development for organizing this conference understanding that the innovative ideas and trends followed in multidisciplinary research for getting research grants is the need of the hour. I strongly believe that this conference would enhance the researchers in writing research proposals and appropriate research design and the concepts salient to the research process. I extend my heartfelt congratulations to the Dean of Research, Members of the Crossian Research Forum and organizing secretaries of the conference for making this event a grand success.

**Dr. Sr. S. Sahayaselvi**

Principal

Holy Cross College (Autonomous)

Nagercoil.

## Message from the Dean of Research.....

Dear Readers,

It is my distinct pleasure to present the proceedings of the International Conference on Integrating Innovative Pedagogies and Multidisciplinary Research for Successful Research Grants. This book includes the full-length papers of the research work presented during the conference, reflecting the diverse and dynamic discourse that took place.

In today's fast-changing academic world, the integration of innovative pedagogies and multidisciplinary approaches is essential for fostering a thriving research environment. This conference brought together scholars and researchers from various disciplines, united by the common goal of nurturing inter-, trans- and multi- disciplinary collaboration. The resulting discussions and papers underscore the transformative potential of these integrations in achieving successful research grants and impactful outcomes. As you explore these proceedings, you will find insights, methodologies and findings that contribute to the ongoing evolution of our academic and research landscapes. Each contribution highlights the commitment of our scholars and practitioners to advancing both knowledge and practices.

I would like to extend my gratitude to all the authors, reviewers and editors whose efforts have made this publication possible. Your expertise and dedication are greatly appreciated.

I hope these proceedings serve as a valuable resource for scholars, educators and researchers. Also, I hope they inspire innovation and teamwork.

Thank you for your support.

Sincerely,

**Dr. S. Mary Mettilda Bai**

Associate Professor of Zoology

Holy Cross College (Autonomous), Nagercoil

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**Keynote Address**

**The Role of Innovation in the Current Transformative Shift: Implications  
for Research Grant**

**Dr. Jebamalai Vinanchiarachi**

*Former Principal Advisor to the Director General of United Nations Industrial  
Development Organization.  
Vienna Austria*

We are living in an era of transformative shift from quantitative increase to qualitative improvements with a priority accent on protecting the planet and the people. In the new era of creative destruction triggered by disruptive technologies knowledge serves as a source, research emerges as a force and innovation acts as key to unlock the development potential of countries with a focus on ushering in economic efficiency, ecological compliance and social inclusion in the rapidly changing patterns of production and consumption.

Innovations could be classified into national, sectoral and incremental. In an ideal national innovation system new knowledge is generated by institutions, exploited by laboratories and commercialized by dynamic firms. The degree of an effective interactive framework between educational institutions and firms is critical. Sectoral innovation systems entail exceptionally good performance of sectors which successfully penetrate global markets with innovative products as a result of research and innovation. Incremental innovation stems from enhanced adaptive capabilities and skills to use what has been already invented, leading to a shift from imitation to innovations which befit a given country specific context.

Output oriented research and innovation matter. Today, world trade is underpinned by the lion's share of high tech and sophisticated products in manufacturing value added and manufacturing trade. A major focus of research and innovation is gravitating in and around those products which rekindle new and dynamic sources of growth across all sectors of the economy.

The implications for research grant are crystal clear. Research is not for the sake of research, and innovation is not for the sake of innovation. Search and innovation should result in tangible impact and compact through output. Research grant is given to those who demonstrate output which makes an indelible impact on fostering sustainable development with a priority accent on promoting circular economies where waste is not a waste but a potential source of sustainable wealth creation.

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**Plenary Talk**  
**Creative Approaches to Enhancing Research Grant Acquisition**

**Dr. Dhanushkodi Sivaganesh**

*Postdoctoral Researcher*  
*Institute of Physics and Technology, Ural Federal University*  
*Russia*

Securing research grants is crucial for advancing scientific and academic projects, but the competition is intense, necessitating creative strategies to stand out. To enhance research grant acquisition, researchers must focus on innovation, relevance, clarity, effective communication, and continuous improvement. Groundbreaking ideas that address current gaps and pressing issues are essential. Collaborative brainstorming and interdisciplinary partnerships can foster innovation and ensure the research's relevance and potential impact. Crafting a compelling proposal involves storytelling; clearly articulating the vision, objectives, methodology, and expected outcomes in a structured, jargon-free manner. Visual aids such as diagrams and charts can succinctly convey complex ideas. Aligning the proposal with the funding agency's mission and priorities is vital. Effective communication extends beyond the written proposal; building a robust network through active engagement with funding agencies, attending conferences, and participating in relevant forums can provide valuable insights and enhance visibility. Advocacy for the research, both within and outside the academic community, can attract support. Leveraging technology, such as grant management software and data visualization tools, can streamline the application process and enhance the presentation of data. Finally, continuous improvement through feedback is essential. Constructive criticism from reviewers should be used to refine future proposals, and participating in grant review panels can offer insights into common pitfalls and the evaluation process. By adopting these creative approaches, researchers can significantly increase their chances of securing funding and advancing their scientific endeavors.

\*\*\*\*\*

## **Plenary Talk**

### **Developing a Conceptual Model for Research Proposals**

**Dr. Rajesh Elangovan**

*Assistant Professor in the Department of Commerce  
Bishop Heber College (Autonomous) in Tiruchirappalli, India*

#### **Introduction**

A conceptual model serves as a visual or theoretical framework that outlines the relationships between various variables in a research study. It aids in understanding how different factors interact and influence each other, providing a structured approach to analyzing complex phenomena. This talk will guide you through the essential steps of developing a conceptual model, ensuring a robust and theoretically grounded research proposal.

#### **Identifying the Research Problem**

The first step in developing a conceptual model is to clearly define the research problem. For instance, if the research aims to explore the factors influencing job satisfaction, the problem statement should be precise and focused. This clarity helps in setting the direction for the subsequent steps.

#### **Review of Literature**

Conducting a comprehensive literature review is crucial to understand existing theories and models related to the research topic. This step involves identifying gaps in the current knowledge and building on previous research to develop a solid theoretical foundation for the study.

#### **Defining Variables**

Identifying and defining key variables is a critical step in developing a conceptual model. Variables can be classified into dependent, independent, mediating, and moderating categories. For example, in a study on job satisfaction, variables such as work environment, compensation, work-life balance, recognition, and job security might be considered. Each variable must be clearly defined and its role within the model established.

#### **Developing Hypotheses**

Formulating hypotheses involves establishing the expected relationships between the identified variables. Hypotheses should be based on theoretical insights and empirical evidence gathered from the literature review. For instance, one might hypothesize that recognition and rewards are positively related to job satisfaction.

#### **Drawing the Model**

Creating a visual representation of the conceptual model is an essential step. This model should depict the relationships and directions of influence among the variables. Tools such as path diagrams can be used to illustrate these connections clearly.

#### **Ensuring Theoretical Grounding**

A robust conceptual model must be grounded in established theories. This theoretical foundation not only lends credibility to the model but also provides a framework for

interpreting the results of the study. Ensuring that the model aligns with existing theories enhances its validity and reliability.

### **Types of Variables**

Understanding the different types of variables is fundamental in developing a conceptual model:

1. Independent Variable: The variable manipulated by the researcher to observe its effect on the dependent variable.
2. Dependent Variable: The variable measured to assess the impact of the independent variable.
3. Control Variable: Variables held constant to prevent them from influencing the study outcomes.
4. Mediating Variable: A variable that explains the relationship between the independent and dependent variables.
5. Moderating Variable: A variable that affects the strength or direction of the relationship between the independent and dependent variables.
6. Extraneous Variable: Variables that are not of primary interest but could influence the study results and need to be controlled.

### **Measurement Models**

Measurement models specify how latent variables or unobserved constructs are measured. There are two main types:

1. Formative Measurement Model: Indicators define the latent variable, with arrows pointing from the indicators to the construct.
2. Reflective Measurement Model: The latent variable influences the indicators, with arrows pointing from the construct to the indicators.

### **Structural Models**

Structural models illustrate how latent variables relate to one another. They show the constructs and their path relationships, typically moving from left (independent variables) to right (dependent variables). Variables can be exogenous (only serving as independent variables) or endogenous (serving as dependent or both independent and dependent variables).

### **Conclusion**

Developing a conceptual model is a systematic process that requires careful planning and theoretical grounding. By following the outlined steps, researchers can create robust models that provide valuable insights into the relationships between variables, ultimately contributing to the advancement of knowledge in their field.

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## **DFT Computations on Structural, Electronic and Pharmaceutical Evaluation of (2E)-3-(3,4-dimethoxyphenyl)-1-(2-hydroxyphenyl) prop-2- en-1-one**

**D. Jebisha<sup>1,3</sup>, V. Bena Jothy<sup>2,3\*</sup>, S. Muthu<sup>4</sup>**

<sup>1</sup> *Research Scholar, Register Number: 23213282132005, Department of Physics and Research  
Centre, Women's Christian College, Nagercoil 629 001, Tamil Nadu, India.*

<sup>2</sup> *Associate Professor, Department of Physics and Research Centre, Women's Christian College, Nagercoil 629  
001, Tamil Nadu, India, Affiliated to Manonmaniam Sundaranar University, Abishekapatti 627 012, Tirunelveli,  
Tamil Nadu, India.*

<sup>4</sup> *Department of Physics, Arignar Anna Govt. Arts College, Cheyyar 604 407, Tamil Nadu, India.  
Email: [benaezhil@yahoo.com](mailto:benaezhil@yahoo.com), ph:9994769009\**

### **Abstract**

Chalcone derivatives have wide applications in pharmaceutical industry. (2E)-3-(3,4-dimethoxyphenyl)-1-(2-hydroxyphenyl) prop-2-en-1-one (2DPHP) has been studied for its structural, spectroscopic, and reactive properties. Density Functional Theory (DFT) computations have been performed to obtain an optimized structure and bond lengths, bond angles, and dihedral angles of the molecule have been calculated. Frontier Molecular Orbitals (FMOs), specifically the highest occupied molecular orbital (HOMO) and the lowest unoccupied molecular orbital (LUMO), have been analyzed to predict the molecule's bioactivity, reactivity, and stability. Topological investigations Electron Localization Function (ELF) and Localized Orbital Locator (LOL), have been conducted to identify the main bonding regions. Using Lipinski's rule of five, substance's drug-like properties has been proven and molecule is recommended for use in pharmaceuticals using ADMET.

**Keywords:** 2DPHP, DFT, ELF, LOL, FMO

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### **Introduction**

DFT method is preferred for molecular studies due to highly precise outcomes it produces, all the while being computationally cost-effective (Garcia et al. 2020). Chalcone derivatives hold significant promise in the pharmaceutical industry due to their diverse biological activities. These naturally occurring compounds are found in various fruits, vegetables, and plants, serving as precursors in the synthesis of flavonoids and isoflavonoids from the amino acid phenylalanine. Structurally, chalcones are characterized by the presence of two aromatic rings connected by a three-carbon  $\alpha,\beta$ -unsaturated ketone chain, classifying them as  $\alpha,\beta$ -unsaturated ketones (Bakar et al. 2020). This structural framework is crucial for their biological activities, including antimicrobial properties. Phenolic groups in chalcones enhance their affinity for proteins in microorganisms, thereby inhibiting their growth and



development. The versatile nature of chalcones and their derivatives makes them attractive for drug development and various pharmaceutical applications (Kumar et al. 2018).

Adole et al. (2020) investigated the Computational Insights on Molecular structure, Electronic properties, and Chemical reactivity of (*E*)-3-(4-Chlorophenyl)-1-(2-Hydroxyphenyl)prop-2-en-1-One. The study aimed to provide a comprehensive analysis of the compound's structural, spectroscopic, and electronic properties, as well as its potential biological applications. The findings of this research contribute to the understanding of the compound's molecular structure and its potential implications in biological systems. Fleming has reported that Frontier molecular orbital (FMO) provides information about the electronic properties of molecules and also the electron-donating behavior of the HOMO and electron-accepting character of the LUMO (Fleming 1976). Mathialagan have reported on drug likeness analysis to validate the potentially active nature of drugs based on various pharmacophoric characteristics such as bioavailability, reactivity, and metabolic stability. Prediction of human pharmacokinetic properties is a crucial step in drug design process, which aids in identification and selection of candidate molecule that are more likely to be successful in the clinic (Mathialagan et al. 2017).

The primary aim of this study is to conduct a comprehensive analysis of the molecular structure and properties of a given compound. This involves determining the bond length, bond angles, and dihedral angles, which are critical parameters that define the three-dimensional conformation of the molecule. Furthermore, the stability and nature of the chemical bonds within the molecule will be scrutinized to understand its chemical behavior and reactivity. Another key objective is to elucidate the electronic structure and energy levels of the molecule, providing insights into its electronic properties and potential reactivity patterns. Finally, the study will assess the potential of the molecule as a drug, focusing on its theoretical suitability for oral administration, which includes evaluating its safety profile and pharmacokinetic properties.

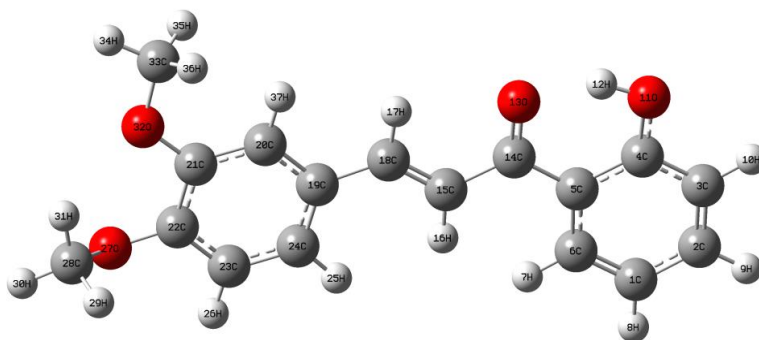
### **Computational Details**

DFT computational analysis has been carried out using Gaussian'09 software (Frisch et al. 2009) and the outcomes are depicted utilizing Gauss View 5.0. ELF and LOL have been conducted using Multiwfn program (Lu and Chen 2012). Swiss ADME (Daina et al.2017) and pkCSM (Pires et al. 2015) online tools have been utilized to further scrutinize the chemical concerning pharmaceutical factors like Drug likeness and ADMET.

## Results and Discussion

### Optimization

Geometric optimization employing B3LYP/ 6-311++G(d,p) basis set has been employed to determine Bond length, Bond angle, and Dihedral angle. Figure.1 depicts the structure of (2E)-3-(3,4-dimethoxyphenyl)-1-(2-hydroxyphenyl)prop-2-en-1-one. Table 1 displays bond analysis of 2DPHP. BL of  $C_4 - C_5$  (1.425Å) in phenyl ring has been raised due to O-H....O intramolecular interaction, whereas BL of  $C_{21} - C_{22}$  (1.4127Å) is slightly elevated from the typical value due to oxygen atom connected to ring. Computed C-H bonds range from 1.0816 Å – 1.0951Å, which are longer than experimental values (0.8200- 0.9600). Highest bond angle has been observed in atoms  $C_{15} - C_{18} - C_{19}$  (127.93°), while lowest bond angle has been found in  $O_{32} - C_{33} - H_{34}$  (105.70°). Both angles deviate from the expected trigonal angle of 120° due to double bond of carbon and electronegative atoms attached to them.



**Figure.1** Optimized Structure of (2E)-3-(3,4-dimethoxyphenyl)-1-(2-hydroxyphenyl)prop-2-en-1-one.

**Table 1**

Comparison of Optimized bond length and bond angle of 2DPHP with their  
Experimental data.

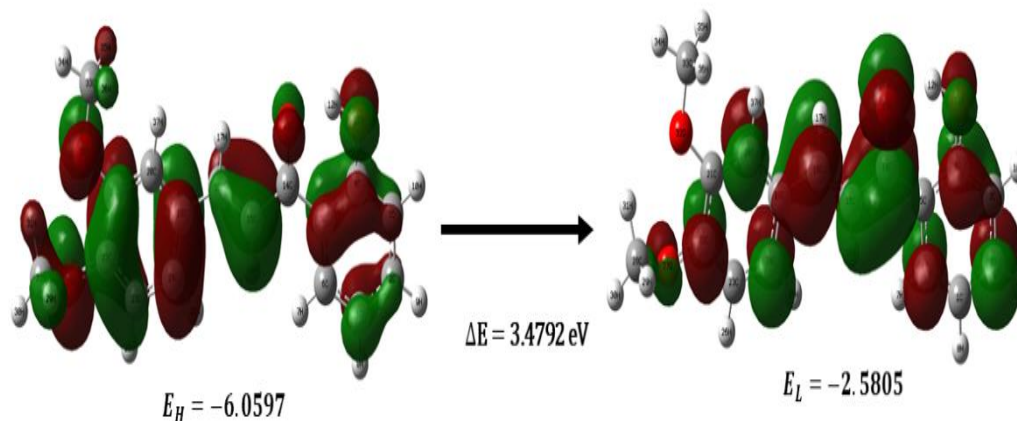
Bond Length	Theoretical (Å)	Experimental (Å)	Bond Angle	Theoretical (°)	Experimental (°)
$C_3 - C_4$	1.4033	1.382	$C_3 - C_2 - H_9$	119.48	119.8
$C_4 - C_5$	1.425	1.418	$C_2 - C_3 - H_{10}$	121.65	119.7
$C_4 - O_{11}$	1.3381	1.349	$C_4 - C_3 - H_{10}$	117.97	119.7

$C_5 - C_6$	1.411	1.392	$C_3 - C_4 - C_5$	119.95	119.88
$C_5 - C_{14}$	1.4779	1.470	$C_3 - C_4 - O_{11}$	117.59	118.35
$O_{11} - H_{12}$	0.9929	0.8200	$C_4 - C_5 - C_6$	117.84	118.03
$O_{13} - C_{14}$	1.2468	1.2454	$C_4 - C_5 - C_{14}$	119.02	118.35
$C_{14} - C_{15}$	1.4733	1.4623	$C_6 - C_5 - C_{14}$	123.13	122.90
$C_{15} - H_{16}$	1.0804	0.9300	$C_1 - C_6 - C_5$	121.83	121.2
$C_{15} - C_{18}$	1.3482	1.331	$C_5 - C_6 - H_7$	119.69	119.4
$H_{17} - C_{18}$	1.0872	0.9300	$C_4 - O_{11} - H_{12}$	106.40	109.5
$C_{18} - C_{19}$	1.4573	1.4517	$C_{15} - C_{18} - C_{19}$	127.93	127.97
$C_{20} - C_{21}$	1.3921	1.3784	$C_{18} - C_{19} - C_{24}$	123.68	122.41
$C_{20} - H_{37}$	1.082	0.9300	$C_{20} - C_{19} - C_{24}$	118.33	118.47
$C_{21} - C_{22}$	1.4127	1.4121	$C_{19} - C_{20} - C_{21}$	121.68	120.76
$C_{33} - H_{36}$	1.0949	0.9600	$O_{32} - C_{33} - H_{34}$	105.70	109.5

### Frontier Molecular Orbital

Frontier Molecular Orbital (FMO) scrutiny assesses stability and reactivity in compounds by examining interactions between HOMO and LUMO. Analysis of HOMO-LUMO energies enables the determination of energetic properties and energy distribution of molecules. Chemical parameters are computed and the outcomes are listed in Table 2. Energy gap diagram is displayed in Fig.2. Capacity to provide an electron is symbolized by HOMO, while LUMO has the capacity to gain an electron. Colors red and green, accordingly, stand for positive and negative phases. HOMO is distributed across the whole molecule of hydrogen atoms, while LUMO spans the entirety of the molecule except methoxy group and some hydrogen atoms. LUMO energy is directly related with the molecular electron affinity and characterizes the susceptibility of the molecule toward an attack by a nucleophile. FMO's energy gap ( $\Delta E$ ) for the mentioned molecule is determined to be 3.4792 eV. A molecule is considered to be hard (chemically hard) if its energy gap is large, and soft (chemically soft) if

its energy gap is small. A large HOMO-LUMO gap implies high stability with respect to chemical reaction (Ternavisket al.2014).



**Figure.2** Frontier molecular orbital of 2DPHP.

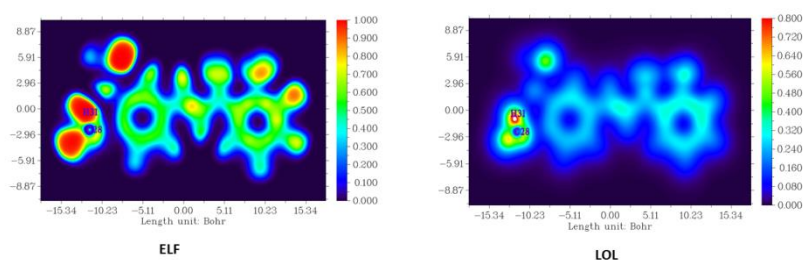
**Table 2:** Calculated energy values of 2DPHP

Parameters	B3LYP/6-311++G(d, p)
HOMO	- 6.0597
LUMO	- 2.5805
Energy gap (eV)	3.4792
Ionization Potential (IP)	6.0597
Electron Affinity (EA)	2.5805
Chemical Hardness ( $\eta$ )	1.7396
Chemical Softness (S)	0.5748
Chemical Potential ( $\mu$ )	- 4.3201
Electrophilicity Index ( $\omega$ )	5.3650
Electronegativity ( $\chi$ )	4.3201

### ELF and LOL

ELF and LOL are established computational tools instrumental in analyzing covalent bonds within molecular structures. ELF is a representation of the electron pair density and helps identify areas where electrons are localized. High ELF values indicate strong electron localization, typically found in covalent bonds, where electrons are tightly bound to specific

regions. On the other hand, low ELF values indicate strong electron delocalization, where electrons are spread over a larger area, contributing to stability of the molecule. LOL illustrates that the gradients associated with localized orbitals, reaches their maximum when these orbitals overlap. Red areas near hydrogen atom H31 indicate regions with the peak ELF and LOL values; in contrast, blue zones denote areas with minimal ELF and LOL values. Blue circles encircling carbon (C28) depict areas of electron depletion situated between the inner and valence electron shells.



**Figure. 3** ELF and LOL plot of 2DPHP

### Pharmaceutical Evaluation

Rule of 5 based on Lipinski, which is a cornerstone in the realm of drug discovery, was utilized to determine bioavailability and drug-likeness specifications of the titled compound. Based on these criteria, a ligand is regarded as a pharmaceutical drug if it fulfills the following particular conditions: molar mass below 500 Dalton, fewer than 10 HBA, no more than 5 HBD, as well as log P below 5. The indicated molecule demonstrates drug-like characteristics, with a molecular weight of 284.31 g/mol, it comprises 4 HBA, it has 1 HBD, its Log P value stands at 3.305 and molar refractivity of 81.26, all within permissible limits. The title molecule satisfies all of Lipinski's requirements, resulting in a strong contender for use as a drug. ADMET attributes of the title molecule were assessed through utilization of pkCSM-ADME tool which helps medical chemists strike an acceptable balance during toxicology evaluations. A good human intestinal absorbance ranges from 70% to 100%, and for this molecule the obtained result is 92.15%, signaling proficient uptake by the human system. Notably, the substance does not induce skin sensitivity which is common side effects of many toxic substances. It's also essential to note down that the compound does not interfere with regular liver function and is therefore not hepatotoxic.

## Conclusion

A comprehensive analysis of the spectroscopic parameters using quantum chemical computations has been conducted for 2DPHP under investigation. Theoretical calculations have been conducted to determine geometrical parameters, including bond lengths and bond angles. According to FMO calculations, molecule's Band gap energy is 3.4793 eV, indicating that it is stable and has pharmacological potential. Topology study (ELF and LOL) were not considerably altered, indicating a favourable outcome. Drug Likeness and ADMET analyzes revealed that 2DPHP is an excellent contender to be used as a drug since it complies with all Lipinski requirements and it has no toxicity which can be effectively consumed by human body.

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## **Fuzzy Interference in Predicting Air Pollutants**

**P.S. Gayathri<sup>1</sup>, R.Krishna Sharma<sup>2\*</sup>, S.Nagaveena<sup>3</sup>**

<sup>1</sup>*Research scholar, Department of Physics, S.T.Hindu College, Nagercoil-629002, Kanyakumari, Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamil Nadu-627012, India.*

*Contact no. 9003304198, e-mail ID: ps2gayathriraj24@gmail.com*

<sup>2</sup>*Assistant Professor, Department of Physics, S.T. Hindu College, Nagercoil - 629002, Kanyakumari.*

<sup>3</sup>*Assistant Professor, Department of Nanoscience and Nanotechnology, S.T. Hindu College, Nagercoil - 629002, Kanyakumari.*

### **Abstract**

Air pollution is a significant environmental concern with profound impacts on public health and ecological balance. Predicting air pollutant concentrations accurately is crucial for effective mitigation strategies and policy formulation. Traditional predictive models frequently face challenges in accurately capturing the complexity and uncertainties that are inherent in environmental data. In response, this study proposes a fuzzy logic-based approach for predicting air pollutants. Fuzzy logic offers a framework to handle imprecise and uncertain data by integrating linguistic variables and expert knowledge. This research applies fuzzy logic to develop predictive models for key air pollutants such as nitrogen dioxide (NO<sub>2</sub>), and Surface Ozone (O<sub>3</sub>). The methodology involves fuzzy inference systems that utilize input variables such as meteorological data to forecast pollutant concentrations. The effectiveness of the proposed fuzzy logic models is evaluated using real-world data collected from monitoring stations in Nagercoil city. The findings highlight the potential of fuzzy logic as a robust tool for air quality prediction, offering insights for policymakers, environmental agencies, and researchers involved in air pollution management. By enhancing prediction accuracy and accommodating uncertainties, fuzzy logic contributes to proactive measures aimed at improving air quality and public health.

**Keywords:** Fuzzy Logic, Interference system

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### **Introduction**

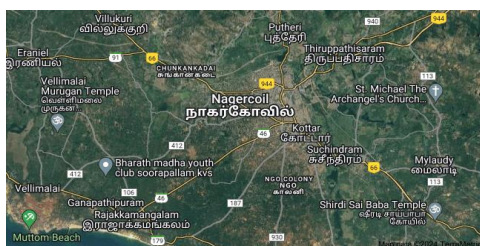
Air pollution occurs when substances known as pollutants are introduced into the atmosphere, posing risks to human and environmental health by compromising air quality and potentially harming living organisms, climate stability, and materials (<https://www.who.int/health-topics/air-pollution>). Recently, surface ozone has emerged as a significant contributor to air pollution. It typically has an average concentration of 20-30 parts per billion by volume (ppbv), but can reach nearly 100 ppbv in areas affected by pollution (Warneck, Peter (1999). Chemistry of The Natural Atmosphere. Academic Press. ISBN 9780080529066). While tropospheric ozone is less concentrated than stratospheric ozone, it is concerning due to its significant health effects ("Ozone in the



Troposphere | UCAR Center for Science Education". scied.ucar.edu. Retrieved 2018-11-12). High concentrations of surface ozone (O<sub>3</sub>) can cause damage to both living organisms (biotic factors) and non-living components of the environment (abiotic factors). (Avol et al., 1998). Tropospheric ozone is primarily formed when nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), and volatile organic compounds (VOCs) react in the atmosphere under sunlight, particularly in the UV spectrum ("Ozone in the Troposphere | UCAR Center for Science Education". scied.ucar.edu. Retrieved 2018-11-12). Among these pollutants, NO<sub>2</sub> is the primary precursor (which is emitted globally by road transport, followed by combustion in power plants and industries) for the formation of surface ozone, particularly under conditions with suitable temperatures, highlighting the significant role temperature plays in this process. Currently, Surface Ozone levels are monitored in only a few cities across India, with very limited monitoring stations in Tamil Nadu.

### **Study Area & Methodology**

The study area chosen for this study is Nagercoil (8.1833° N, 77.4119° E) and is shown in the fig.1. The city, along with the district of Kanyakumari, ranks at the top in many Human Development Index parameters in Tamil Nadu state, including education, per capita income, and health indices (Ramakrishnan, T. (17 May 2017). The town experiences its summer season from March to May, followed by the southwest monsoon (SWM) from June to September. The northeast monsoon (NEM) occurs from October to December, with the winter season spanning January and February. The average summer temperature is approximately 32°C, and the average annual rainfall is 1456mm. Humidity and temperature levels in this area remain relatively high throughout the year. The air quality data such as NO<sub>2</sub>, surface O<sub>3</sub> including parameters like temperature and humidity were collected from air quality index website for past three months (<https://www.aqi.in/in/dashboard/india/tamil-nadu/nagercoil>).



**Fig 1. Study Area**

## Fuzzy Logic

The term "fuzzy" describes things that are not precisely defined or are vague in nature. In the real world, there are many situations where it's difficult to determine whether a state is true or false. Fuzzy logic provides valuable flexibility for reasoning in such cases. It allows us to consider the inaccuracies and uncertainties inherent in any situation, thereby offering a more realistic approach to decision-making and problem-solving. Fuzzy systems are prevalent across various industrial sectors such as automobile manufacturing, control engineering, finance, medicine, logistics, and telecommunications. Their key advantage lies in their inherent simplicity. Fuzzy inference systems offer a robust framework for modeling intricate nonlinear relationships. They leverage human-understandable reasoning mechanisms, integrate linguistic insights from experts with numerical data, manipulate both numerical and linguistic information concurrently, approximate complex nonlinear functions with straightforward models, and represent systems through local linear time-invariant models (Sebastian camilo et al.,2023)

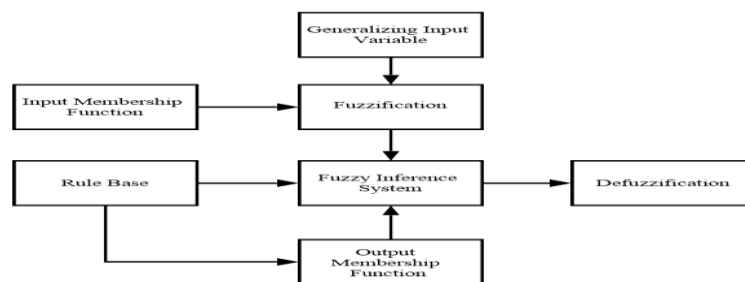


Fig 2. Flowchart of Fuzzy Logic Controller Design

A fuzzy set contains elements that possess varying degrees of membership within the set. Each element's degree of membership is mapped to a universe of discourse using a function-theoretic approach.

When the universe of discourse  $X$  is discrete and finite, fuzzy sets are often denoted using a notation where  $A$  is

$$A = \{(\mu_A(x_1))/x_1 + (\mu_A(x_2))/x_2 + \dots\dots\dots\}$$

$$= \sum \{(\mu_A(x_i))/x_i\}$$

Here,  $(\mu_A(x_1))$  represents the membership value of  $x_1$  in the fuzzy set  $A$ .

## Result and Discussion

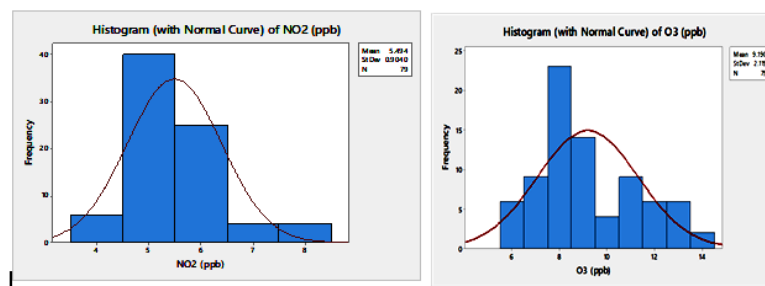
### Descriptive Statistics

Descriptive statistics refers to a branch of statistics that involves summarizing, organizing, and presenting data meaningfully and concisely. It focuses on describing and

analyzing a dataset's main features and characteristics without making any generalizations or inferences to a larger population. The descriptive statistics of the data is given in table 1 and the histogram curve is shown in figure.

Table1: The descriptive statistics

Variable	Mean	SE Mean	StDev	Variance	Sum of Squares	Minimum	maximum
NO <sub>2</sub> (ppb)	5.494	0.102	0.904	0.817	2448	4.00	8.00
TEMP (°C)	26.734	0.118	1.046	1.095	56548	25.00	30.0
HUMID (%)	84.671	0.418	3.713	13.788	567439	75.00	92.0
O <sub>3</sub> (ppb)	9.190	0.238	2.119	4.489	7022	6.000	14.0



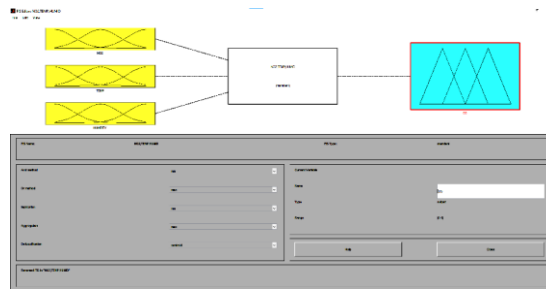
**Fig .3 Histogram of NO<sub>2</sub> & O<sub>3</sub>**

### Fussy Interference System

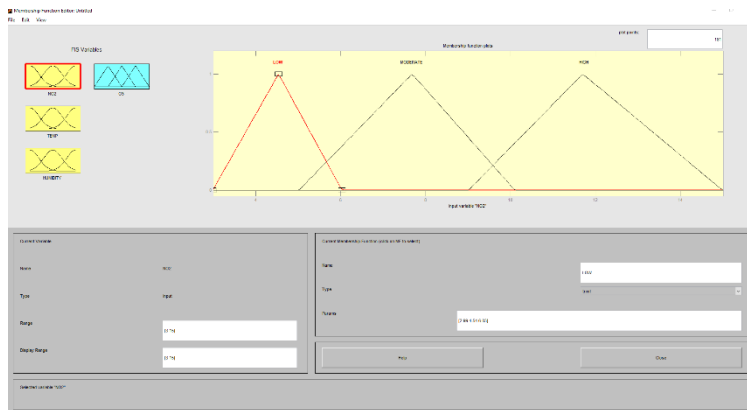
The fuzzy-based air quality index prediction model is designed using the Fuzzy Toolbox and the Mamdani FIS, which are integrated within the MATLAB environment. This setup facilitates the creation of a robust model that predicts the air quality index based on fuzzy logic principles. The diagram depicts the impact of various air pollutants on the Air Quality Index. NO<sub>2</sub>, temperature, and humidity serve as input variables, while Surface Ozone concentration in parts per billion (ppb) is the output. Corresponding membership functions are assigned to these variables, defining their fuzzy ranges. Figure 4 depicts the sample input/output designs for the fuzzy inference system variables, along with plots of their respective membership functions.

This illustration provides a visual representation of how different variables are processed within the fuzzy inference system. Figure 5 illustrates the fuzzy inference system for input variables related to NO<sub>2</sub>, including Low, Medium, and High categories, along with their corresponding membership function plot. This visual representation helps in understanding how NO<sub>2</sub> levels are categorized and interpreted within the fuzzy inference framework. Fuzzy rules dictate that if NO<sub>2</sub> is high, temperature is high, and humidity is low,

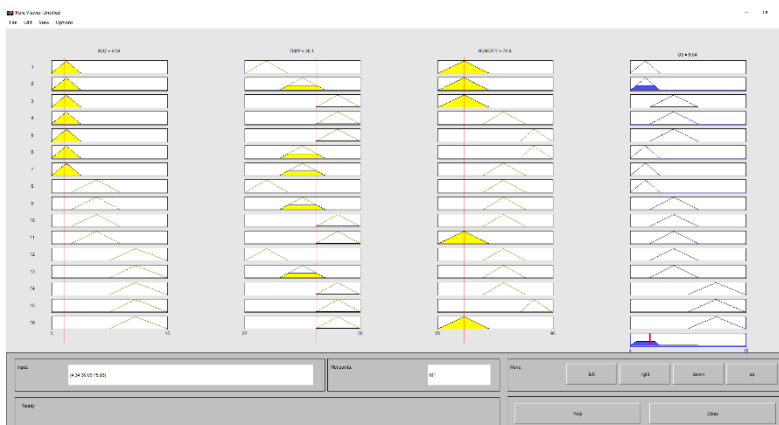
the system infers a high Surface Ozone concentration in ppb. Similarly rules were framed depending upon the variations of O<sub>3</sub> studied from literature survey. The figure 6 demonstrates the resultant Air Quality Index based on the concentration values of the air pollutants NO<sub>2</sub>, Temperature and humidity. It illustrates how these pollutant levels collectively influence and determine the overall Air Quality Index. Table2. shows the predicted values using Fuzzy inference system.



**Fig.4 Three input fuzzy logic**



**Fig.5 NO<sub>2</sub> Input variable**



**Fig.6 fuzzy predictions**

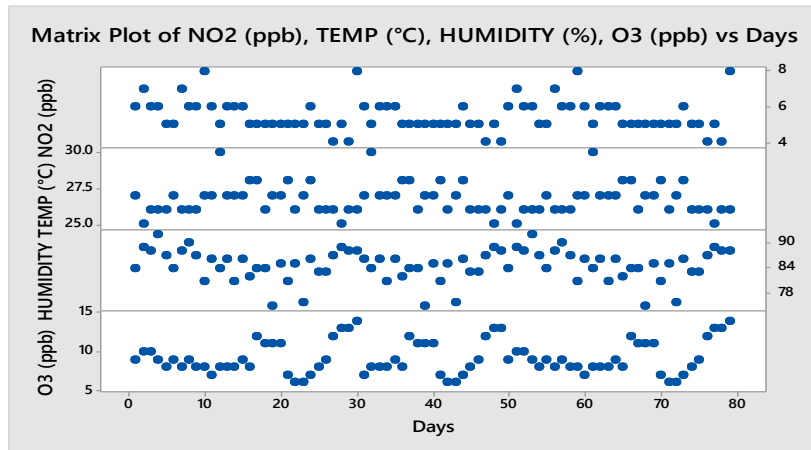


Fig.7 Matrix Plot

Table2: Predicted data using fuzzy

NO <sub>2</sub> (ppb)	TEMPERATURE (°C)	HUMIDITY (%)	O <sub>3</sub> (ppb)
4.34	30.1	75.8	6.04
6.43	27.2	78.6	10
7.99	27.2	86.1	8.55
9.19	30.4	80.6	10.3
9.49	30.1	88.5	9.78
10.3	26.7	88.5	8.58
10.6	30	86.1	8.81
11	31.5	80.5	13
11.7	28.8	78.1	10
12.9	31.6	76.4	12.9

### Conclusion

In conclusion, employing a fuzzy logic approach to predict air pollutants offers a robust method that integrates uncertainty and imprecision inherent in environmental data. By leveraging fuzzy inference systems, this approach enhances accuracy in forecasting pollutant levels, aiding in proactive environmental management and policy formulation. As research progresses, refining fuzzy logic models will be crucial in addressing complex atmospheric dynamics and achieving sustainable urban development goals.

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## **Theoretical and Structural Investigation of 2-N-(4-Aminophenyl)-5-Methyl-3H-1,2-Oxazole-2,3-Diamine using Density Functional Theory with the Aid of Quantum Computational Methods.**

**Daphne D. Ann<sup>a</sup>, V. Bena Jothy<sup>b\*</sup>, S. Muthu<sup>c</sup>**

<sup>a</sup>*Research Scholar, Register Number: 241132813027, Department of Physics and Research Centre, Women's Christian College, Nagercoil 629 001, Affiliated to Manonmaniam Sundaranar University, Abishekapatti 627012, Tirunelveli, Tamil Nadu, India.*

<sup>b\*</sup>*Associate Professor, Department of Physics and Research Centre, Women's Christian College, Nagercoil 629 001, Tamil Nadu, India.*

<sup>c</sup>*Department of Physics, Arignar Anna Govt. Arts College, Cheyyar 604407, Tamil Nadu, India.  
Email: [dafydaphne@gmail.com](mailto:dafydaphne@gmail.com).*

### **Abstract**

2-N-(4-aminophenyl)-5-methyl-3H-1,2-oxazole-2,3-diamine containing heterocyclic system has been evaluated computationally by the DFT method. The quantum chemical DFT approach is used to estimate the equilibrium geometry of the molecule at the B3LYP/6-311++G (d,p) level. The ultimate charge transfer interaction within the molecule is explained by the highest occupied molecular orbital (HOMO) and lowest unoccupied molecular orbital (LUMO), which also sheds light on the stability and chemical reactivity of molecules. The global reactivity characteristics show the molecule's bioactivity. Molecular electrostatic potential (MEP) surfaces have been used for electrophilic and nucleophilic attacks; these surfaces are essential for determining the charge distribution of molecules in three dimensions. Molecular docking experiments (ligand-protein interactions) have been carried out to investigate the binding interactions of the compound to the targeted protein inhibitors. The lowest binding energy proves the biological application of the titled compound, 2AMOD.

**Keywords:** DFT, MEP, HOMO, LUMO, Docking.

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### **Introduction**

A condition known as epilepsy affects the central nervous system and is typified by the excessive, hypersynchronous, paroxysmal discharge of an excessive number of neurons (Gasior et al., 1997). There is a need to discover novel medications for epilepsy because many individuals with epilepsy fail to achieve seizure control or acquire it only with hazardous side effects despite using present antiepileptic drugs (AEDs). Many medications and compounds of biological significance contain heterocyclic systems. Preferential specificities in their biological reactions are frequently conferred by the presence of heteroatoms or groupings. And one such moiety that has attracted attention recently is oxazole, which is becoming more and more significant in the field of medicinal chemistry

(Swellmeen 2016). 2-N-(4-aminophenyl)-5-methyl-3H-1,2-oxazole-2,3-diamine (2AMOD) is a compound with important antibacterial and anti-inflammatory characteristics. Additionally, the subcutaneous pentylenetetrazole (ScPTZ) test (Tatee et al., 1986), one of the primary techniques used to assess a compound's anticonvulsant effectiveness, demonstrates the oxazole ring contained in 2AMOD to have anticonvulsant activity. Anticonvulsant medications, also referred to as antiepileptic medications, are mostly used to prevent or alleviate seizures in people who have been diagnosed with epilepsy.

### **Literature Review**

A review of the literature suggests that the title compound has not been subjected to a comprehensive spectroscopic analysis. This encourages a thorough examination of the molecule in order to clarify theoretical and vibrational spectroscopy investigations.

- DFT approach of oxazole was reported by *Jasleen Kaur et al.*, which gives a picture of structural analysis of oxazole ring present in the titled molecule.
- Biological applications of oxazole derivatives has been reported by *Swellmeen*.
- The structural and electronic parameters reported by *Miar et al.*, shows a clear picture of frontier molecular orbital and global reactivity.

### **Objectives**

Initially, the title molecules are analysed using several DFT computational methods. Geometry optimisation DFT techniques were used, and HOMO-LUMO energies were used to study the electrical characteristics. With the aid of molecular electrostatic potential (MEP), the reactive locations of electrons were examined. Drug likeness ADME approaches have been used in this study to predict the different physicochemical and pharmacokinetic properties of the titled compound. The results based on physicochemical and pharmacokinetic properties leads us to perform the molecular docking experiments (ligand-protein interactions). Docking has been carried out to investigate the binding interactions of the compound to the targeted proteins (5fdc, 3oy0, and 3oys) inhibitors to confirm the anticonvulsant property of the titled compound.

### **Materials and Methods**

To complete the DFT computations and visualisations, the programmes Gaussian 09 W (Frisch and Clemente 2009) and Gauss View 05 (Dennington et al., 2009) are utilised. The corresponding compound 2AMOD has had its geometrical foundations strengthened through the application of DFT/B3LYP and the basis set 6-311++G (d,p). To perform drug-likeness

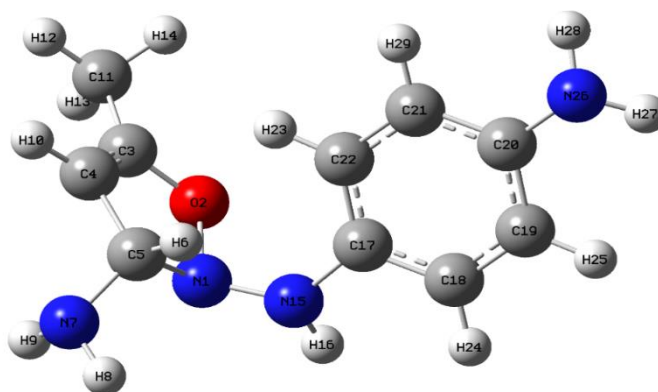


ADME properties, the software tools PKCSM and Swiss ADME (Daina et al., 2017) are utilized. Using Auto Dock Tools 1.5.6 (Morris et al., 1998), molecular docking studies are conducted against target proteins and PyMOL (Schrodinger 2015) serves to visualize the docked postures. Additionally, the PAS online tool was used to predict bioactivity in order to choose the target protein (Systemes 2020).

## Results and Discussion

### Optimized molecular structure

The optimized molecular geometry of 2-N-(4-aminophenyl)-5-methyl-3H-1,2-oxazole-2,3-diamine optimised using Gaussian'09 software and Gauss view programs with B3LYP 6-311G++(d,p) basis set is shown in Fig.1. The molecule is composed of oxazole ring and aminophenyl ring attached to each other through a nitrogen atom (N<sub>15</sub>). The oxazole ring is substituted with a methyl group and both oxazole and aminophenyl ring is substituted with a NH<sub>2</sub> group in it. The optimized geometrical parameters such as bond lengths and bond angles are tabulated in Table 1. Due to the presence of electronegative atoms, the bond lengths of N<sub>1</sub> – O<sub>2</sub> and N<sub>1</sub> – C<sub>5</sub> highly increase. C<sub>3</sub> = C<sub>4</sub> bond length decreases when compared with C<sub>4</sub> – C<sub>5</sub> bond length; this is due to the presence of a stable double bond. In the present calculation, since the presence of a N – H group attached to the aminophenyl ring, the bond angles of (C<sub>18</sub> – C<sub>17</sub> – C<sub>22</sub>) and (C<sub>19</sub> – C<sub>20</sub> – C<sub>21</sub>) are found to be decreasing  $\approx 118.44^\circ$  and  $\approx 117.87^\circ$  respectively. And the bond angles for (C<sub>17</sub> – C<sub>18</sub> – C<sub>19</sub>)  $\approx 121.11^\circ$ , (C<sub>18</sub> – C<sub>19</sub> – C<sub>20</sub>)  $\approx 120.77^\circ$  and (C<sub>20</sub> – C<sub>21</sub> – C<sub>22</sub>)  $\approx 121.46^\circ$ , increases from the standard value, which is  $\approx 120^\circ$ .



**Fig. 1.** Optimized molecular structure of 2AMOD

**Table 1.** Optimized Parameters of 2AMOD by B3LYP/6-311G++(d,p)

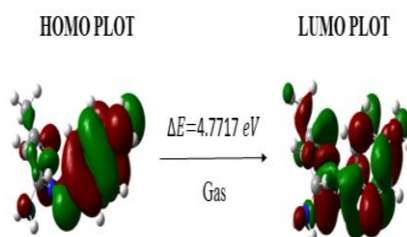
Bond Length (Å)	B3LYP/6311++G(d,p)	Bond Angle (°)	B3LYP/6311++G(d,p)
N <sub>1</sub> – O <sub>2</sub>	1.5692	C <sub>18</sub> – C <sub>17</sub> – C <sub>22</sub>	118.44
N <sub>1</sub> – C <sub>5</sub>	1.5182	C <sub>19</sub> – C <sub>20</sub> – C <sub>21</sub>	117.87
C <sub>3</sub> – C <sub>4</sub>	1.3397	C <sub>17</sub> – C <sub>18</sub> – C <sub>19</sub>	121.11
C <sub>4</sub> – C <sub>5</sub>	1.4976	C <sub>18</sub> – C <sub>19</sub> – C <sub>20</sub>	120.77
C <sub>11</sub> – H <sub>13</sub>	1.0937	C <sub>20</sub> – C <sub>21</sub> – C <sub>22</sub>	121.46
N <sub>7</sub> – H <sub>8</sub>	1.0153	O <sub>2</sub> – N <sub>1</sub> – C <sub>5</sub>	105.27
N <sub>7</sub> – H <sub>9</sub>	1.0155	O <sub>2</sub> – C <sub>3</sub> – C <sub>4</sub>	115.14
C <sub>20</sub> – N <sub>26</sub>	1.4028	C <sub>4</sub> – C <sub>3</sub> – C <sub>11</sub>	129.99
N <sub>26</sub> – H <sub>27</sub>	1.0099	C <sub>3</sub> – C <sub>4</sub> – C <sub>5</sub>	110.89
N <sub>26</sub> – H <sub>28</sub>	1.0099	N <sub>1</sub> – C <sub>5</sub> – C <sub>4</sub>	102.51

### Frontier Molecular Orbital Analysis

DFT has been found to be successful in providing insights into the chemical reactivity and stability of molecules and in studying electron excitation from the highest occupied orbital (HOMO) to the lowest unoccupied molecular orbital (LUMO). The HOMO represents the ability to donate an electron and LUMO as an electron acceptor. The 3D plot of the HOMO and LUMO for 2AMOD is shown in Fig. 2. The difference between the HOMO and LUMO energy values is the HOMO-LUMO energy gap, which explains the eventual charge transfer interaction within the molecule. In the titled compound 2AMOD, HOMO mainly concentrates over the aminophenyl ring, LUMO ranges all over the molecule. The energy gap value is found to be 4.7717 eV. Also with the help of HOMO - LUMO values, global reactivity descriptors were found and tabulated in table 2. Chemical softness has been detected at a value of 0.4 eV which is incredibly low and reveals that the titled molecule is naturally non-toxic. And the electrophilicity index is > 1.5 indicating the bioactivity of the molecule (George et al., 2018).

**Table 2** Energy parameters of 2AMOD

Properties	B3LYP/6-311++G(d,p)(Gas)
E <sub>HOMO</sub> (eV)	-5.3818
E <sub>LUMO</sub> (eV)	-0.61008
Energy gap (eV)	4.7717
Chemical hardness ( $\eta$ )	2.3858
Chemical softness (S)	0.41914
Electrophilicity index ( $\omega$ )	1.881

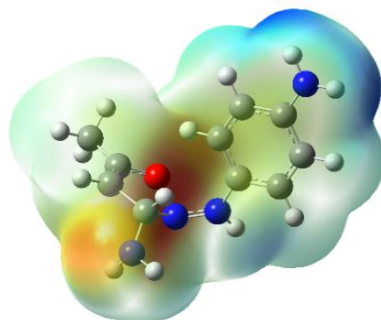


**Fig. 2.** HOMO-LUMO Plot of 2AMOD

### Molecular Electrostatic Potential Analysis

The molecular electrostatic potential (MEP) is a plot of electrostatic potential map which shows the charge distribution of molecules in a three dimensional manner. They enable us to visualise variably charged regions of a molecule; and acquiring nucleophilic and electrophilic actions in the structure's chemical structure (Ezzat et al., 2019). In MEP, the different values of electrostatic potential at the surface are represented by different colours. The maximum positive region is represented by a deep blue colour. In this region the presence of electrons is less. Hence this region has the possibility for nucleophilic attack. Red colour indicates the maximum negative region which is electron rich. This region has the possibility for electrophilic attack. The colour code of this map is in the range between  $-5.802 \text{ e}^{-2}$  to  $5.802 \text{ e}^{-2}$ . The molecular electrostatic potential map of 2AMOD is illustrated in Fig.3. In 2AMOD the negative electron density is present around the oxygen ( $\text{O}_2$ ) which is due to the presence of lone pairs. And the most positive region is identified around hydrogen atoms.

The existence of a lone pair of nitrogen atom present across the oxazole ring in the molecule is shown by the negative region. The green colour shows the neutral part of the titled molecule.



**Fig.3.** Molecular Electrostatic Potential Map (MEP) of 2AMOD

### **Drug Likeness**

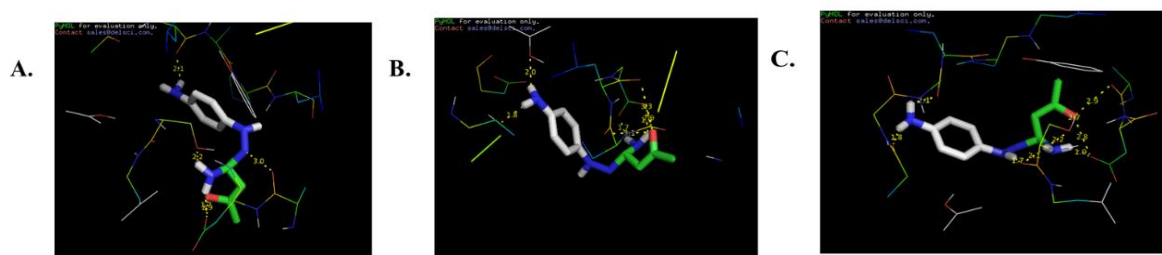
"Drug-likeness" refers to the stability between various molecular properties and structural traits that dictate drug discovery and production. Using drug-likeness, a compound's potential to function as an orally active medication can be processed using Lipinski's rule, which was developed based on five rules (Lipinski 2004). As described by Lipinski's rule of five, the physicochemical characteristics and ranges of the compound 2AMOD are as follows: The Van der Waals topological polar surface area (TPSA) value is  $76.54 \text{ \AA}^2$  ( $40\text{-}120\text{\AA}^2$ ), the molecular weight is found to be  $206.24 \text{ g/mol}$  ( $<500\text{g/mol}$ ), the hydrogen bond donor is 3 ( $<5$ ), the hydrogen bond acceptor is 3 ( $<10$ ), and the high lipophilicity LogP is 1.03 ( $<5$ ). Since 2AMOD did not break any of the five Lipinski rules, it is permissible to use it as an oral active pharmaceutical molecule.

### **Molecular Docking**

In order to understand biologically active chemicals against pathogenic protein strains, molecular docking is mostly used to compute the binding affinity with protein, bonding interaction, and bonding mode in their method for bonding between ligand and protein (Ragusa et al., 2018). According to the 2AMOD prediction made by the PASS Online program, the anticonvulsant had the highest probability of activity ( $P_a = 0.77$ ). We chose three distinct anticonvulsant proteins (PDB codes: 5fdc, 3oy0 and 3oys) for molecular docking in the context of this investigation for 2AMOD. Anticonvulsant proteins' original three-dimensional (3D) crystal structures were retrieved from the RSCB Protein Data Bank (PDB). Next, Auto Dock Suite 4.2.6 was used to determine the interactions between ligands

and proteins. Subsequently, the PyMOL software examined the final docked file. The ligand's interaction with many target proteins is shown in Fig.4. The receptors that bind strongly to the ligand

with the lowest binding affinity and lowest inhibition constant are depicted in the figure by the dotted line. Table 3 presents the docking findings. As a result, 5fdc has the lowest binding energy (-5.92 kcal/mol) among the three proteins. The previously cited arguments provide credence to the potential of 2AMOD as a very efficacious medication against brain diseases.



**Fig. 4. Docking of 2AMOD with (A. 5fdc, B. 3oy0, C. 3oys) proteins**

**Table 3** The interaction energy analysis of 2AMOD with targeted protein

Properties	Protein ID	Residue	Bond Distance Å	Inhibition Constant (micromolar)	Binding Energy (Kcal/mol)	RMSD
Anticonvulsant	5fdc	ASP190	1.7	45.61	-5.92	37.31
		LEU44	2.1			
		SER259	2.2			
		ASP190	2.9			
	3oy0	ASP85	1.7	75.03	-5.63	35.21
		THR208	1.8			
		ASP85	1.9			
		TYR88	2.0			
	3oys	SER259	1.7	75.4	-5.62	39.22
PRO42		1.8				
ASP190		1.9				
LEU44		2.1				

### Conclusion

This work presents a theoretical optimisation of the structural compound 2-N-(4-aminophenyl)-5-methyl-3H-1,2-oxazole-2,3-diamine utilising the B3LYP/6-311++G (d,p) basis set and the DFT method. In the HOMO-LUMO study, the molecule's bioactivity is

shown by the larger electrophilicity index. Sites where electrophilic and nucleophilic attacks could occur are indicated by a molecular electrostatic potential map, where the presence of lone pairs causes the oxygen atom to have a negative electron density. The outcomes from the molecular docking study show that the target protein, 5fdc, has the lowest binding energy (-5.92 kcal/mol) and is the most potent inhibitory anticonvulsant drug molecule. Based on the aforementioned findings, it can be concluded that the molecule 2AMOD can be used for those who are at high risk of developing epilepsy.

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## **DFT Computation and Pharmacokinetic Characterization of Piperidine Derivative to Determine its Bioactivity**

**E. Evelin Jinila<sup>1</sup>, V. Sarojini<sup>2\*</sup>, S. Muthu<sup>3</sup>**

<sup>1</sup>*Research Scholar, Register Number 241132813025, Department of Physics & Research Centre, Women's Christian College, Nagercoil – 1, Affiliated to Manonmaniam Sundaranar University, Triunelveli – 12, Tamil Nadu, India.*

<sup>2</sup>*Associate Professor of Physics, Lekshmpuram College of Arts & Science, Neyyoor 629 802, Tamil Nadu, India.*

<sup>3</sup>*Department of Physics, Arignar Anna Govt. Arts College, Cheyyar – 604 407, Tamil Nadu, India.*  
Email: [evelinjinila@gmail.com](mailto:evelinjinila@gmail.com).

### **Abstract**

Tert-butyl (2R)-2-(2-azidoethyl) piperidine-1-carboxylate (tBAPC) is a derivative of piperidine, which is composed of carboxylic units and azidoethyl piperidine connected at a dihedral angle of 104.30A°. Weak intramolecular hydrogen bonds that target particular binding sites were identified in tBAPC, increasing its potency as a bioactive molecule. Using DFT techniques, the molecular structure parameters and its spectroscopic characteristics were theoretically clarified. Utilizing FMO analysis, the charge transfer occurring within the molecule was examined. Areas that were open to nucleophilic and electrophilic molecules were depicted in MEP plot. The chemical has good intestinal absorption, a low excretion value, and no toxicity in terms of pharmacokinetic properties.

**Keywords:** tBAPC, DFT, FMO, MEP, Pharmacokinetic

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### **Introduction**

Biology and medicinal chemistry have investigated heterocyclic molecules for ages, and they are now more significant. One of the most prominent nitrogen heterocyclic compounds that are found in the majority of significant medications is piperidine (Rishikesan et al. 2021). This fascinating class of N-heterocycle skeleton is found in medicinal drugs as antioxidants, antiproliferatives, and antituberculars. They are also known to be chiral molecules with significant biological activity, including antihypertensive, antitumor, antibacterial, local anesthetic, antioxidant, and antimicrobial properties, as well as anticonvulsant, antimalarial, and anti-inflammatory properties (Vimala et al. 2021). Also, it is utilized as a fungicide, insecticide, and herbicide frequently in the agrochemical industry (Lee et al. 2001). In addition, the azide function has significant medicinal uses as a non-protonated inhibitor of human carbonic anhydrase and as an enzyme inhibitor (Jönsson et al. 1993). Majority of medications containing azides are approved as therapeutic components and are produced in laboratories and not from organic sources (Bräse et al. 2005). A new path for



drug development has been made possible by synthetic chemistry by binding organic azides to nucleoside analogues (Fang-Fang Chen and Feng Wang 2009). For this reason, a piperidine derivative with an azidoethyl group is selected for investigation.

### **Literature Review**

The review of the literature confirms that there is currently no published information on tert-butyl (2R)-2-(2-azidoethyl) piperidine-1-carboxylate. The compound under scrutiny, tBAPC, is an N-heterocyclic compound with a molecular weight of 254.334 g/mol. The geometric optimization of piperidine derivatives, as documented by (Parkin et al. 2004) shows clearly whether there are any differences in the geometric parameter of the compound under study. The prediction of global chemical characteristics using FMO analysis aids in determining whether the molecule is bioactive or not (Parr et al. 1999). As stated by (Politzer et al. 2021), the MEP plot makes it evident which regions are susceptible to intermolecular interactions. The compound acts as hydrogen bond donor and acceptor and opens a wide range of possible hydrogen interactions. Thus, it plays a vital role in molecular interactions (Kinga Roszak et al. 2017). According to the concept given in (Maliar et al. 2023), the pharmacokinetic properties and drug likeness of the molecule based on comparative analysis are carried out.

### **Aim and Objectives**

The prime objective of this work is to probe if there is any physical basis for the enhancement of their bioactivity, selectivity and stability of the molecules using electronic structure theory and the structural determination of the molecule obtained through DFT techniques and Pharmacokinetic properties. This present study is aimed at optimizing the geometry to investigate the bond lengths and bond angles, to perform HOMO – LUMO studies and to analyze the Molecular Electrostatic Potential (MEP), to visualize the weak interactions using RDG analysis, and to perform Pharmacokinetic Characteristics.

### **Computational Methods**

Computational calculation allows one to calculate molecular geometries, reactivities and other properties. DFT calculations of tBAPC were carried out using Gaussian'09 software package, using B3LYP/6-311++G(d,p) basis set for the gaseous phase (Hohenberg and Kohn 1964). The optimized structure, frontier molecular orbital and MEP plot are visualized using GaussView 5.0 software. Multiwfn and Visual Molecular Dynamics (VMD)

visualization program were used to perform RDG analysis. Pharmacokinetic properties were carried out with Swiss ADME online platform (Daina et al. 2017).

## Result and Discussion

### Optimized Geometry

The output parameters such as bond length and bond angle obtained from the aforementioned computation method are reported in Table 3.1, whereas Figure.3.1 shows the optimized structure of tBAPC. From the computed data taken, the maximum bond length ( $\sim 1.54\text{Å}$ ) is observed at  $C - C$  bonds and minimum bond length ( $\sim 1.09\text{Å}$ ) is observed at  $C - H$  bonds which are in good agreement with the reported values. The  $C_{25} = O_{26}$  bond length  $1.21\text{Å}$  is shortened when compared with  $C_{25} - O_{27}$  this is due to the presence of stable double bond.  $N_1 = N_2 = N_3$  of the azide possess the maximum bond angle value of  $174.01\text{Å}$  which clearly indicates the non-linear asymmetric chain structure of the raft polymer. The structure is optimized in the view of minimizing the energy of a molecule by iteratively modifying its structure to attain stability.

**Table 3.1.** The optimized geometric parameters of tBAPC

Bond Length	( $\text{Å}$ )	Bond angle	( $\text{Å}$ )
all ( $C - C$ )	$\sim 1.54$	$N_1 = N_2 = N_3$	174.014
all ( $C - H$ )	$\sim 1.09$	$C_{10} - N_{15} - C_{14}$	117.022
$C_{25} = O_{26}$	1.218	$O_{26} = C_{25} - O_{27}$	124.183
$C_{25} - O_{27}$	1.361	$N_{15} - C_{25} = O_{26}$	124.209
$N_1 = N_2$	1.136	$N_{15} - C_{25} - O_{27}$	111.607
$N_2 = N_3$	1.227	$N_{15} - C_{10} - C_{11}$	106.561
$N_3 - C_4$	1.485	Dihedral Angle	( $\text{Å}$ )
$C_{14} - N_{15}$	1.467	$C_7 - C_{10} - N_{15} - C_{25}$	104.30

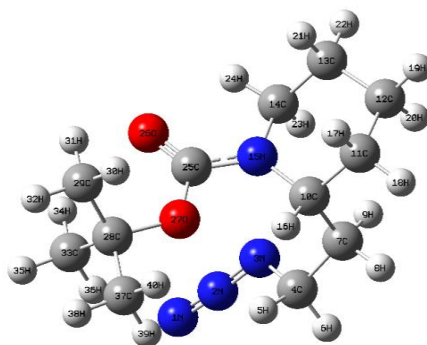


Figure 3.1 Optimized Molecular Structure of tBAPC

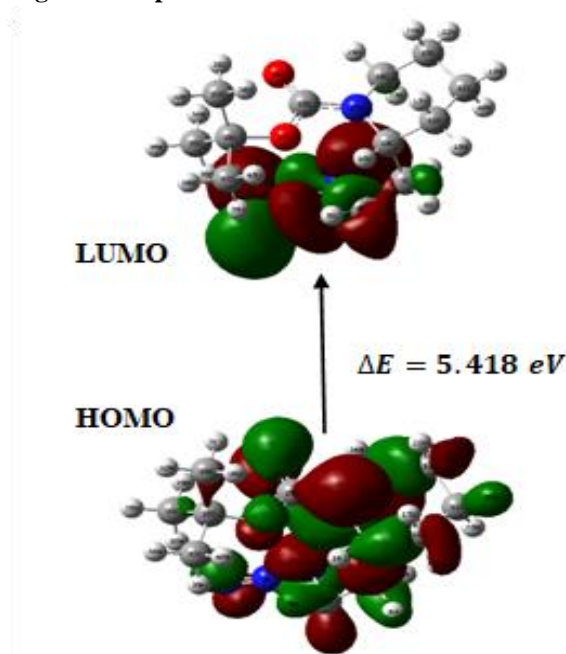


Figure 3.2 Frontier Molecular Orbitals of tBAPC

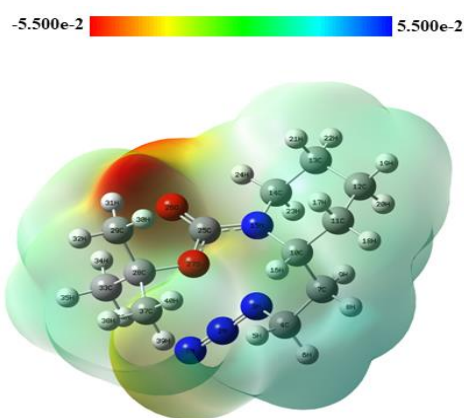
### 3.2 Frontier Molecular Orbital Analysis

The Frontier molecular orbital energy gap helps to characterize the chemical reactivity and kinetic stability of the molecule. The band gap energy of one electron excitation from HOMO to LUMO is calculated to be 5.418eV. Since the compound has high band gap energy, it is more stable and less reactive hence termed as hard molecule. From figure 3.2, the HOMO of tBAPC presents a charge density localized over the azidoethyl group and the carboxylic group together with the charges from the ring. However, LUMO is characterized by a charge distribution over the azidoethyl group. Also, with the aid of Homo-Lumo values,

global reactivity descriptors were found and are tabulated in Table 3.2. The electrophilicity index greater than 1.5 shows that the headline compound is biologically active.

**Table 3.2.** Calculated energy values of tBAPC

Parameters	Gas
HOMO	-6.468
LUMO	-1.050
Energy Gap (eV)	5.418
Ionization Potential (IP)	6.461
Electron Affinity (EA)	1.050
Global Hardness ( $\eta$ )	2.706
Chemical Softness (S)	0.370
Chemical Potential ( $\mu$ )	-3.759
Electronegativity ( $\chi$ )	3.759
Electrophilicity ( $\omega$ )	2.611



**Figure 3.3** Molecular Electrostatic Potential plot of tBAPC

### 3.3 Molecular Electrostatic Potential

The MEP provides a visual method to understand the relative polarization of molecule. Such surfaces depict the size, shape, charge density and site of chemical reactivity of the molecules. Molecular electrostatic potential surface of tBAPC is shown in Figure 3.3, from which it is concluded that the highest electronegative oxygen atom in the carboxylic group behaves as the electrophile region, the yellow shades observed over the nitrogen atom of the azidoethyl group behaves as partially negative and partially positive electrostatic potentials and the hydrogen atom behaves as the nucleophile region. These regions give information about intermolecular interactions.

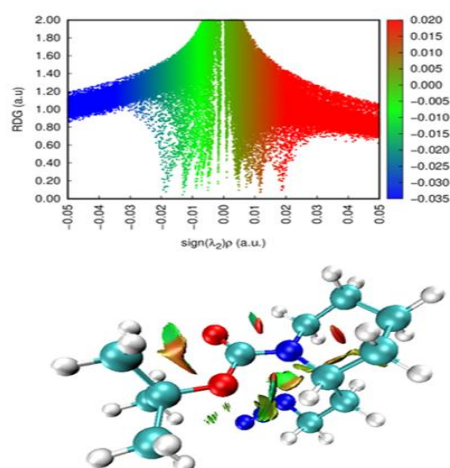
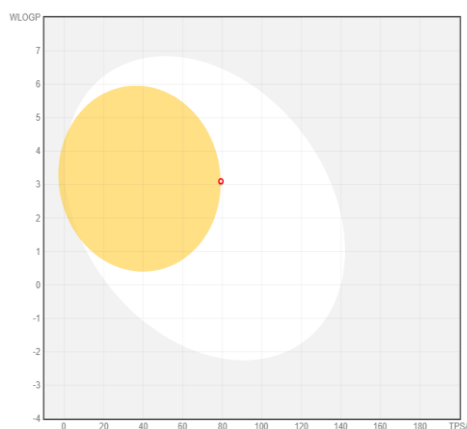


figure 3.4 2D Scatter Plot and Isosurface Density Plot of tBAPC

### 3.4 RDG Analysis

RDG approach is a topological tool which reveals non-covalent interactions such as van der Waals, hydrogen bonds and steric clashes. 2D scatter plot and the 3D RDG isosurface density plot of tBAPC are depicted in Figure 3.4. Flaky patches in green colour located close to the nitrogen and hydrogen atoms suggest the presence of weak Van Der Waals interactions which are indicative of non-covalent H-H interactions. Stronger attractive interactions, corresponding to hydrogen bonds, are indicated by a blue colour patch. Weak intramolecular hydrogen bonding observed between  $H_{16} \dots O_{27}$  and  $H_{24} \dots O_{26}$  are evidenced by blue spikes seen between them.

### 3. Pharmacokinetic Properties



**Figure 3.5 Boiled Egg Plot for tBAPC**

A drug likeness insight into the compound's potential as a drug candidate in accordance with the Lipinski's RO5 shows tBAPC has good pharmacological application in drug design. In addition, the compound's gastrointestinal absorption and effectiveness in BBB permeability were forecasted using boiled egg model. Figure 3.5 illustrates the Boiled Egg model. Based on comparative analysis taken for five different compounds that has structural groups that are analogous to those found in tBACP, it is well concluded that the presence of azidoethyl group makes the compound resistant to BBB permeation which reduces CNS related side effects. Thus, this compound is a better suit for targeting peripheral organs or tissues rather than CNS and can be used for treating conditions outside CNS.

While determining the pharmacokinetic properties of tBAPC, the compound shows good intestinal absorption (89.46%) and low excretion value that implies improved drug retention in the body and possess no toxicity. The calculated data of lipophilicity and ADMET properties go well within the desired range. Thus, the compound possess good oral bioavailability.

#### **Conclusion**

The present study employed DFT computational methods to investigate the structural, chemical, and electronic properties of tBAPC. These techniques included Geometric Optimization, Frontier Molecular Orbital Analysis, Molecular Electrostatic Potential and RDG analysis. From the aforementioned studies, I draw a conclusion that the molecule is stable, non-toxic, and active biologically. The MEP plot indicates that the electron-withdrawing action of two oxygen atoms causes the carbon atom C25 to have a positive

charge which determines the effective deprotonation of carbonyl groups that makes the compound significant in drug receptor interactions. The weak intramolecular hydrogen bonding observed between H16...O27 and H24...O26 are evidenced in RDG analysis by blue spikes seen between them, enhance the compound's ability to bind to specific targets making it more effective as a drug or bioactive molecules. The pharmacokinetic properties foretell that the compound has good oral bioavailability and can be used for treating conditions outside Central Nervous System disorder.

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## **Structural Conformations, Reactive Parameters and Molecular Docking on 3-(3-(4-Chlorophenyl)-1-phenyl-1H-pyrazol-4-yl)-5-ethoxy-4H-1,2,4- triazole – Adenosine agent.**

**M.B. Arthina Titlin<sup>1,3\*</sup>, T.R. Beena<sup>2,3</sup>**

<sup>1</sup>*Reg. No: 19213162132034, Research Scholar, Department of Physics & Research Center, Scott Christian College (Autonomous), Nagercoil – 629003.*

<sup>2</sup>*Assistant Professor, Department of Physics & Research Center, Scott Christian College (Autonomous), Nagercoil -3, Affiliated to Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, INDIA.  
Email: [arthinatitlin@gmail.com](mailto:arthinatitlin@gmail.com)*

### **Abstract**

A theoretical density functional theory (DFT) simulation was performed on the title chemical to predict its structural features, conduct frequency analysis, and determine electronic parameters. In global reactive parameters, solvents significantly altered the molecule's characteristics and behaviors, gas and water have high electrophilicity index, which triggers their biological activity. In addition, we assessed the molecule's biological activity by performing molecular docking with an adenosine receptor. The protein 1Y56, which inhibits the replication of adenosine, exhibits the highest binding affinity (-7.10 kcal/mol) and engages with other molecules mostly through non-covalent interactions. According to Lipinski's rule of five, the utilisation of an amount of chemicals that is equivalent to the size of a tablet is generally considered to be safe.

**Keywords:** FMO, DFT, Molecular Docking and Solvent.

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### **Introduction**

The nervous system, blood circulation, respiratory, renal, and immune systems all include adenosine receptors (ARs) (Raugei et al. 2006). Adenosine is the physiological stimulator for these receptors outside of cells. 3-(3-(4-Chlorophenyl)(1-phenyl-1H-pyrazol-4-yl)-5-ethoxy-4H-1,2,4-triazole is a mixture of methanol, semicarbazide (2.0 mmol), and pyrazolecarbaldehyde (2.0 mmol). The chloro-substituted phenyl ring and pyrazole derivatives are utilised as analgesics, antipyretics, and in the respiratory, renal, and immune systems. DFT simulations are exceedingly advantageous in the evaluation of various chemical attributes, as per quantum-mechanical principles (Mennucci B 2012). In recent years, the development and research of therapeutics have been substantially influenced by theoretical computation (DFT), spectroscopy, and modelling. It is a computational method that is employed in the delivery of medications to improve the comprehension, design, and improvement of medicinal molecules and applications (Muthu et al. 2014). To the best of our

knowledge, the title chemical has never been the subject of a DFT calculation or spectroscopy research. The present study aims to conduct a comprehensive analysis of the stability of the compound by utilising in conjunction with structural and biological characterisation. Furthermore, the global reactor descriptor was calculated for a variety of solvents, and HOMO-LUMO analysis was conducted. Furthermore, molecular docking with two separate protein targets implicated in suppressing adenogenic growth was performed.

### **Literature Review**

An important part of every scientific study is reviewing the relevant literature to get a sense of the topic's history, present state of knowledge, and the contributions of other researchers. Maccari et al. have reported the use of computational methods in the design of antimicrobial compounds and discussed about the various computational tools available for the design of new drugs including DFT calculations. They have also highlighted the importance of understanding the electronic and molecular properties of potential drug candidates (Giuseppe Maccari et al. 2015). Fleming has reported that Frontier molecular orbital (FMO) provides information about the electronic properties of molecules (Fleming 1976). Various authors have reported on the electron-ating behaviour of the highest occupied molecular orbital (HOMO) and electron-accepting character of the lowest unoccupied molecular orbital (LUMO) (Chaitanya 2012).

### **Computational details**

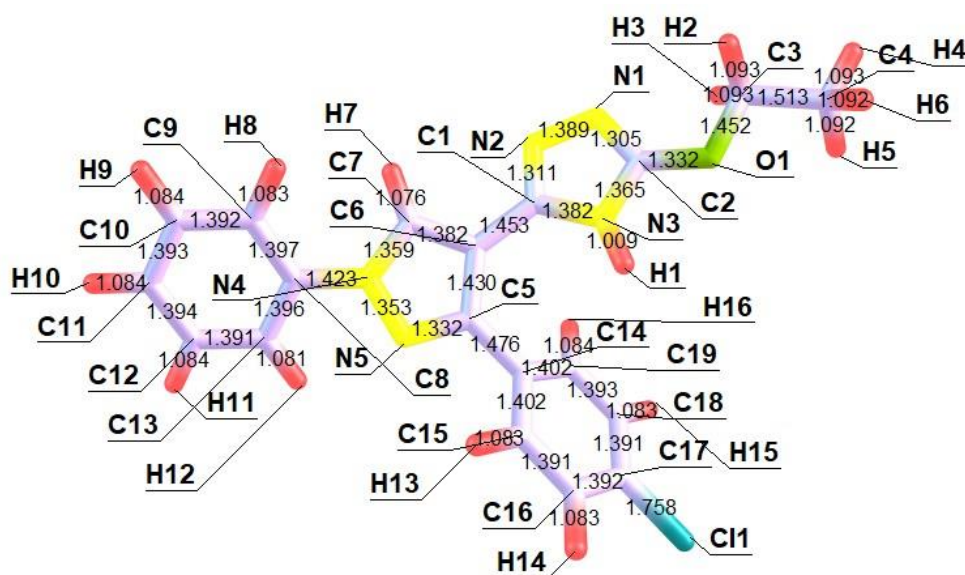
The theoretical computation of title compound has been conducted from DFT/B3LYP/6-311G(d,p) basic level set by Gaussian software (Frisch 2009) . The frontiers molecular orbital (HOMO LUMO), and optimized geometry were calculated and visually viewed and animated by GaussView 6.0 software (Dennington et al.2016). The RCSB protein library was provided to figure out the 3D crystalline layout of a protein receptor for docking investigation.

### **Results and discussion**

#### **Geometrical structure**

The title compound's optimal molecular arrangement was implemented in the DFT simulation through incorporating BL and BA (bond length and bond angle). Figure 1 illustrates the optimal atomic configuration. CCH and OCH angles have been determined to be 109.5 to 129.09° and 107.42 to 108.38°, respectively. Consequently, the OC bond lengths are approximately 1.355 and 1.422. NC bond's length was determined to be 1.30 to 1.311Å,

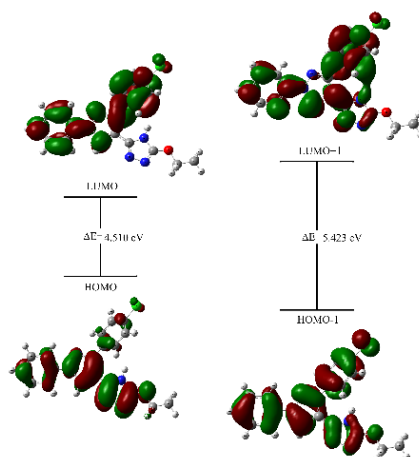
while the corresponding angles of the NCH and NCN were 111.32 to 123.89°, respectively. CCC dihedral angles have been identified and found to be between 104 and 130 degrees, while the C-C BL ranged from 1.305 to 1.42 degrees. The expected CCH angles were 109.42 and 111°, respectively, and the estimated lengths of the CH bonds were calculated to be within 1.082 and 1.092 Å. The C1-C2 BL is longer than other C-C bonding values due to the presence of an electronegative oxygen atom.



**Figure 1. Optimized molecular structure of title compound in gas phase.**

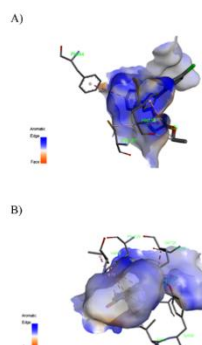
### Homo Lumo Analysis

HOMO-LUMO energies or a bandgap illustrates a number of quantum chemical characteristics (QCDs). These QCDs are essential for revealing the chemical reactivity and behaviour of substances (Rizwana et al. 2020). The HOMO-LUMO plot is illustrated in Figure 2. The elements are neutral due to their favourable ionisation potential of 6.2015 eV. Gas and water exhibited the lowest softness (0.427 eV) among the solvents DMF, DMSO, ethanol, gas, benzylalcohol, and TFE. Chloroform has the lowest electron affinity (0.9856 eV), while gas and water have the maximum IP (6.2015 eV).



**Figure 2. FMO at different phases**

### Molecular Docking



**Figure 3. 3D plot of docked ligand and protein**

The molecular-docking strategy has become a prominent method for investigating the connection between pharmaceutical innovation and structures and functions (Mishma et al. 2023). The biological effects of the label molecule were predicted by the PASS online instrument, which utilised an optimised structure in SMILES format (Druzhilovskiy et al. 2017). This methodology is recognised for its ability to generate outcomes that are exceedingly precise. The binding energy and location of the ligand, as well as the ligands, can be ascertained. The docking interactions between proteins and the selected ligand are depicted in Figures 3, which designate the configurations with the smallest binding energies as the best-docked. We utilised the RCSBs protein to generate the adenosine target proteins, 1Y56 and 3VC1. Proteins 1Y56 and 3VC1 demonstrated substantial docking responses, with binding energies of -7.10 and -5.18 kcal/mol, respectively. The prescription substance is included in (PDB-1Y56), which has the highest binding value (-7.10 kcal/mol) and numerous

connections. Two hydrogen atoms Protein residues have been identified as interacting. The functional group H-N-H in 3VC1 and interactions between TYR693 and GLN729 have been identified. The bound residues, inhibition constants, binding energies, reference RMSD values and bond lengths are all included in Table1.

**Table 1. The interaction energy analysis of title compound with targeted protein**

Properties	Protein (PDB ID)	Residue	Bond distance (Å)	Inhibiton Constant (micromolar)	Binding Energy (kcal/mol)	RMSD
Adenosine receptors	1Y56	TYR693	5.06	59.08	-7.10	22.64
		GLN729	2.86			
		ALA243	3.06			
		HIS119	4.52			
		PHE443	5.50			
		CYS121	4.24			
	3VC1	VAL678	5.60	42.23	-5.18	29.15
		PHE729	4.70			
		GLN726	1.18			
		TYR693	2.72			
		LLE692	5.82			
		TYR843	2.73			

### Conclusion

Based on the analysis of the differences between the calculated and observed experimental geometrical characteristics, it seems that every bond showed a satisfactory agreement. The high chemical stability and low reactivity of are demonstrated by the 4.510 eV band gap observed in the gas phase between HOMO and LUMO. This work illustrates the pharmacological characteristics of bioactive in a clear and concise manner by focusing on the interactions and binding affinities that are formed between the title compound and the selected proteins.

### Acknowledgment

The authors express their sincere appreciation to the Researchers Supporting Project number (RSPD2024R679), King Saud University, Riyadh, Saudi Arabia.

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## Efficient Photocatalytic Breakdown of Congo Red Using Cobalt-Terephthalate MOFs

S. Sabadini, Y. Christabel Shaji\*

*Department of Chemistry, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [sabadini2000@gmail.com](mailto:sabadini2000@gmail.com)*

### Abstract

Metal-organic frameworks (MOFs), an emerging class of porous crystalline materials, have become a significant focus in materials research. These structures seamlessly integrate metal ions and organic ligands to form a three-dimensional network characterized by a large surface area and versatile functionality. Recently, MOFs have gained attention for their remarkable adaptability and broad range of applications, including gas storage, catalysis, sensing, drug delivery, and more. Notable features of MOFs include their large surface area, flexibility, and well-ordered porous structure. In this study, we present the hydrothermal synthesis of a non-toxic Cobalt-based MOF in a Teflon autoclave, utilizing DMF as a solvent and terephthalic acid as a linker. The synthesized MOFs were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM) with energy-dispersive X-ray spectroscopy (EDX), Fourier transform infrared (FT-IR) spectroscopy, and ultraviolet (UV) spectroscopy. The proposed mechanism for the photocatalytic degradation of the Co-based MOF under UV light involves electron transfer from the photoexcited organic ligand to the metallic clusters. We investigated the degradation process through a series of characterization techniques. The results indicate that Congo Red can be effectively degraded in the presence of the cobalt-based MOF, suggesting its potential as a valuable catalyst for environmental remediation.

**Keywords** Co-based MOFs, Teflon autoclave, Solvothermal method, Photocatalyst

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### Introduction

Metal-organic frameworks (MOFs), also known as porous coordination polymers (PCPs), are composed of inorganic nodes connected by organic linkers. These materials exhibit high porosity, diverse compositions, and customizable pore structures, making them highly promising. Their unique properties have garnered significant interest across various fields, including gas adsorption and separation, catalysis, luminescence, sensing, biomedicine, and energy. [1] MOFs have been applied in many different fields, but two very interesting ones where they have demonstrated their usefulness are in the photocatalytic degradation of dyes. The dual functioning of MOFs demonstrates their flexibility and versatility, as they effectively bridge the environmental remediation domains [2]. Due to their

inherent catalytic activity, the synthesized Co-based MOFs are highly suitable for the photocatalytic degradation of Congo Red. Their unique catalytic properties and tailored architectures make Cobalt-MOFs promising candidates for this purpose. MOFs can harness light energy for environmental cleanup through photocatalysis. The active sites within MOFs can initiate photochemical reactions upon light exposure, making them effective in breaking down organic pollutants, including various dyes. [3]. This study synthesises and characterises cobalt-based MOF using a variety of methods, then examines its potential for photocatalytic destruction of Congo Red.

## **Materials and Methods**

### **Chemicals required**

Cobalt (II)nitrate hexahydrate  $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ , terephthalic acid (1,4-benzene dicarboxylic acid), dimethyl formamide (DMF), and Congo Red are the ingredients and reagents utilised in the production of metal organic frameworks. Each and every reagent was analytical grade.

### **Synthesis of Co-based MOFs**

Based on the synthesis procedure, the Teflon Autoclave was used to produce the metal organic framework using a hydrothermal approach. 1g of terephthalic acid and  $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$  was dissolved in about 20 mL of DMF. After that, the mixture was transferred to a 100 ml Teflon flask and placed inside a reactor that was heated to 180°C for 18 hours. After that, the dried precipitate was repeatedly washed to remove impurities.

### **Preparation of Congo Red dye solution**

The Congo Red (CV) solution was prepared by dissolving 0.0479 grams of CV in a 100 mL Standard Measuring Flask (SMF). From this 100 mL solution, 1 mL was withdrawn and then further diluted in a 100 mL SMF, resulting in a final Congo Red solution with a concentration of 0.01 millimoles per millilitre.

### **Characterization**

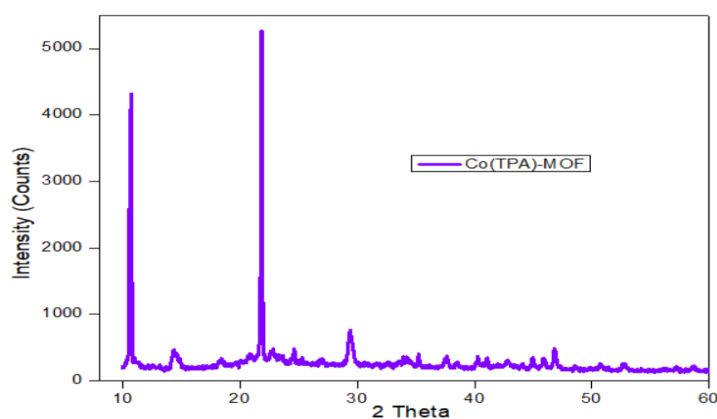
Several techniques were employed for the characterisation of Co-based MOF. Firstly, XRD analysis utilising the Debye Scherrer formula was utilised to determine the phase purity and crystal structure of samples. The XPERT-PRO diffractometer system, which uses  $\text{CuK}\alpha$  radiation (1.5406 Å) for automated data capture, is used for X-ray diffraction. Using the SEM device, the materials' particle morphology was examined. Ni-based MOF synthesis and characterisation for photocatalytic degradation. By using energy dispersive X-ray



microanalysis (EDS), Congo Red and element composition analysis are performed. The adsorbate model of the BJH/DH technique was employed to quantify the N<sub>2</sub> adsorption/desorption of certain surface areas and sample pore sizes. Prior to measurement, the samples were degassed for 3.5 hours at 180°C in a vacuum. The SHIMADZU IR Affinity-1 Fourier infrared spectrometer (FT-IR), which has a wave number range of 4000 ~ 400 cm<sup>-1</sup>, was used to measure the functional groups of the substance. The Shimadzu UV-1700 UV/VIS Spectrometer was used to detect the dye concentration during the degradation process.

## Result and Discussion

### XRD Analysis



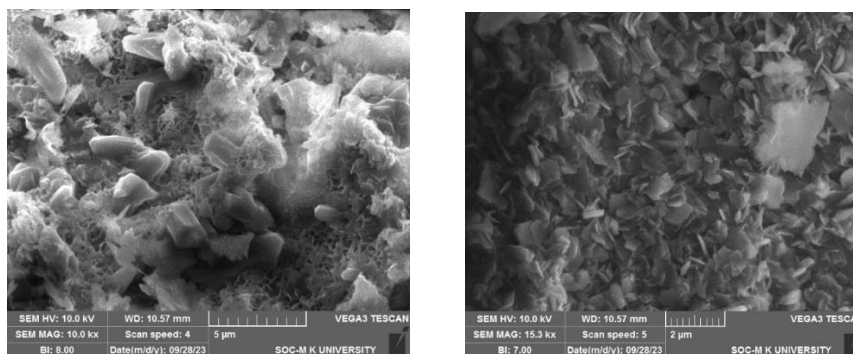
**Fig. 1 XRD spectrum of synthesized Co-MOF (TPA)**

The produced material's purity, crystallinity, and crystal structure were assessed using the single crystal XRD method. The diffraction peaks that were found are consistent with previous research [4]. Excellent crystallinity was demonstrated by the prepared sample, as indicated by the crisp and strong diffraction peaks. Additionally, the crystallite size was calculated using the Debye-Scherrer equation and the following equation:

$$D = K\lambda/\beta\cos\theta,$$

where D, k,  $\lambda$ ,  $\beta$  and  $\theta$  corresponds to size of the crystallite, constant, X-ray wavelength, FWHM value and diffraction angle, respectively.[5] Hence, the average crystallite size of synthesized Co-MOF is 28 nm and suggested that the Co-MOF is microcrystalline nature.

## SEM Analysis



**Fig. 2 SEM image of synthesized Co-MOF (TPA)**

Scanning electron microscope (SEM) was used to analyse the surface morphology of the synthesized Co-MOF. The average crystalline size an average crystalline size of 5-40 $\mu$ m.

## Energy Dispersive X-Ray Analysis (EDX)

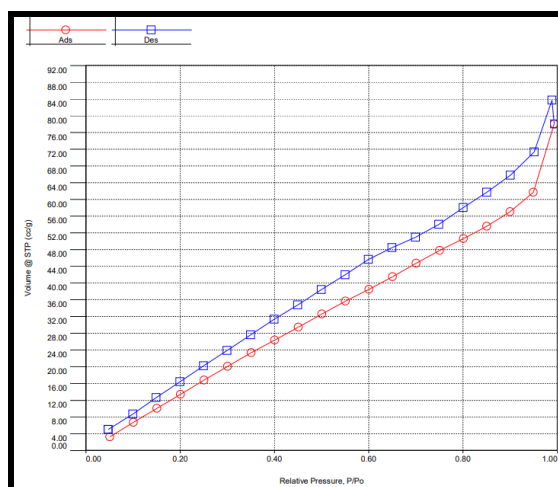
The chemical elements and their concentrations in the sample were determined using EDX analysis. The even distribution of cobalt in the framework is depicted in the related EDAX elemental mapping, indicating that the cobalt ion may likewise be favourably bonded in the framework. 29% of N, 28.73% of O, 35.58% of C, and 24.60% of Co were found in the elemental dot mapping of a chosen location. The lack of contaminants was demonstrated by the findings, indicating the MOF's purity.

## BET surface area

**Table 1.** Specific surface area and pore size of Co-MOF (TPA)

Sample	Specific surface area ( $\text{m}^2 \text{g}^{-1}$ )	Pore Size (nm)
Co-MOF (TPA)	44.758	2.8

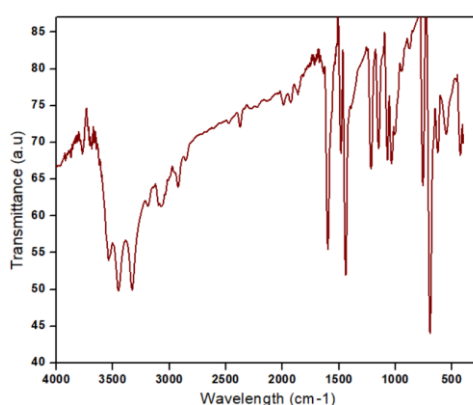
The synthesized Co-MOF materials were degassed at 180 $^{\circ}$ C for 3 hours before the BET measurement. The BET results are summarized in Table 1. The results show that the micro-flower structure's specific surface area of Co-MOF (TPA) was 44.758  $\text{m}^2 \text{g}^{-1}$  with a pore size of 2.8 nm. It was proved with the SEM image of Co -MOF that the micro flower like structure had the highest specific surface area.



**Fig. 3 Adsorption isotherm for nitrogen in Co-MOF at 77K**

### FT-IR Spectra

The synthetic Cobalt-MOF's FT-IR spectra reveal absorption bands at 3545, 3163, 3012, 2964, 2853, 1597, 1248, 1362, and 1239  $\text{cm}^{-1}$ , in that order. The carboxylic acid's (TPA) free OH stretching is the cause of the band at 3545  $\text{cm}^{-1}$ . The Dimethyl formamide group's C=C and C-N bond stretching is what causes the strong band at 1597  $\text{cm}^{-1}$ . The COOH group's C=O stretching is the cause of the band at 1248  $\text{cm}^{-1}$  (TPA). The COOH group's C=O stretching is the cause of the band at 1248  $\text{cm}^{-1}$  (TPA). The COO-asymmetric stretching in the COOH group (TPA) is responsible for the strong band at 1597  $\text{cm}^{-1}$ . [6-7]

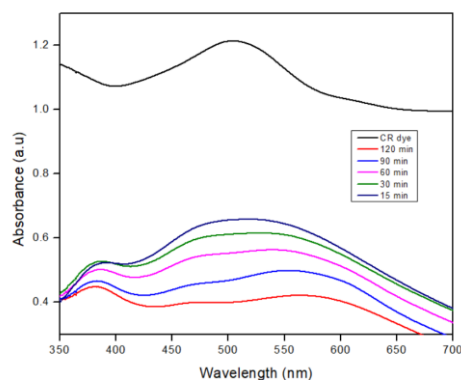


**Fig. 4 FT-IR spectrum of Co-MOF (TPA)**

### Photocatalytic degradation of Congo Red

Under UV radiation, studies are carried out to see how Congo Red degrades with and without MOF. At regular intervals, a 25 ml aliquot is removed from the reaction mixture, and

the absorbance is measured spectrophotometrically at 504 nm. At concentrations of 0.025g of Co-MOF, the synthesised Co-MOF demonstrates remarkable UV light absorption along with enhanced photocatalytic degradation of Congo Red. The absorbance of the solution decreases with increasing time intervals, indicating that the dye concentration decreases with increasing exposure time. By monitoring the dye's absorption, the Co-MOF that breaks down the dye has been verified. When 0.025g of Co-MOF is used, the degradation efficiency of Congo Red is 80.72%. The dissimilarity in their molecular structures accounts for the higher degradation efficiency of Congo Red. Congo Red is more prone to deterioration than Brilliant Yellow because of its more complicated structure [8]



**Fig. 5. UV-Vis spectra of Congo Red degradation**

## Conclusion

In conclusion, this study used the solvothermal approach to effectively synthesise a non-toxic Co-based metal-organic framework (MOF) employing terephthalic acid as a linker and DMF as a solvent. Analysis of the synthesised MOFs with structural durability was done using XRD, SEM with EDX, BET, FT-IR, and UV. With an approximate 80.72% degradation efficiency, co-based MOF was investigated for the degradation of Congo Red under UV light irradiation. The study that is being presented opens up new possibilities for the investigation and development of these adaptable materials while also providing insightful information on the use of MOFs in photocatalysis.

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## Anti-Diabetic Activity of Chelating Bis N- Propylethylenediamine Zinc Complex

<sup>1</sup>M. Jaya Brabha and <sup>2</sup>Dr. M. Anitha Malbi\*

<sup>1</sup> M. Jaya Brabha, Assistant Professor, Department of Chemistry, Annai Velankanni College, Tholayavattam,  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli, Tamil Nadu, India

<sup>2</sup>Assistant Professor, Department of Chemistry, Holy Cross College, Nagercoil, Affiliated to Manonmaniam  
Sundaranar University, Tirunelveli, Tamil Nadu, India.

Email: [vasanthdony@gmail.com](mailto:vasanthdony@gmail.com), [anithamalbi@holycrossngl.edu](mailto:anithamalbi@holycrossngl.edu)

### Abstract

Metals are an integral part of many structural and functional components in the body, and the critical role of metals in physiological and pathological processes has always been of interest to researchers. Metals have been used in the treatment of diseases of humans since ancient time. The primary objective of the study is, to describe anti-diabetic activity by bis N-propylethylenediamine zinc (II) complex. The synthesised complex is characterised by elemental analysis, UV visible spectra of ligand and synthesized complex, FTIR, powder X-ray diffraction and EDAX. Stability of the complex is determined by TGA & DTA. Anti-Diabetic activity is studied by invitro alpha glucosidase and alpha amylase assay.

**Keywords:** Chelate complex, Charge Transfer Transition, Thermal analysis, Co-ordination Compound, Alpha glucosidase and Alpha amylase.

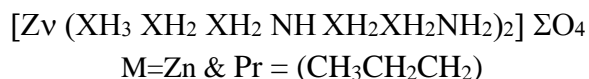
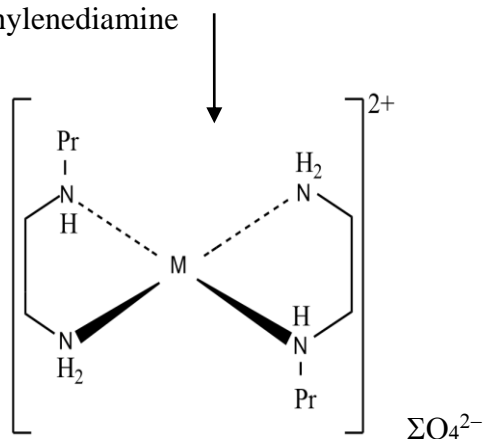
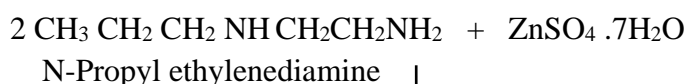
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### Introduction

The average human body contains 3 g of zinc, which makes it the second most abundant trace element in the body after iron. Zinc is the only metal that appears in all enzyme classes. It is mainly distributed in the blood, kidney, liver and bone. Studies have shown that Zn(II) has important antibacterial and antiviral effects, and high zinc ion concentrations may have some antibacterial properties [1]. Metal ions are necessary for many important operation in humans and some diseases are caused due to deficiency of metal ions. Iron deficiency might result in pernicious anemia. Zinc deficiency causes growth retardation, copper deficiency leads to heart disease in infants. A fundamental aspect of medicinal bioinorganic chemistry is to notice and interpret at the level of molecular of the diseases, initiated by unsatisfactory in function metal-ion. Especially chelating complexes are used as the scavengers of heavy metal ions [2]. This present study is aimed to synthesis and identifies the efficiency of chelating complex. This activity of transition metals has started the development of metal based drugs with promising pharmacological application and may offer unique therapeutic opportunities

## Materials and Methods

The chelating complex bis N-propylethylenediamine Zn (II) was prepared from zinc sulphate hepta hydrate and N-propylethylenediamine. 2 mM aqueous solution of metal salt was taken in a beaker and 6 mM of N-propylethylenediamine was added drop by drop. With order to get proper mixing continuous stirring for an hour, 2 ml of ethyl alcohol was added for complete precipitation then transferred into a Petri dish to remove solvent in hot air oven at 45°C. After 3 days, white-coloured bis N-propylethylenediamine Zn (II) complex was formed. [3]



## Results and Discussion

### Elemental Analysis

The empirical formula and possible geometry of the complex is confirmed by elemental analysis. The analytical data (**Table.1**) suggest that the chelating complex is mono nuclear with the ligand coordinated to the central metal atom. The metal to ligand ratio of N-propylethylenediamine zinc (II) complex is 1:2 with empirical formula ZnN<sub>4</sub>C<sub>10</sub>H<sub>28</sub>SO<sub>4</sub>. The N-propyl ethylenediamine Zn (II) complex exhibits as square planar complex.

The molar conductivities for the complex is measured in deionised water. Electrolytic nature of the metal complex is confirmed by their higher conductance values in deionised water. The presence of the sulphate ion outside of the coordination sphere confirms that the ligand neutral and support the low conductance value of the complex. It is a good agreement with those reported for similar complexes. The physical parameters and percentage of C, H,

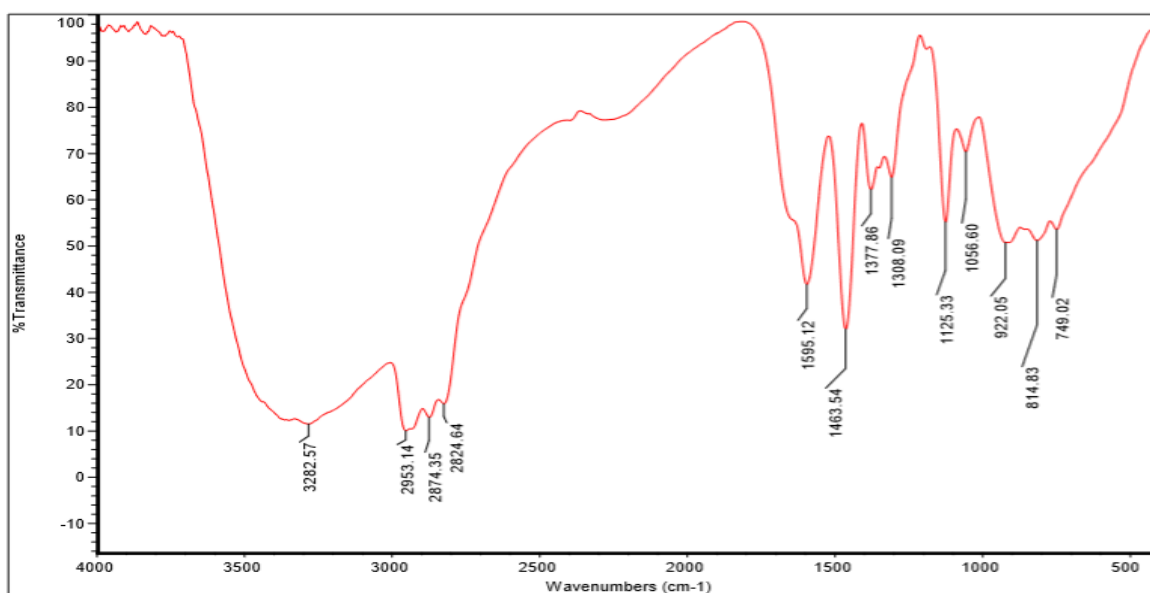
N & S are given in **Table.1** The observed and calculated values of the percentage of elements are well agreed with each other. [4]

**Table.1 Elemental Analysis and physical parameters**

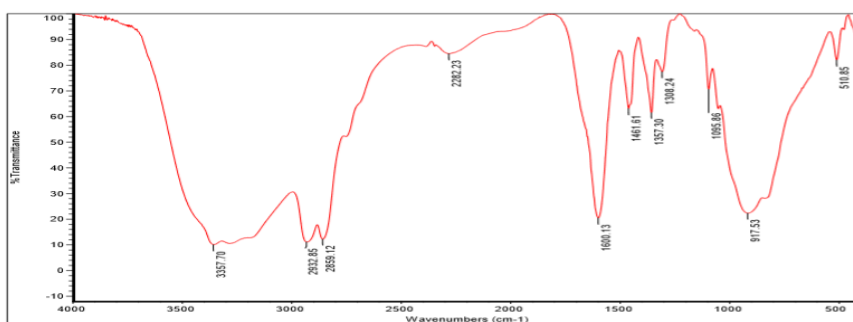
Complex	Molecular Weight	Colour	pH	Molar Conductance	C % Obs. (Cal)	H % Obs. (Cal)	N % Obs. (Cal)	S % Obs. (Cal)
ZnN <sub>4</sub> C <sub>10</sub> H <sub>28</sub> SO <sub>4</sub>	365.85	White	8.43	70.6	32.80 (32.83)	7.68 (7.73)	15.31 (15.35)	9.78 (8.76)

### FT-IR Spectroscopy

In order to study the bonding of the ligand to the metal, the infrared spectrum of the ligands compared with spectra of the corresponding metal chelates. The infrared spectra provide valuable information regarding the nature of the bonding attached to the metal ion. [6]



**Fig.1. FT-IR Spectrum of N-propyl ethylenediamine (Ligand)**



**Fig.2. FT-IR Spectrum of [Zn (pren)<sub>2</sub>]<sup>2+</sup> Complex**



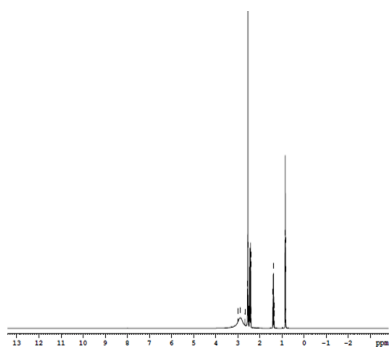
The ligand N-propylethylenediamine (**Fig.3 & 4**) exhibits N-H stretching frequency at 3287  $\text{cm}^{-1}$ , the aliphatic amine of C-H stretching frequency at 2953  $\text{cm}^{-1}$  and C-N stretching frequency at 1377  $\text{cm}^{-1}$ . The chelating bis N-propylethylenediamine Zn (II) complex shows that, (**Table 2**) the N-H stretching frequency at 3308  $\text{cm}^{-1}$ , the aliphatic amine of C-H stretching frequency at 2932  $\text{cm}^{-1}$  and C-N stretching frequency at 1357  $\text{cm}^{-1}$  and M-N stretching frequency at 510  $\text{cm}^{-1}$ . The free ligand with stretching frequency is greater than the corresponding metal complex. It is due to the electron flow from the ligand to the metal (CTT). The stretching frequency  $\nu_{\text{C-N}}$  constantly decreases in the metal complex compared with free N-propylethylenediamine. It is evident that the ligand surely co-ordinated with the ligand. [5]

**Table 2 Vibrational Frequencies of Ligand (pren) and Complexes**

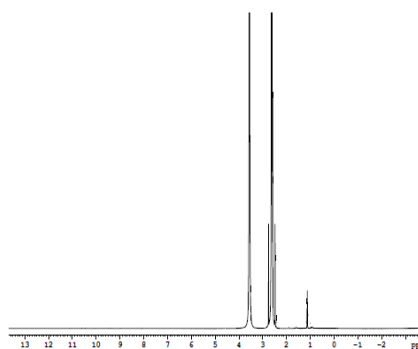
Ligand & Compound	Stretching $\nu_{\text{C-H}}$	Stretching $\nu_{\text{N-H}}$	Stretching $\nu_{\text{C-N}}$	Stretching $\nu_{\text{M-N}}$
$\text{CH}_3\text{CH}_2\text{CH}_2\text{NHCH}_2\text{CH}_2\text{NH}_2$	2953	3287	1377	-
$[\text{Zn}(\text{pren})_2]^{2+}$	2932	3357	1308	510

### **<sup>1</sup>H Nmr Spectroscopy**

The <sup>1</sup>H NMR spectrum of ligands and Zn complexes (**Fig.3 & 4**) are recorded. Deuterated DMSO is used as solvent. The -CH<sub>3</sub>, -CH<sub>2</sub>- ( $\beta$  to N), -CH<sub>2</sub>- ( $\alpha$  to N) proton of N-propylethylenediamine and  $[\text{Zn}(\text{pren})_2]^{2+}$  are  $\delta$  0.8 ppm,  $\delta$  1.4 ppm,  $\delta$  2.5 ppm and  $\delta$  1.1 ppm,  $\delta$  2.8 ppm, 3.7 ppm respectively. Downfield shifts of complexes in <sup>1</sup>H NMR spectra, confirms the complexation [6].



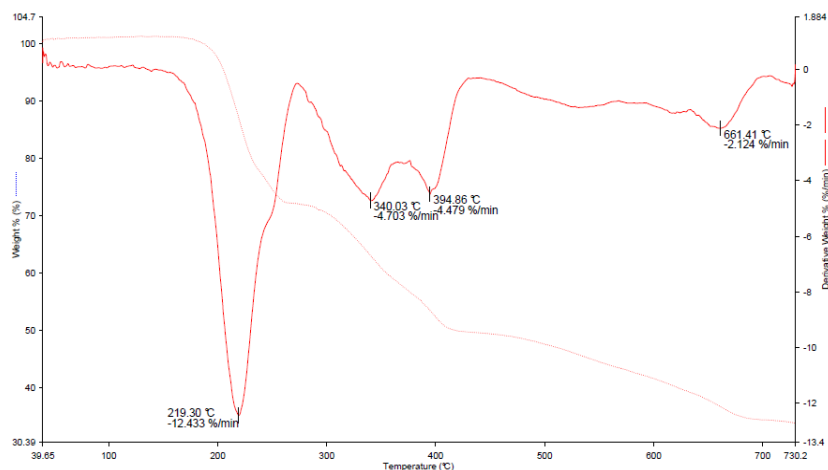
**Fig.3 pren ligand**



**Fig.4 [Zn(pren)<sub>2</sub>]<sup>2+</sup>**

## Thermal Analysis

The thermal behaviour of the synthesized chelating complexes are studied to establish different decomposition pattern and to confirm the proposed stoichiometry. The results are summarized in (Table 3)



**Fig.5. TGA &DTA Spectrum of [Zn (pren)<sub>2</sub>]<sup>2+</sup> Complex**

The chelating bis N-Propylethylenediamine zinc complex (**Fig.5**) exhibits four endothermic peaks. The complex is stable up to 218.13 °C. The ligand N-methyl ethylenediamine liberates at this temperature, by the loss of 30% weight. Upon increasing the temperature the two methylamine gets liberates at 338.87 °C and 394.86 °C, by the loss of 10% weight respectively. At 660.25°C zinc sulphate dissociate into SO<sub>3</sub> and ZnO. Above the temperature stable metal oxide is appeared. The decomposition pattern of the chelating complex confirms the proposed stoichiometry and geometry. [7]

**Table 3 TGA and DTA of chelating N-propyl ethylenediamine complexes**

Compound	Number of Endo peaks	T (°C)	Temp: Range (°C)	Wt. Loss % (Cal %)	Removed Fragments	Residue
[Zn(pren) <sub>2</sub> ] SO <sub>4</sub>	I	219.30	200-260	28(27.89)	Pren	ZnO
	II	340.03	260-380	15(16.3)	CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub>	
	III	394.86	380-450	8(8.47)	CH <sub>3</sub> NH <sub>2</sub>	
	IV	661.41	450-700	16(15.69)	SO <sub>3</sub>	

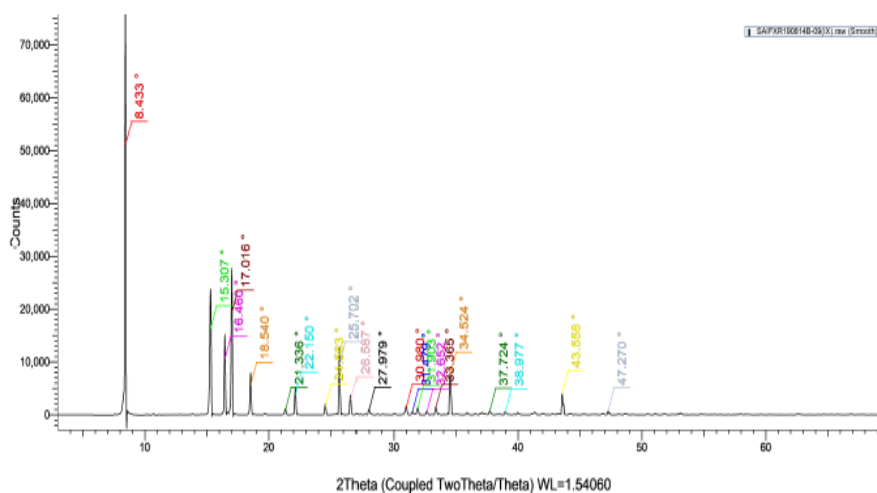
## Powder X-Ray Diffraction Study

The X-Ray diffraction method is the most powerful technique available for the examination of complex in the solid state. X-Ray diffraction is used to obtain information

about the structure and composition. Average crystalline sizes of the complex and hkl planes are given in the (Table 4)

**Table 4 XRD data of bis N-propylethylenediamine zinc complex**

Complex	2θ Angle (degree)	θ Radian	Sin θ	Sin <sup>2</sup> θ	Ratio 1	Ratio 2	M	hkl	Average particle size D
[Zn (pren) <sub>2</sub> ] <sup>2+</sup>	8.433	0.07357	0.07350	0.005402	1	2	2	110	80
	15.307	0.1335	0.1313	0.01723	3.1895	6.379	6	211	
	17.016	0.1484	0.1478	0.02184	1.2675	2.535	3	111	



**Fig.6. XRD Spectrum of [Zn (pren)<sub>2</sub>]<sup>2+</sup> Complex**

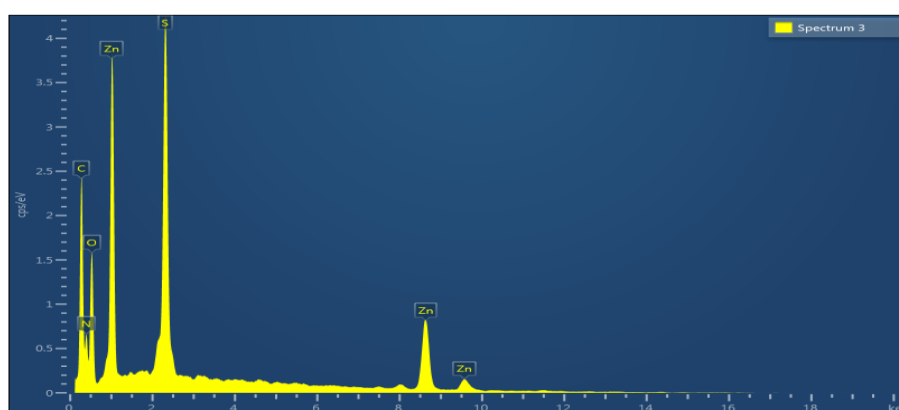
The XRD patterns of chelating bis N-propylethylenediamine Zn (II) complex is shown in (Fig.6). The chelating Zn (II) complex shows that the sharp peak at 8.433°, 15.307° and 17.016°. Which indicates the complex is high quality and polycrystalline in nature. It exhibits 100% intensity peak at 8.433°. The hkl plane of the complex is calculated by sin<sup>2</sup>θ method. The high intense peak with hkl planes are 8.433° (110), 15.307° (211) and 17.016° (111). The crystalline sizes are predicted for prominent peaks for the synthesised chelating complexes by using Debye-Scherrer's formula. The complex with average crystalline size is 80. [8]

### Energy Dispersive X-Ray Analysis

EDX Spectroscopy used for elemental identification by measuring the number and energy of x-rays emitted from a specimen after excitation with an electron beam. The elemental percentage is shown in (Table. 5). Metal complex with their elements are shown in (Fig.7).

**Table 5 EDAX Data**

Complex	Element	Weight %	Atomic %
[Zn (CH <sub>3</sub> CH <sub>2</sub> CH <sub>2</sub> NHCH <sub>2</sub> CH <sub>2</sub> NH <sub>2</sub> ) <sub>2</sub> ] SO <sub>4</sub>	C	33.26	48.17
	N	15.45	18.28
	O	23.59	24.22
	S	8.78	4.53
	Zn	18.92	4.8



**Fig.7. EDAX Spectrum of [Zn (pren)<sub>2</sub>]<sup>2+</sup> Complex**

Bis N-propylethylenediamine zinc complex exhibits the weight percentage of carbon is 33.26%. This is well agreed with the percentage of carbon obtained from CHNS analyser 32.80%. The weight percentage of nitrogen is 15.45%, which is well agreed with the percentage of nitrogen observed from CHNS analyser 15.35%. The weight percentage of sulphur is 8.78%, which is agreed with the percentage of sulphur observed from CHNS analyser 9.78%. The weight percentage of zinc is 18.92%, which is well agreed with the percentage of zinc obtained from calculated 17.87%. All these data further prove the square planar geometry of this complex. [9]

### In-vitro Anti-Diabetic Activity of Metal Complexes

Diabetes is characterized by hyperglycemia, altered lipids, carbohydrates, and proteins metabolism which affect the patient quality of life in terms of social, psychological well-being as well as physical ill health [10]. Two forms of diabetes (Types 1 and 2) differ in

their pathogenesis, but both have hyperglycemia as a common hallmark. In type 2 diabetes, hyperglycemia is caused due to impairment in insulin secretion combined with or without impairment of insulin action [11].

### **In- vitro Alpha Glucosidase Inhibition Assay**

Alpha glucosidase activity was measured by the determination of reducing sugar arise from hydrolysis of sucrose by alpha glucosidase enzyme. The effects of samples were assayed according to the method Matsui et al., with slight modifications. Acarbose drug (10mg/mL DMSO) was used as reference.

### **Procedure**

Different volumes of sample such as 12.5µL-100µL from the stock solution given were taken and was incubated for five minutes before initiating the reaction with substrates sucrose(37mM), in a final reaction mixture of 1mL of 0.1 M phosphate buffer (pH 7.2). The reaction mixture was incubated for 20 and 30 min at 37<sup>o</sup>C and the reaction was stopped incubating in a boiling water bath for 2 minutes. A tube with phosphate buffer and enzyme was maintained as control. The tubes were added with 250µL of glucose reagent and incubated for 10 minutes followed by measuring absorbance at 510nm using a micro plate reader.

### **Calculation**

$$\% \text{ inhibition} = \frac{\text{control} - \text{test}}{\text{control}} \times 100$$

**Table.6 Anti-Diabetic Data (Alpha Glucosidase Inhibition Assay)**

Sample concentration(µg/mL)	OD at 540nm	Percentage inhibition
Control	0.8714	0
<b>Sample code: Acarbose Drug</b>		
125	0.5124	42.51
250	0.4228	52.32
500	0.3442	61.20
1000	0.1956	72.86

Concentration(µL)	OD at 540nm	Percentage inhibition
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Control	0.2519	0
<b>Sample code: Zn(pren)<sub>2</sub></b>		
12.5	0.1933	23.63
25	0.1652	37.24
50	0.1143	51.45
100	0.0894	63.57

**IC50 Value- Acarbose- 269.77µg/mL(Calculated using ED50 PLUS V1.0 Software)**

**Zn- 43.3948µL(Calculated using ED50 PLUS V1.0 Software)**

### 3.11. B In vitro Alpha Amylase Inhibitory Assay

The reducing sugars produced by the action of  $\alpha$  amylase react with dinitrosalicylic acid and reduce it to a brown coloured product, nitro amino salicylic acid. Acarbose drug (10mg/mL DMSO) was used as reference.

#### Procedure

Different volumes of sample such as 12.5µL - 100µL from the stock solution given and make up to 1000µl using 25mM phosphate buffer pH 6.9, containing 25µl of porcine  $\alpha$  amylase at a concentration of 0.5 mg/ml were incubated at 25°C for 10 min. After pre incubation, 25µl of 0.5% starch solution in 25mM phosphate buffer pH 6.9 was added. The reaction mixtures were then incubated at 25°C for 10 min. The reaction was stopped with 50µl of 96mM 3, 5 dinitro salicylic acid colour reagent. The micro plate was then incubated in a boiling water bath for 5 min and cooled to room temperature. Absorbance was measured at 540nm using a microplate reader.

#### Calculation

$$\% \text{ inhibition} = \frac{\text{control} - \text{test}}{\text{control}} \times 100$$

**Table 7 Anti-Diabetic Data (Alpha Amylase Inhibition Assay)**

Concentration(µg/mL)	OD at 540nm	Percentage of inhibition
<b>Control</b>	<b>0.1150</b>	
<b>Standard: Acarbose Drug</b>		
125	0.0513	58.48
250	0.0519	60.56

500	0.0462	63.37
1000	0.0302	75.94

Concentration( $\mu$ L)	OD at 540nm	Percentage inhibition
Control	0.7916	0
<b>Sample code: Zn</b>		
12.5	0.5172	36.83
25	0.4256	47.62
50	0.2734	65.54
100	0.1262	84.79

**IC<sub>50</sub> Value: Acarbose- 111.907 $\mu$ g/mL(Calculated using ED50 PLUS V 1.0 Software)**

**Zn- 38.2118 $\mu$ L(Calculated using ED50 PLUS V 1.0 Software)**

The In vitro anti-diabetic study of metal complex is carried out by alpha glucosidase inhibition assay and alpha amylase inhibition assay. Chelating zinc complex exhibits greater anti- diabetic activity in both these assays than standard Acarbose. Zinc is a natural component of insulin, a substance crucial to the regulation of carbohydrate metabolism.

**Table. 8 IC<sub>50</sub> Values of complex**

Reference / Sample	IC <sub>50</sub> Value ( $\mu$ g/mL)	
	Alpha Glucosidase	Alpha Amylase
Acarbose Drug	209.6717	242.0614
[Zn (pren) <sub>2</sub> ] <sup>2+</sup> Complex	8.8802	55.4223

The IC<sub>50</sub> values indicate the efficiency of complex is better than the drug Acarbose (Table.8). Among the metal complex [Zn (pren)<sub>2</sub>]<sup>2+</sup> and drug, the efficiency of the complex is better.

### Conclusion

The advances in inorganic chemistry offer enhanced opportunities to use metal complexes as therapeutic agents. Metals have been used in the treatment of diseases of humans since ancient times. The empirical formula and geometry of the complexes are confirmed by elemental analysis (CHNS). [Zn(pren)<sub>2</sub>]<sup>2+</sup> complex with the percentage of C,

H, N, and S exhibit 1:2 ratio with the empirical formula  $ZnN_4C_{10}H_{28}SO_4$ . The binding of the ligand to the metal, confirms through the infrared spectroscopy. The free ligands with stretching frequencies are greater than the corresponding metal complexes. It is due to the electron flow from the ligand to the metal (CTT). The  $^1H$  NMR spectrum of ligands and Zn complex is conclude the complexation by downfield shifts of complex. The XRD patterns of all the three chelating complexes show the sharp peaks indicates the complex is high quality and polycrystalline. Anti-Diabetic Activities of chelating metal complex is determined by invitro alpha-glucosidase inhibition assay and invitro alpha-amylase inhibition assay.

The complex,  $[Zn(pren)_2]^{2+}$  exhibits greater percentage inhibition (63.57%). Zinc is a natural component of insulin, a substance crucial to the regulation of carbohydrate metabolism.

### **Acknowledgment**

I gratitude almighty God for provide good health to do research. I thank SAIF STIC, Cochin, IIT Chennai, for taking characterisation.

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## Ni(BPCA)-MOF: Dual-function as photocatalyst for Congo red degradation and Drug Delivery System for Breast cancer MDA-MB-231 cells

A.H. Hatin Betseba<sup>1</sup>, S. Ajith Sinthuja<sup>2</sup>, Y. Christabel Shaji<sup>\*3</sup>

<sup>1,2, \*3</sup> Department of Chemistry, Holy Cross College (Autonomous), Nagercoil – 629004.

Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

Email: [christabelshaji@holycrossngl.edu.in](mailto:christabelshaji@holycrossngl.edu.in)

### Abstract

Metal-organic frameworks (MOFs) have recently emerged as novel photocatalysts and drug nanocarriers owing to their unique properties such as high surface area, flexibility, well-ordered porous structure and functionality. In this paper, we report the synthesis procedure of Ni(BPCA)-MOF through a hydrothermal method using Nickel as metal ions, biphenyl 4 carboxylic acid as ligand and dimethyl formamide as solvent. Ni(BPCA)-MOF was characterized using XRD, SEM with EDAX, FT-IR, UV-visible DRS, XPS and TGA. The characterization results showed that the crystals of Ni(BPCA)-MOFs had wire-shaped morphology with an average crystal size of 20.3nm. The photocatalyst Ni(BPCA)-MOF exhibited superior performance towards the photocatalytic degradation of Congo red under UV-visible light irradiation with a degradation efficiency of 97% after 160 minutes attributed to the efficient separation of photogenerated electrons from hole pairs. Furthermore, as demonstrated by the MTT assay, the cisplatin-loaded Ni(BPCA)-MOF by simple liquid impregnation method shows low cytotoxicity, good biocompatibility, and anticancer activity against breast cancer MDA-MB-231 cell line with the cell viability and IC<sub>50</sub> value of 40.7% and 61.2µg/mL.

**Keywords:** Ni(BPCA)-MOF, photocatalytic degradation, congo red, cisplatin, breast cancer MDA-MB-231 cell, MTT assay.

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### Introduction

In recent times, water pollution has become a significant issue for developing countries due to its potential to harm the ecosystem and result in catastrophic consequences. Many factors, including organic contaminants, pigmentation, and heavy metal ions, can contaminate water [1]. Wastewater must be cleaned of its primary contaminant, colour, before it is dumped onto land or into aquatic bodies. Wastewater containing dyes are released into the environment by producers and users in the food, printing, leather, textile, and paper sectors. A lot of colors are thought to be harmful, even cancerous [2]. Traditional techniques, including physical, chemical, and biological processes, have been applied to remove dyes; nevertheless, they have drawbacks, such as low cost and challenging recycling [3]. Therefore,

the visible light-driven photocatalyst approach was used in the cleaning and environmental modification industry because it can offer high efficiency, cheap cost, minimal harmful byproducts, and low energy consumption [4].

Because of its high incidence, complexity, and risky patient fatality rate worldwide, cancer is one of the most common diseases. As of right now, 12.5 percent of newly reported yearly cancer cases worldwide are breast cancer, making it the most common type of cancer internationally [5]. Triple-negative breast cancer (TNBC) is extremely dangerous due to its quick metastasis to other body areas and increased risk of early recession and death. Every year, one million women are diagnosed with breast tumours, and TNBC accounts for 15% to 20% of all cases of breast cancer that are recorded. There are few therapy options for MDA-MB231, a triple-negative breast cancer that is extremely aggressive and invasive. TNBC is an appropriate candidate for chemotherapy but not for hormonal therapy due to its lack of human epidermal growth factor receptor 2, progesterone, or estrogen receptors [6].

MOFs are a kind of crystalline materials composed of metal or metal-cluster linking nodes and well-defined molecular building units. MOFs now have a wide range of possible applications such as photocatalysis, gas storage and separation, drug delivery, and luminescence detection owing to their capacity to create micro- or meso-porous extended networks with large surface area, interesting morphology, easily adjustable pore size and their flexible properties [7].

## **Materials and Methods**

### **Chemicals**

Nickel chloride hexahydrate, biphenyl 4 carboxylic acid, dimethyl formamide, sodium hydroxide, cisplatin, congo red. All chemicals used in this work are purchased from Sigma Aldrich and used without further purification. The breast cancer MDA-MB-231 cell line was procured from the National Centre for Cell Sciences (NCCS), Pune, India.

### **Synthesis:**

#### **Synthesis of Ni(BPCA)-based MOF**

Using the hydrothermal technique, 1.010 mmol of  $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$  is dissolved in 20 mL of deionized water (sol A) and 1 mmol of biphenyl 4 carboxylic acid is dissolved in 20 mL of DMF (sol B) to synthesize Ni(BPCA)-MOF. To create a homogeneous solution, sol A is gradually added to sol B along with 0.2g of NaOH at room temperature. The mixture is then agitated for an hour. The resultant homogenous solution is then sealed and heated for eight

hours at 185°C in an autoclave with a 100 mL Teflon lining. Once the product has cooled to room temperature, it is filtered and washed thrice with DMF. The final step is to dry the resultant product for four hours at 100°C.

### **Loading of cisplatin inside MOFs**

By liquid impregnation method, the anticancer drug cisplatin was loaded inside Ni(BPCA)-MOF. About 500mg of the synthesized Ni(BPCA)-MOF powder was immersed in the solution of cisplatin and stirred continuously in the dark for about 3 days. The solvent was then removed by centrifugation. The loading of cisplatin in Ni(BPCA)-MOF was further confirmed by FT-IR, TGA, UV-Vis DRS analysis. The cisplatin-encapsulated Ni(BPCA)-MOF was examined against breast cancer MDA-MB-231 cell line.

### **Characterization Techniques**

Powder X-ray diffraction (PXRD) pattern was carried out on an x-ray diffractometer system Bruker binary V4 X-ray diffractometer with Cu K $\alpha$  (1.5406Å) radiation to characterize the crystal structure of synthesized samples. The morphology and composition of the synthesized material was examined by scanning electron microscopy using Quanta FEG-250 equipped with an EDS attachment. FT-IR spectroscopy analysis was measured on SHIMADZU IR Affinity-1 with the wavelength range from 400cm<sup>-1</sup> to 4000cm<sup>-1</sup>. The X-ray photoelectron spectroscopy data was examined with an electron spectrometer from PHI-VERSAPROBE III by Al K $\alpha$  radiation. N<sub>2</sub> sorption measurement was conducted on Quantachrome Nova 1200 surface area analyzer at 77K.

### **Degradation of Congo Red**

The photocatalytic activity of Ni(BPCA)-MOF catalyst as synthesized by the hydrothermal method was evaluated for the photocatalytic degradation of congo red in the double distilled water under UV-visible light irradiation. About 1ppm of congo red was dissolved in 1000mL of double distilled water. For a model reaction, 40mg/L of congo red solution and 0.005g of catalyst were taken and continuously stirred in the dark condition to reach equilibrium between the dye and catalyst. Then the solution was exposed to UV-visible light irradiation. About 4mL of the solution was withdrawn at regular time intervals and their absorbance was measured by UV-visible light irradiation. During the recyclability test, the used Ni(BPCA)-MOF crystal was removed after the reaction, washed and dried under dark conditions and then added to successive degradation experiments.

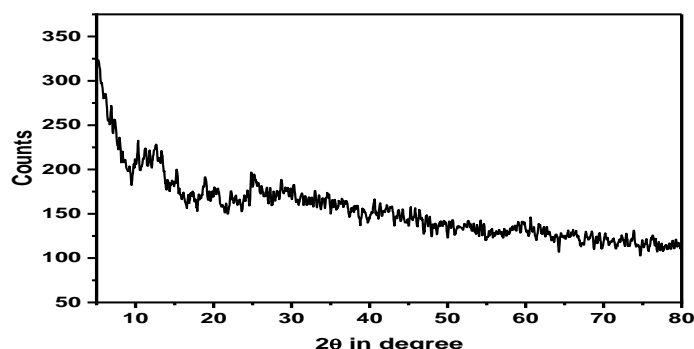
### **Determination of Anticancer Activity by MTT Assay**

The biocompatibility of Cis@Ni(BPCA)-MOF was quantified by MTT assay. The 96-well plates were used to culture cells (2500 cells per well) for 24 hours. Then, serial dilutions of different Cis@Ni(BPCA)-MOF formulations were used to incubate with cells. After 24 hours, the medium was removed and cells were washed with PBS. Following, MTT was added in the plates and incubate with cells for 4 hours to generate formazan crystals. Following, 100 $\mu$ L DMSO was added into each cell. The absorbance of dissolved formazan crystals at 570nm were measured by a microplate reader (ELISA). Three replicates were included in each group. The cell viability was expressed using the following formula

### **Results and Discussion**

#### **XRD analysis**

The Ni(BPCA)-MOF crystal structure was examined by XRD analysis. Fig. 1 shows distinct peaks at 12.93 $^{\circ}$ , 20.45 $^{\circ}$  and 24.81 $^{\circ}$ . The peaks observed in the spectrum closely correspond to the tetragonal structure. The average crystallite size is measured by applying the Scherer formula



**Fig 1: XRD of Ni(BPCA)-MOF**

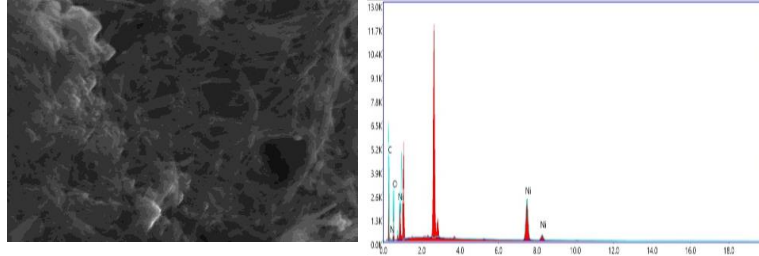
$$D = k\lambda/\beta\cos\theta$$

Where, k is the constant with a value of 0.98,  $\lambda$  is the wavelength of the X-ray source,  $\beta$  is the full width at half maximum of the diffraction peak and  $\theta$  is Bragg's angle corresponding to the maximum intensity peak in the XRD pattern. The average crystallite size calculated is found to be 20.3nm [8].

#### **SEM with EDAX analysis**

Fig.2 displays the image captured by scanning electron microscope that vividly illustrates the size, shape and morphology of the synthesized Ni(BPCA)-MOF. The

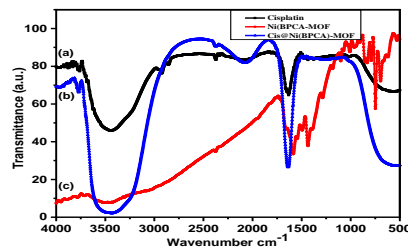
synthesized Ni(BPCA)-MOF have measured diameters of approximately 20nm and are wire-shaped aggregated to form a nest-like structure, as the detailed structural characterization shows their crystallographic arrangement.



**Fig 2: SEM with EDAX of Ni(BPCA)-MOF**

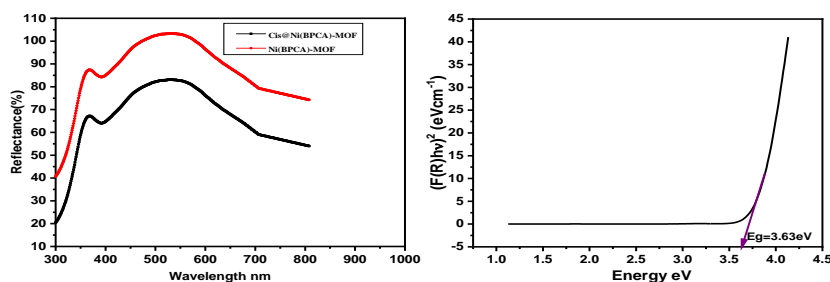
The elemental compositions were evaluated using the EDAX study. Fig.2b depicts the presence of nickel, carbon, oxygen, and nitrogen in the synthesized Ni(BPCA)-MOF [9].

### FT-IR analysis



**Fig 3: FT-IR of Ni(BPCA)-MOF**

FT-IR spectroscopic analysis is employed to identify the functional group of the synthesized Ni(BPCA)-MOF. FT-IR range shows the presence of various functional groups at different positions. Two intense bands at  $671$  and  $727\text{cm}^{-1}$  are assigned to C-H stretching vibration and antiplanar bending vibration of an aromatic ring. The four bands at  $846$ ,  $1463$ ,  $1517$  and  $1554\text{cm}^{-1}$  correspond to the  $-\text{COO}^-$  stretching vibration coordinated to the metal centre.



The band at  $1651\text{cm}^{-1}$  corresponds to the  $-\text{C}=\text{C}$  stretching of the benzene ring. The bands at  $1463$  and  $1553\text{cm}^{-1}$  attributed to the symmetric and asymmetric stretching of  $-\text{COO}^-$  groups coordinated to  $\text{Ni}^{2+}$  by bidentate ligand. Similar bands are shown by  $\text{Cis@Ni(BPCA)-MOF}$  with an additional peak at  $3271\text{cm}^{-1}$  attributed to weak stretching of  $-\text{NH}_2$  group [10].

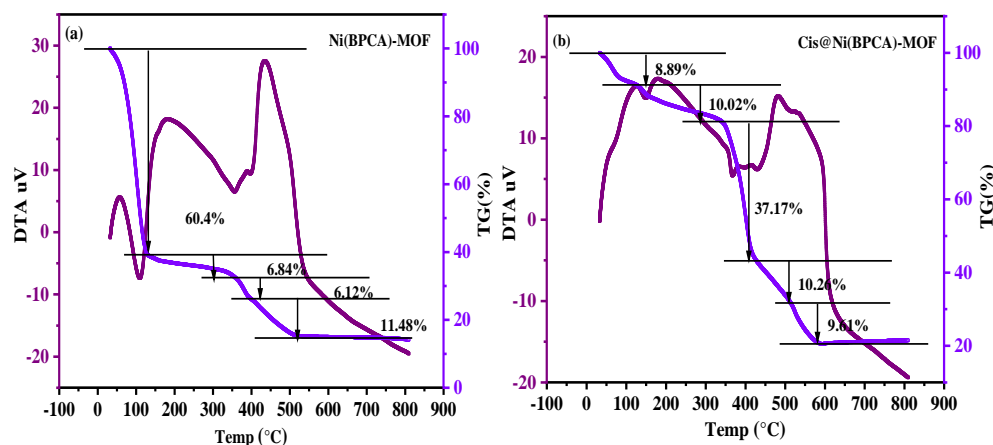
### UV-Vis DRS analysis

**Fig 4: UV-Vis DRS and bandgap of Ni(BPCA)-MOF**

The optical properties of the  $\text{Ni(BPCA)-MOF}$  photocatalyst was investigated by DRS. The optical band gap of the samples can be estimated by Kubelka Munk plot,

$$\frac{K}{S} = \frac{(1 - R)^2}{2R}$$

Where  $K$  is the molar absorption coefficient,  $S$  is the scattering factor and  $R$  is the reflectance. The plot of  $(F(R)h\nu)^2(\text{eVcm}^{-1})$  vs energy (eV) of the absorbed light would give the band gap of the samples. As can be seen from fig 3b, the optical band gap was between  $300\text{-}700\text{nm}$ . The band gap was estimated to be  $3.63\text{eV}$ , respectively by Kubelka Munk plot. After the incorporation of Cisplatin, the absorption intensity was decreased [11].



**Fig 5: TGA of (a) Ni(BPCA)-MOF (b) Cis@Ni(BPCA)-MOF**

### TGA analysis

The stability of  $\text{Ni(BPCA)-MOF}$  and  $\text{Cis@Ni(BPCA)-MOF}$  was studied using TGA analysis. According to fig5a, the TGA curve presents that the decomposition of  $\text{Ni(BPCA)-MOF}$  was carried out in four stages. A huge weight loss was seen from room temperature to

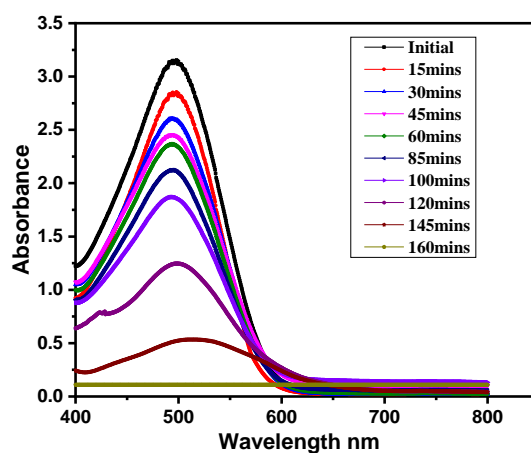
120°C. In the case of Cis@Ni(BPCA)-MOF, five mass drops occurred. A massive drop of 37.17% occurred at 340°C. The final low drop in mass of 9.61% occurred between 510°C and 580°C. Compared to Ni(BPCA)-MOF, Cis@Ni(BPCA)-MOF was found to be thermally stable [12].

### **BET analysis**

The specific surface area and porosity of the synthesized Ni(BPCA)-MOF and Cis@Ni(BPCA)-MOF were measured by nitrogen atmosphere at 77k. The surface area, pore size and pore volume of Ni(BPCA)-MOF was detected as 1.671nm and 0.265cm<sup>3</sup>/g. whereas, after the incorporation of Cisplatin the surface area, pore size and pore volume were reduced to 1.417nm and 0.108cm<sup>3</sup>/g, both exhibiting type IV isotherms which are typical mesoporous materials [13].

### **Photocatalytic degradation activity**

The photocatalytic degradation of congo red was conducted to investigate the efficiency of Ni(BPCA)-MOF as a photocatalyst. The photocatalytic activity was monitored from the variation of colour in the reaction system by measuring the maximum absorbance intensity of Congo red at 498nm. The degradation of congo red was negligible under UV-visible light in the absence of the photocatalyst whereas the concentration of congo red decreased obviously with exposure time in the presence of Ni(BPCA)-MOF photocatalyst indicating the photocatalytic degradation of congo red was attributed to photolysis. About 97% degradation of congo red was observed after 160 minutes under UV-visible light irradiation.

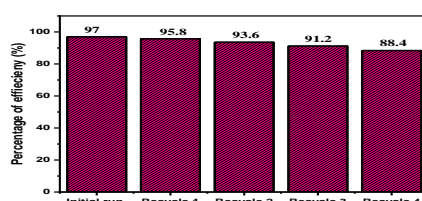


**Fig 6:** UV-Visible photocatalytic degradation of Congo red



### Recyclability test

Due to the significant impact of photocatalysis, recycling reactions for congo red photodegradation under UV-visible light irradiation have been used to assess the stability of Ni(BPCA)-MOF. To fully remove Congo red, the photocatalyst was recovered by centrifugation after being thoroughly cleaned three times in water and ethanol throughout each cycle. Ni(BPCA)-MOF's degrading efficiency dropped from 97% to 88% after four cycles.

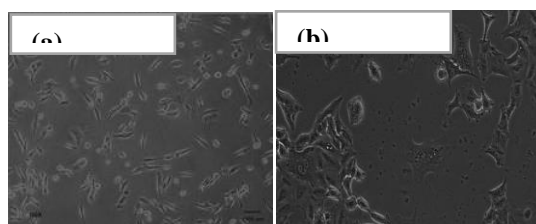


**Fig 7:** Recyclability of Ni(BPCA)-MOF

### Antiproliferative evaluation of Cis@Ni(BPCA)-MOF on MDA-MB-231 cell line

Cis@Ni(BPCA)-MOF's inhibitory effect on MDA-MB-231 cells is examined using the MTT assay method. The framework has an inhibitory effect on human breast cancer MDA-MB-231 cells that is dose-dependent, according to the examination of cell viability. As the concentration rises, the viability of the cells declines. The framework demonstrates good anticancer activity against the MDA-MB-231 cell line, as evidenced by its IC<sub>50</sub> value of 62.15 $\mu$ g/mL on this cell line.

The MDA-MB-231 cells remained morphologically spindle-shaped before treatment. When the Cis@Ni(BPCA)-MOF concentration increased, MDA-MB-231 cells lost their morphology. This morphological change is brought on by the production of reactive oxygen species (ROS), which interferes with the potential of the mitochondrial membrane. Cell viability dropped from 94.2% to 40.7% when the concentration was raised from 6.25 $\mu$ g/mL to 100 $\mu$ g/mL.



**Fig 8:** MDA-MB-231 cell line treated with Cis@Ni(BPCA)-MOF

## Conclusion

This work reports the synthesis of Ni(BPCA)-MOF by hydrothermal method from Nickel as metal ion and biphenyl 4 carboxylic acid as ligand and extensively characterized by XRD, SEM, FT-IR, UV-visible DRS, TGA, BET analysis. Ni(BPCA)-MOF used as photocatalyst showed good degradation efficiency of 97% after 160mins for congo red dye and maintained stability upto four cycles. On the other hand, Ni(BPCA)-MOF acted as a nanocarrier for Cisplatin and showed good anticancer activity against MDA-MB-231 cells with an IC<sub>50</sub> value of 61.2µg/mL.

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## Investigating the Anticancer Efficacy and Selectivity of Ruthenium(II)- Terpyridine Complex in HCT-116 and Normal L6 Cell Lines

Arul Mary. S<sup>1,2</sup> and Sheeba Daniel<sup>3\*</sup>

<sup>1</sup>Research Scholar, (Reg. No: 20123042032005), Department of Chemistry,  
Holy Cross College (Autonomous), Nagercoil – 629004.

Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

<sup>2</sup>Department of Basic Engineering, Government Polytechnic College, Nagercoil.

<sup>3\*</sup>Department of Chemistry, Holy Cross College (Autonomous), Nagercoil.

Email: [sheebadaniel@holycrossngl.edu.in](mailto:sheebadaniel@holycrossngl.edu.in), [arulmary685@gmail.com](mailto:arulmary685@gmail.com)

### Abstract

The *in vitro* anticancer efficacy and cytotoxicity of [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex (Cl-Ph-tpy = 4'-chlorophenyl terpyridine and Cl-tpy = 4'-chloroterpyridine) are evaluated using MTT assay method on human colorectal HCT-116 and normal L6 cell lines. The synthesized [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex is characterized by UV-visible, FTIR, <sup>1</sup>H NMR, and MALDI-TOF-MS spectroscopic techniques. The *in vitro* studies on HCT-116 and normal L6 cell lines, conducted at concentrations ranging from 6.25 to 100 μM, revealed IC<sub>50</sub> values of 16.26 μM for HCT-116 and 51.51 μM for L6. Morphological changes observed at various concentrations suggest the involvement of reactive oxygen species (ROS) in the observed effects. The complex demonstrated significant anticancer activity against HCT-116 cells, with reduced viability and induced apoptosis, while showing relatively low cytotoxicity towards normal L6 cells. These findings indicate the potential of this complex as a promising candidate for developing novel anticancer drugs.

**Keywords:** [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex; HCT-116 cell line; cellular viability; anticancer activity

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### 1. Introduction

Cancer is one of the leading causes of death worldwide. In India, colorectal cancer (CRC) is the third most common cancer diagnosed in both men and women. Coordination chemistry is a field of scientific research that primarily focuses on medicine and pharmacy, although it also spans various other areas of life (Skoczynska et al. 2023). The discovery of cisplatin as an anticancer drug opened a new pathway for cancer chemotherapy (Jiang et al. 2019). However, due to its severe side effects, such as nephrotoxicity and ototoxicity, there is an urgent need to find new antitumor drug candidates. In the past two decades, ruthenium coordination compounds have attracted considerable interest as potential anticancer agents due to their rate of ligand exchange, range of accessible oxidation state, low toxicity, and efficacy against platinum drug-resistant tumors, with promising results in various stages of

preclinical to early clinical studies (Milutinović et al. 2017). Among the various oxidation states of ruthenium, the +2 state is most preferred for antitumor activity due to the stability of ruthenium(II) complexes. Ruthenium(II) complexes interact with DNA through non-covalent mechanisms such as electrostatic interactions, groove binding, and intercalative binding (Ezhilarasu and Balasubramanian 2018). The oligopyridine compound 2,2':6',2''-terpyridine (tpy) and its derivatives have garnered significant interest in recent years. This is because they consist of three aromatic pyridine rings connected by three single bonds, with three nitrogen atoms capable of chelating a wide range of transition metal and lanthanide ions as tridentate ligands. Consequently, the resulting coordination complexes exhibit high stability due to the  $\sigma$ -donor/ $\pi$ -acceptor character of the M-Npyridine bonds formed (Elnagar et al. 2021).

In particular, the ease of functionalizing tpy's at the 4'-position with various organic moieties, along with their ability to form stable complexes with different transition metal ions has led to a multitude of potential applications including colorimetric metal determination, DNA studies, and use as anticancer and antitumor agents. The extended conjugation of the directly linked aromatic ring with tpy through  $\pi$ -expansion significantly enhances its medicinal applications by improving photosensitization and light-harvesting abilities (Elnagar et al. 2021). The present study aims to synthesize, characterize, and evaluate the antiproliferative and cytotoxic effects of the  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex on human cancerous HCT-116 cell line, as well as its cytotoxicity on normal L6 cell lines. This work seeks to contribute to the development of novel anticancer agents with potential therapeutic applications.

## **2. Experimental methods**

$\text{RuCl}_3 \cdot 3\text{H}_2\text{O}$ , Cl-Ph-tpy and Cl-tpy were procured from Sigma-Aldrich. Analytical grade solvents and  $\text{NH}_4\text{PF}_6$  were purchased from Merck. The complexes were synthesized and biological tests were conducted using double distilled deionized water.

### **2.1 Synthesis of $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})](\text{PF}_6)_2$**

A mixture of  $\text{RuCl}_3 \cdot 3\text{H}_2\text{O}$  (0.5 mmol), Cl-Ph-tpy (0.5 mmol), and Cl-tpy (0.5 mmol) were suspended in 30 mL of ethylene glycol and heated to 100 °C while stirring continuously. The reaction mixture was then refluxed for 24 hours under nitrogen atmosphere. After cooling, the solution was poured into an aqueous solution of  $\text{NH}_4\text{PF}_6$  to precipitate out the complex as a hexafluorophosphate salt. The precipitate was filtered,

washed with water and dried in a vacuum desiccator. The synthesized complex was recrystallized from a 1:1 mixture of acetonitrile and methanol with a few drops of  $10^{-4}$  M hexafluorophosphoric acid.

## 2.2 Characterization techniques

The UV-Visible absorption spectrum was recorded with a Shimadzu UV 1800 spectrometer. FTIR spectral analysis was performed using a SHIMADZU FTIR double beam spectrophotometer. The  $^1\text{H}$  NMR spectrum was obtained with a Bruker Advance III spectrometer at 400 MHz, using DMSO- $d_6$ . MALDI-TOF MS spectral analysis was conducted with a Bruker Autoflex max LRF mass spectrometer to determine the m/z peaks.

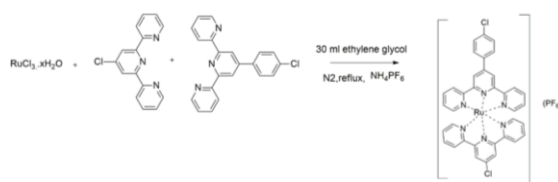
## 2.3 Determination of Anticancer Activity by MTT Assay Method

The anticancer and cytotoxicity activities of the complex on HCT-116 cells and non-tumor L6 cells was evaluated by MTT assay method. The cell lines HCT-116 (human colorectal cancer), and L6 (rat skeletal muscle) were obtained from the National Centre for Cell Sciences (NCCS) in Pune, India. The cells were cultured in Dulbecco's Modified Eagles Medium (DMEM-Himedia), supplemented with 10% heat-inactivated Fetal Bovine Serum (FBS) and 1% antibiotic cocktail, which included Amphotericin B (2.5  $\mu\text{g}/\text{mL}$ ), Streptomycin (100  $\mu\text{g}/\text{mL}$ ), and Penicillin (100 U/mL). The cells were incubated in tissue culture flasks (25  $\text{cm}^2$ ) at 37°C in a 5%  $\text{CO}_2$  environment with humidity within a cell culture incubator. Cells (2500 cells/well) were seeded in 96-well plates and incubated at 37°C with 5%  $\text{CO}_2$  for 24 hours. The test samples (complex) were prepared in DMEM and added to the wells at concentrations ranging from 6.25 to 100  $\mu\text{M}$ , with untreated wells serving as controls. The  $\text{IC}_{50}$  value, representing the half-maximal inhibitory concentration of the sample, was calculated using GraphPad Prism 10.2.1 software. Representative photomicrographs of cells from each experimental group were taken using an inverted phase contrast microscope (LABOMED, TCM 400, USA).

## 3. Results and Discussion

### 3.1 Synthesis and characterization of $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$ complex

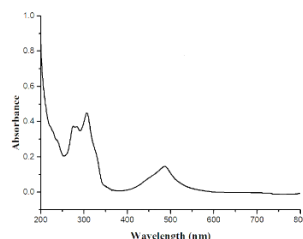
**Scheme 1** depicts the schematic representation of the synthesis process for the  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex. The synthesized complex exhibits strong coloration, stability, and solubility in various common organic solvents such as acetonitrile, DMF, and DMSO.



**Scheme 1** Synthesis of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex

### 3.1.1 Absorption spectral analysis

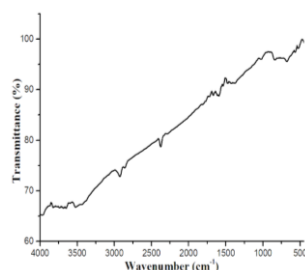
The absorption spectrum of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  occurs at 283, 306, 486 nm (**Fig. 1**). The broad intense peak observed at 486 nm is attributed to MLCT transition. The high energy band at 283 nm is due to  $\pi-\pi^*$  ligand centered transitions. The bands at 306 nm is due to intra ligand charge transfer (ILCT) transitions among the coordinated ligands(Deb et al. 2021).



**Fig. 1** UV-vis absorption spectrum of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex

### 3.1.2 FTIR spectral analysis

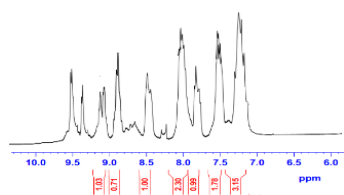
The FTIR spectrum of the  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex is displayed in **Fig. 2**. A weak peak at  $2920\text{ cm}^{-1}$  is attributed to the C-H stretching vibration of the pyridine rings. The  $\nu(\text{C}=\text{N})$  imine group vibrations of the tpy rings appear at  $1663\text{ cm}^{-1}$ . The bands at  $1469$  and  $1413\text{ cm}^{-1}$  correspond to the aromatic skeleton stretching vibrations of the pyridine rings (Wei et al., 2015). The band at  $1021\text{ cm}^{-1}$  is associated with the ring breathing modes of the individual pyridine rings (Ćanović et al., 2017). The presence of  $\text{PF}_6^-$  as a counterion is confirmed by the very strong stretching frequency at  $836\text{ cm}^{-1}$ . A weak and sharp band at  $559\text{ cm}^{-1}$  corresponds to the Ru-N stretching frequency of the complex (Ezhilarasu Balasubramanian, 2018). Additionally, the band at  $520\text{ cm}^{-1}$  is due to the C-Cl stretching vibration. Thus, the FTIR data confirms the formation of the  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex with  $\text{PF}_6^-$  counterions.



**Fig. 2** FTIR spectrum of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex

### 3.1.3 $^1\text{H}$ NMR spectral analysis

The  $^1\text{H}$  NMR spectrum of complex shows that 9 resonances (some are overlapped) of 24 protons from the Cl-Ph-tpy and Cl-tpy ligand in the region 7.26-9.56 ppm (**Fig. 3**). The  $\text{H}^5$  (2H) from the Cl-Ph-tpy and  $\text{H}^{10}$  (2H) from the Cl-tpy is equivalent protons appears multiplet in the region 7.26-7.39 ppm. The  $\text{H}^6$  (2H) from the Cl-Ph-tpy and  $\text{H}^9$  (2H) from the Cl-tpy resonance appeared at 7.57-7.62 ppm as multiplet. The resonances of the terminal aromatic rings of Cl-Ph-tpy experience a remarkable upfield shift as a consequence of the aromatic shielding region of the ligand (Čanović et al. 2017). The  $\text{H}^7$  (2H) resonance appeared at 7.88 ppm as doublet due to the coupling with the  $\text{H}^8$ . The  $\text{H}^4$  (2H) and  $\text{H}^{11}$  (2H) resonances from both the ligands appears as multiplet at 8.08-8.10 ppm.  $\text{H}^8$  (2H) experience a strong depletion of electrons occurred due to the large electronegativity of Cl, results in the down-field shift  $\delta = 8.55$  ppm (Hou et al. 2023).  $\text{H}^{12}$  (2H) experience a downfield shift  $\delta = 8.93$  ppm is due to Van der Waals deshielding by  $\text{H}^{13}$ .  $\text{H}^3$  (2H) experience a more downfield shift  $\delta = 9.25$  ppm respectively upon coordination, which is usually attributed to Van der Waals deshielding by  $\text{H}^{3'}$ ; it has been suggested that this is a direct consequence of the change from transoid to cisoid configuration about the interannular C-C bonds upon coordination. The signal in the NMR spectrum at  $\delta = 9.40$  ppm belongs to the  $\text{H}^{13}$  (2H) proton. The downfield shift for this proton is less due to its remote location from the coordination site (Tripathy et al. 2021).  $\text{H}^{3'}$  (2H) is highly deshielded ( $\delta = 9.56$  ppm) due to Vander Waals interactions, and in part to the fact that the interaction of the metal with the central ring is greater than that with the terminal rings.

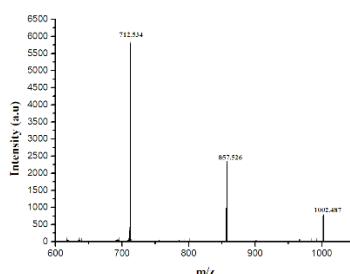


**Fig. 3**  $^1\text{H}$  NMR spectrum of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex



### 3.1.4 Mass spectral analysis

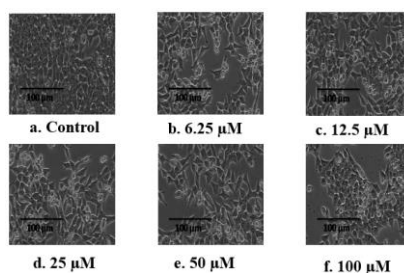
The  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex shows a molecular ion peak ( $\text{M}^+$ ) at  $m/z = 1002.48$ . The peak at  $m/z = 857.52$  represents the loss of one hexafluorophosphate ion from the molecular ion ( $\text{M}^+ - \text{PF}_6^-$ ). The peak at  $m/z = 712.534$  is obtained by the loss of two hexafluorophosphate ions from the molecular ion ( $\text{M}^+ - 2\text{PF}_6^-$ ). The molecular mass obtained from MALDI-TOF mass spectrum of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex is in good agreement with the theoretical values calculated from the molecular formula of the corresponding complex. Thus, the MALDI-TOF mass spectral data validate the assigned structure of the complex (**Fig. 4**). All the spectroscopic analysis data confirms the formation of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex.



**Fig. 4** MALDI-TOF mass spectrum of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex

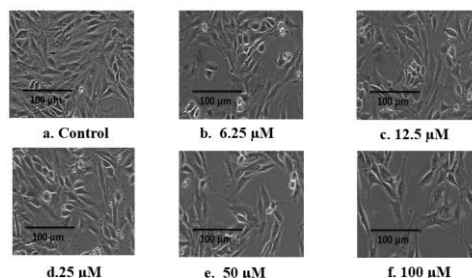
### 3.2. In Vitro Antiproliferative and Cytotoxic effect of $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$ Complex

The *in vitro* antiproliferative effect of the synthesized complex is assessed by two-fold dilution at various concentrations (6.5, 12.5, 25, 50, 100  $\mu\text{M}$ ) against the colorectal cancer HCT-116 cell line (**Fig. 5**). The percentage of cellular viability of the  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex is determined from these absorbance values using the MTT assay method. The cell viability of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex on HCT-116 decreases with increase in concentration. The  $\text{IC}_{50}$  value of the complex on HCT-116 cell line is 16.26  $\mu\text{M}$ , this indicates that the complex shows good anticancer activity against HCT-116 cell line.



**Fig. 5** Morphological changes of  $[\text{Ru}(\text{Cl-Ph-tpy})(\text{Cl-tpy})]^{2+}$  complex on HCT-116 cell line

The *in vitro* cytotoxicity of the complex on L6 cell line is determined using the MTT assay (**Fig. 6**). The IC<sub>50</sub> of the complex was found to be 51.51  $\mu$ M. The high IC<sub>50</sub> value suggests that the [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex is not toxic and is relatively safe.



**Fig. 6.** Morphological changes of [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex on normal L6 cell line

### Conclusion

The *in vitro* anticancer efficacy of [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex on HCT-116 and normal L6 cell lines is investigated by MTT assay method. The [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex shows high cytotoxic activity against HCT-116 cell line with an IC<sub>50</sub> value of 16.16  $\mu$ M. The complex displayed an insignificant effect on viabilities of normal L6 cell line. Hence, it is evident and clear that the synthesized [Ru(Cl-Ph-tpy)(Cl-tpy)]<sup>2+</sup> complex shows good anti colorectal effect with less cytotoxicity towards living cells and can be suggested as an effective anti- colorectal cancer.

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## Evaluation of the phytochemical and pharmacological characteristics of *Calotropis procera* (Aiton)W.T. Aiton in order to create novel medications

Suchithra M. S.<sup>1\*</sup>, Beena Lawrence<sup>2</sup> and A. R. Florence<sup>3</sup>

<sup>1</sup>Research Scholar (Reg. No: 22223282022004 ), Department of Botany,  
Women's Christian College, Nagercoil - 629001.

Affiliated to Manonmaniam Sundaranar University, Abishekepetti, Tirunelveli - 627012.

<sup>2\*</sup> Associate Professor of Botany, Women's Christian College, Nagercoil – 629001

. Affiliated to Manonmaniam Sundaranar University, Abishekepetti, Tirunelveli – 627012.

<sup>3</sup>Assistant Professor of Botany, Holy Cross College (Autonomous), Nagercoil – 629004.

Email: [suchithrams@gmail.com](mailto:suchithrams@gmail.com)

### Abstract

In traditional medicine, herbal plants have long been used since they are essential to our daily lives and overall health. Herbal products' popularity is believed to be attributed to their accessibility and decreased adverse effects. *Calotropis procera* Linn. is a well-known plant used in traditional medicine because of its many therapeutic characteristics that enable it to treat a wide range of diseases. The current study employed a range of solvent extraction procedures to extract the leaves of *C. procera*, including methanol, ethanol, diethyl ether, ethyl acetate, and chloroform. Distilled water was used as a reference. A wide range of phytochemicals were examined in these extractions. Several phytochemicals, including fatty acids, flavonoids, phenols, terpenoids, alkaloids, steroids, saponins, glycosides, and terpenes, were found in differing amounts in the extracts of *C. procera* leaves. Asthma, colds, epilepsy, fever, indigestion, leprosy, piles, and skin disorders are just a few of the illnesses and ailments that this plant can treat thanks to the presence of these phytochemicals, which also give it anti-inflammatory, anthelmintic, anticancer, antioxidant, and antitumor qualities. Additionally, there is still a great deal of untapped medicinal potential in this plant that needs to be uncovered in order to provide components for the future development of novel medications to treat newly emerging illnesses.

**Key words:** - *Calotropis procera*, Phytochemicals

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### Introduction

*Calotropis procera* Linn. within the Apocyanaceae family, is a massive shrub including six species. Each branch of the plant is covered with cottony, white hairs. Milky latex is another thing it offers. The enormous, bushy shrub *Calotropis* has auriculate, decussate, obovate, coriaceous, and extraaxillary leaves with purple corollas, umbellate, panicle, and upright lobes. The leaves can be broadly oval, ovate-oblong, elliptical, or obovate. Morphological research indicates that the leaves are sessile, measuring 6–15 cm by 4.5–8 cm. Young individuals are pubescent, and as they get older, they become glabrous on both sides. *Calotropis procera* has many medical applications [1]. The plant's edible parts,

including as its latex, bark, flowers, leaves, and roots, have a wide range of potential medical applications. Often referred to as "milkweed," this plant is native to China, Malaysia, and India, but it may be found almost anywhere in the world. Traditional healers frequently employ latex as a wound-healing agent in addition to using it as an abortion aid in folk remedies [2]. The pharmaceutical industry has historically mostly relied on naturally occurring elements from plants and animals to supply lead molecules for the development of novel drugs and therapies [3]. Numerous clinically beneficial medications have been discovered through the quest for novel pharmacologically active chemicals in natural resources like plants, animals, and microbes. However, recent studies indicate that this herb may have therapeutic uses. Therefore, the current study aims to gather information on the phytochemical and biological activities of the plant extracts in order to throw light on the numerous, as-yet-undiscovered, medicinal benefits of the plant leaves (Fig. 1). Because of its pharmacological properties, which include anti-diabetic, anti-toxin, anti-hepatotoxin, antioxidant, and wound-healing properties, *Calotropis procera* is a widely used study material among scientists worldwide [4,5].

## **Materials and Methods**

### **Plant Collection and Extraction**

The *Calotropis procera* plant was harvested when its leaves were still young. After being sprayed with water, the leaves were allowed to air dry. Next, pharmacognostically, the fresh leaf was examined, involving morphological and phytochemical analyses. Leaf specimens were sectioned into rectangles by cutting off sections of the midrib and part of the lamina. By embedding the leaf specimens in paraffin blocks, they were kept preserved. They were subsequently subjected to sectioning, infiltration, and dehydration. Both regular daylight and UV light (254 nm) conditions were used to evaluate the leaf powder and its extracts in various solvents. The fluorescence was measured using Chase and Pratt's techniques [6].

The extraction was done one at a time using a Soxhlet apparatus. To extract roughly 25 of powdered material, a series of procedures including petroleum ether, diethyl ether, chloroform, ethyl acetate, ethanol, and distilled water were utilized. The thimble's solvent was drawn out till it turned clear. To eliminate the solvent, the extract was vacuum-dried at a temperature lower than 45 °C after each extraction. Noted were the yield percentages for

ethanol, diethyl ether, petroleum ether, and distilled water extract. The extracts were stored at 4°C in a refrigerator until their biological activities were investigated.

Quantitative tests were performed on the powdered drug, including physiochemical constant measurements and an initial phytochemical screening [7]. After being weighed, 1 g of powdered *Calotropis procera* leaves was kept at 500°C in the muffle furnace for around six hours. It was decided how much ash there was overall. Dissolving the ash in alcohol, acid, and water allowed for the assessment of certain phytochemical properties.

### Results and Discussion

Medicinal plants are being researched as a possible alternate source of therapeutic compounds because of their therapeutic properties. Phytochemicals enable *Calotropis procera* have many pharmacological properties, including its analgesic, cytotoxic, antibacterial, antioxidant, and anti-inflammatory properties. Both primary and secondary metabolites, which include a range of phytochemical components, can be produced by plants. Some of these bioactive substances, such as flavonoids, phenols, alkaloids, tannins, saponins, steroids, and carbohydrates, have been shown to have a variety of biological activities [7]. A few factors that could influence the phytochemical composition are the type of plant used, the method of extraction, and the region. *Calotropis procera* possess phytochemical content and cytotoxicity were examined in a study conducted in 2014 by Ragasa and Espineli [8].

One possible use for the plant's phytochemical parameter values is as an indicator. Numerous research have demonstrated the presence of alkaloids, flavonoids, and tannins in *Calotropis procera* [8]. Table 1 displays the metabolic component's presence and absence in different solvents. In this observations, alkaloids, steroids, and flavanoids are more prominently displayed. Pharmacologically active ingredients derived from medicinal plants are used in medicine to treat a range of illnesses [4,5]. Research indicates that the ethanolic extract of *Calotropis procera* had the exact same flavonoids, glycosides, and sterols as those found in my investigation [9].

**Table 1-Phytochemical profile of *Calotropis procera* (Aiton)W.T. Aiton**

Phytochemicals	Petroleum ether extract	Chloroform extract	Ethanol extract	Water extract
Alkaloids	–	–	++	–

<b>Sugars</b>	–	–	+	–
<b>Phenols</b>	–	+	+	+
<b>Flavonoids</b>	–	–	++	–
<b>Saponins</b>	–	–	–	+
<b>Steroids</b>	+	–	++	–
<b>Terpenoids</b>	–	+	+	–
<b>Tannins</b>	+	–	+	+
<b>Fatty acids</b>	–	–	–	–
<b>Glycosides</b>	+	+	+	+
<b>'+' = Presence of the compound; '–' = Absence of compound</b>				

Ash value is the term for the residue that remains after burning plant material at a high temperature. Ash values are essential measurements to assess the purity and quality of plant-based medications. Total ash includes both the plant material's physiological (organic) and non-physiological (inorganic) components. The entire mineral content of the sample is represented by its total ash value. The amount of ash that remains insoluble in acid after the organic materials have been removed is referred to as acid-insoluble ash percentage. Typically, silica and other silicates make up acid-insoluble ash. Water-soluble ash is the portion of the total ash that dissolves in water, expressed as a percentage. This plant had an overall ash content of 18.3%. There contains 1.6% of acid-insoluble ash and 1.9% of the ash is water-soluble (Table 2).

**Table 2. Ash values of *Calotropis procera* (Aiton)W.T. Aiton**

Type of ash	Ash Value
Total ash	18.3
Acid insoluble ash	1.6
Water soluble ash	1.9

An effective technique for identifying particular phytochemicals or contaminants in plant material is to examine the fluorescence of pulverized *Calotropis procera* leaf in a range of solvents. The fluorescence intensity and color of the powdered *Calotropis procera* leaf

were assessed in each solvent (Table 3). When *Calotropis procera* leaf powder is subjected to UV light, it fluoresces green, indicating the presence of particular fluorescent compounds. Under UV light, several flavonoid molecules present in plants can glow. A broad class of phytochemicals called flavonoids is well-known for their biological properties and antioxidant properties. Gholamshahi *et al.* (2014) reported that green is one of the several hues of fluorescence that flavonoids can produce. The results of this experiment also show that the leaf is green, which suggests the existence of secondary metabolites such flavanoids and phenolics [10]. There are several factors that can affect the specific luminous compounds present in *Calotropis procera* leaf powder, such as plant genetics, extraction methods, and environmental conditions. In order to identify the specific chemicals that are responsible for the observed fluorescence, additional testing such as spectroscopy or chromatography may be necessary. Fluorescence analysis can also be used for quality control and phytochemical characterization of plant materials.

**Table 3. The fluorescence intensity and color of the powdered *Calotropis procera* (Aiton)W.T. Aiton leaf**

Treatment	Under visible light	U.V. light (short wavelength; 254 nm)
Powder as such	Green	No change
Powder + 1N NaOH (aqueous)	Light green	Green
Powder + 1N NaOH (ethanolic)	Pale green	Light green
Powder + 1N HCl	Green	Green
Powder + 50% HNO <sub>3</sub>	Brown	Green

### Conclusion

Numerous phytochemical substances, including proteins, terpenoids, carbohydrates, alkaloids, glycosides, tannins, flavonoids, phenols, quinones, and coumarins, have been found during pharmacological screens of *C. procera*. Recently, there has been a lot of interest in ethnomedical research because it has uncovered many unknown and hidden health benefits, especially for plant-based remedies. As a result, this plant has a great deal of therapeutic potential and can be a helpful medicinal plant. In addition to its medicinal qualities, *C. procera* grows quickly and needs little care. Notwithstanding the wide range of therapeutic applications of *C. promethora*, more investigation is still required to standardize the phytochemicals and unknown compounds in this plant, find a novel, potent molecule that suppresses a wide range of pathological disorders, and develop a new class of pharmaceutical therapies that will enhance human health. Researchers and pharmacologists are currently



trying to figure out how to add natural sources to allopathic drugs. *Calotropis procera* leaves may be utilized in the future to help create better treatments due to their phytochemical, antibacterial, antifungal, and antioxidant qualities. This study also showed that applying these ethno-medical practices could have a significant positive impact on the production of modern drugs with fewer adverse effects. Systematic research and development efforts should be performed in order to conserve that *C. procera* and to make its use more profitable and therapeutic.

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## Preliminary Phytochemical analysis of *Solanum trilobatum* L. leaf extracts

**A.R. Florence<sup>1\*</sup>, Bojaja A. Rosy<sup>1</sup>, S. Bashidha Banu<sup>2</sup>, Beena Lawrence<sup>3</sup>**

**D.F. Mary Judisha<sup>4</sup> and M. Amutha<sup>5</sup>**

<sup>1</sup>Assistant Professor of Botany, <sup>2</sup>Research Scholar,  
Holy Cross College (Autonomous), Nagercoil – 629004.

<sup>3</sup>Associate Professor of Botany, Women's Christian College, Nagercoil - 629001.

<sup>4</sup>Agriculture, Vanavarayar Institute of Agriculture, Manakadavu, Pollachi- 642103.

Affiliated to TamilNadu Agricultural University (TNAU), Coimbatore- 641003.

<sup>5</sup>Assistant Professor of Botany, St. John's College, palayamkottai, Tirunelveli- 627002.

<sup>1,2,3,5</sup>Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012.

Email: [florence.a@holycrossngl.edu.in](mailto:florence.a@holycrossngl.edu.in)

### Abstract

The current research aimed to analyze the bioactive components found in the leaf extracts of *Solanum trilobatum*. Extracts were prepared using aqueous, petroleum ether, chloroform, ethanol, and acetone by adding 100 g of leaf powder to 1000 ml of each solvent and subjecting the mixtures to Soxhlet extraction. The extracts were then concentrated using a vacuum evaporator and dried at 60°C. Preliminary phytochemical screening was conducted using the Harborne method. The different extracts revealed the presence of various bioactive components, including alkaloids, carbohydrates, glycosides, coumarins, quinones, saponins, steroids, carboxylic acids, terpenoids, proteins, phytosterols, tannins, resins, flavonoids, and essential oils. The study's findings indicated that the various chemical constituents in the leaf extracts of *Solanum trilobatum* possess significant phytopharmaceutical importance.

**Keywords:** Leaf extract, Phytoconstituents, *Solanum trilobatum* L., Solanaceae, Solvents

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### Introduction

Medicines derived from plants have been utilized in Homeopathy, Ayurveda, Allopathy, and traditional medicine since ancient times. Medicinal plants hold significant importance in both traditional and modern healthcare systems. Their usage has expanded through various research and applications due to the numerous side effects associated with synthetic drugs, antibiotics, and their high costs. People in rural areas primarily rely on traditional medicine to treat their ailments due to the lack of access to modern medicines and hospitals. In developing countries, 80% of the population continues to use traditional folk medicines obtained from natural resources[1]. In India, where over 75% of the population lives in rural areas close to natural resources, there is a long-standing tradition among indigenous peoples of using medicinal plants. The healing properties of these plants are primarily attributed to the presence of various complex chemical substances, which occur as secondary metabolites [2].

*Solanum trilobatum* L. is a slender, prickly, scrambling shrub belonging to the Solanaceae family, which is economically significant among flowering plants. The name Solanaceae comes from the genus Solanum, commonly known as "the nightshade plant (fig.1)." This family predominantly consists of herbs and twining plants, encompassing about 98 genera and 3,000 species distributed worldwide [3]. It is commonly referred to as "Climbing Brinjal," is also known as the purple-fruited pea and is called 'Thoothuvalai' in Tamil.

The entire plant is considered medicinally important and is documented as a source of bioactive components with various medicinal properties, including antibacterial and antifungal effects [4,5], anticancer [6-9], antioxidant [10], antidiabetic [11] hepatoprotective [12] Chemoprotective [13] antinociceptive [14], antihyperlipidemic [15] anti-inflammatory and analgesic[16-18] and mosquitocidal effects [19] . In Ayurveda and Siddha medicinal systems, the roots and leaves are used to treat a range of respiratory issues, including acute and chronic bronchitis, asthma, sinusitis, tonsillitis, the common cold, cough, and pulmonary infections [20]. The leaves are primarily used to treat dyspepsia, spermatorrhoea, tuberculosis, ear infections, and bacterial infections [21]. The objective of this study is to provide valuable insights into the secondary metabolites present in the leaf extracts of *Solanum trilobatum* L.

### **Materials and Methods**

**Plant Collection and Identification:** Fresh, healthy, disease-free leaves of *Solanum trilobatum* were gathered from the vicinity of Holy Cross College in Nagercoil, Kanyakumari District, South Tamil Nadu, India, and were identified using taxonomic keys (Gamble and Fischer, 1935).

**Extraction of plant material:** The healthy and mature leaves were freshly collected and thoroughly washed with distilled water to remove all dusts. The excess water in the sample is removed. Take 10gm of fresh leaves of *Solanum trilobatum* were extracted with 20 ml of solvents such as water, petroleum ether, ethanol and benzene were ground well using mortar and pestle and filtered with the help of cheese cloth. The extracts obtained would be subjected to phytochemical investigation to detect the bio principles present in plants.



**Fig.1. *Solanum trilobatum* L.**

### **Preliminary phytochemical screening**

To obtain an overview of the constituents present in the extracts, qualitative chemical tests were conducted on aqueous, petroleum ether, chloroform, ethanol, and acetone extracts. Following the standard methods of Horborne [22], these extracts underwent preliminary phytochemical investigations to identify specific compounds in the plants. The tests aimed to detect the presence of various compounds, including alkaloids, sterols, saponins, tannins, flavonoids, glycosides, terpenoids, quinones, coumarins, carbohydrates, proteins, and phytosterols.

### **Results and Discussion**

Preliminary phytochemical screening of plants is a fascinating research area that can lead to the discovery of new compounds. In this study, the qualitative phytochemical analysis of aqueous, petroleum ether, benzene, and acetone extracts of *Solanum trilobatum* leaves was conducted. The analysis revealed the presence of various compounds, including alkaloids, carbohydrates, glycosides, coumarins, quinones, saponins, steroids, carboxylic acids, terpenoids, proteins, phytosterols, tannins, resins, flavonoids, and essential oils (Table 1).

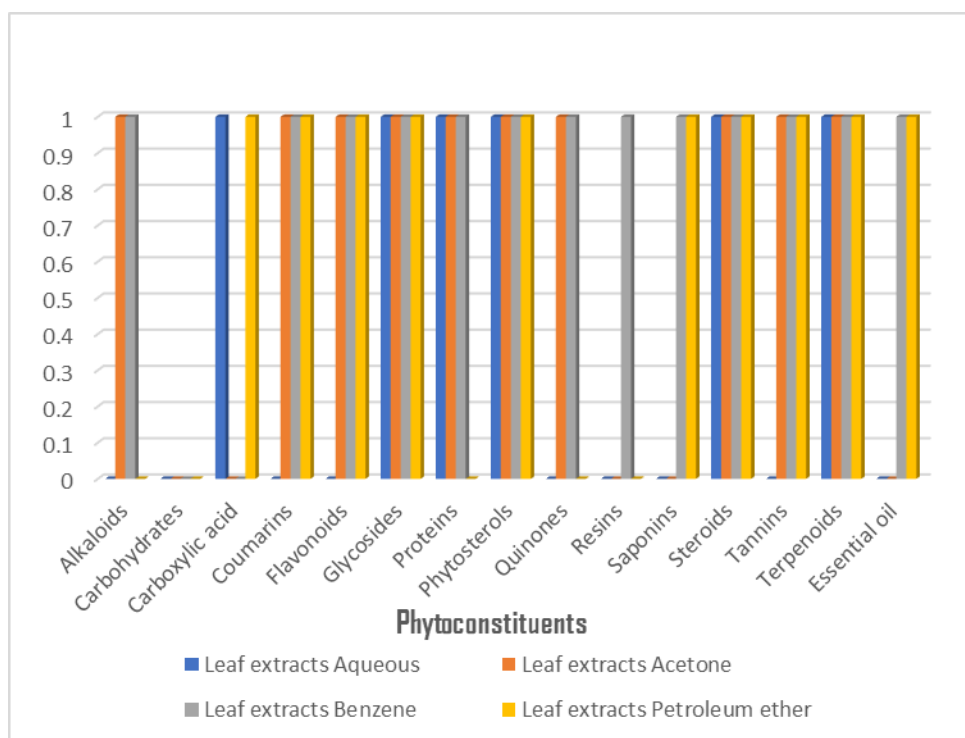
The benzene extract exhibited the highest number of phytoconstituents, detecting 13 out of 15 possible compounds, while the aqueous extract contained the fewest. Both plants' benzene extracts demonstrated optimal separation due to benzene's nonpolar nature and its excellent solubility for various substances, attributed to its hydrocarbon content. Reports indicate that benzene extracts are effective in achieving good separation of phytochemicals.

**Table 1. Preliminary Phytochemical analysis of different extracts of *Solanum trilobatum* L. leaf**

Phytoconstituents	Leaf extracts			
	Aqueous	Acetone	Benzene	Petroleum ether
<b>Alkaloids</b>	-	+	+	-
<b>Carbohydrates</b>	-	-	-	-
<b>Carboxylic acid</b>	+	-	-	+
<b>Coumarins</b>	-	+	+	+
<b>Flavonoids</b>	-	+	+	+
<b>Glycosides</b>	+	+	+	+
<b>Proteins</b>	+	+	+	-
<b>Phytosterols</b>	+	+	+	+
<b>Quinones</b>	-	+	+	-
<b>Resins</b>	-	-	+	-
<b>Saponins</b>	-	-	+	+
<b>Steroids</b>	+	+	+	+
<b>Tannins</b>	-	+	+	+
<b>Terpenoids</b>	+	+	+	+
<b>Essential oil</b>	-	-	+	+

**Abbreviation** (-) Absent; (+) Present

In the present study, the aqueous extract of *Solanum trilobatum* revealed the presence of carboxylic acids, glycosides, proteins, phytosterols, steroids, and terpenoids. The petroleum ether extract showed the presence of carboxylic acids, proteins, glycosides, phytosterols, tannins, terpenoids, steroids, and saponins (fig.2). Similar observations were made by



**Fig. 2: Preliminary phytochemical screening of *Solanum trilobatum* L. leaf extracts**

Annamalai *et al.* [23], who confirmed the presence of steroids, triterpenoids, sugars, reducing sugars, phenolic compounds, tannins, anthraquinones, and amino acids in the leaf extracts of chloroform, ethanol, and water. Chinthana and Ananthi [24] also reported that the aqueous extract of *Solanum trilobatum* contained saponins, tannins, and anthraquinones, which possess antioxidant activity and exhibit a cytoprotective effect in brain tissue by significantly inhibiting lead-induced lipid peroxidation and superoxide generation *in vivo*. Fabiola and Sumathy [25] found that the aqueous extract of *S. trilobatum* showed antibacterial, antifungal, antioxidant, and antidiabetic activities due to the presence of alkaloids, flavonoids, saponins, sterols, glycosides, proteins, amino acids, terpenoids, and quinones, but lacked tannins, anthraquinones, fixed oils, carotenoids, phenols, and carbohydrates. Rajathi *et al.* [26] also demonstrated that both the aqueous and petroleum ether extracts contained alkaloids, tannins, flavonoids, and steroids. The acetone extract showed the presence of carbohydrates, coumarins, flavonoids, glycosides, proteins, phytosterols, quinones, tannins, terpenoids, and steroids.

The benzene extract of *Solanum trilobatum* leaves revealed the presence of alkaloids, flavonoids, glycosides, quinones, steroids, tannins, resins, terpenoids, saponins, proteins, coumarins, phytosterols, and essential oils. Notably, phytosterols, glycosides, steroids, and

terpenoids were present in all extracts. Similar studies conducted by Durgadevi [27] on the ethyl acetate, methanol, chloroform, and benzene extracts of *Solanum trilobatum* leaves showed the presence of flavonoids, glycosides, reducing sugars, sterols, tannins, alkaloids, and saponins; particularly, the benzene extract revealed steroids and tannins. Other studies on *Solanum trilobatum* extracts in various solvents reported that the petroleum ether extract contained alkaloids, terpenoids, sterols, and tannins, while the water extract contained alkaloids, flavonoids, amino acids, proteins, carbohydrates, terpenoids, sterols, glycosides, phenols, and tannins [28].

Tannins, coumarins, and flavonoids were present in all extracts except the aqueous extract. Similarly, proteins were found in all extracts except the petroleum ether extract. Quinones and alkaloids appeared in both acetone and benzene extracts, while saponins and essential oils were present in petroleum ether and benzene extracts. Carboxylic acids were identified in the aqueous and petroleum ether extracts, and resins were exclusive to the benzene extract. Earlier studies confirmed the phytochemical analysis of *Solanum trilobatum* leaves and fruits in chloroform, ethanol, and hexane extracts, highlighting their antimicrobial activity due to the presence of alkaloids, carbohydrates, cardiac glycosides, flavonoids, saponins, polyphenols, tannins, and terpenoids, with the absence of anthraquinones and steroids [29].

Preliminary phytochemical analysis of leaves extracted with chloroform, methanol, petroleum ether, and water revealed the presence of sugars, proteins, alkaloids, flavonoids, saponins, tannins, cardiac glycosides, terpenoids, and lipids, all possessing antibacterial activity (Doss and Rangasamydhanabalan, 2008). Carbohydrates were absent in all extracts. The benzene extract showed the highest number of phytoconstituents (13 out of 15 compounds), while the aqueous extract had the fewest. Literature review indicates that compared to the root, stem, and fruits of *Solanum trilobatum*, leaf extracts contain a wider range of secondary metabolites due to the abundance of nutrients during photosynthesis. The present study confirms that the leaves of *S. nigrum* and *S. trilobatum* produce diverse types of secondary metabolites.

## **Conclusion**

*Solanum trilobatum* is a highly medicinal plant containing various major phytochemicals that are unparalleled in curing a multitude of disorders and have great potential in maintaining human health. A thorough review of the available literature on



*Solanum trilobatum* reveals that it is a popular remedy among various ethnic groups, as well as Ayurvedic and traditional practitioners, for treating various ailments. The discovery and application of such natural drugs are expected to play a key role in both human and veterinary medicine in the future.

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## Optimizing light spectrum for growth and enhanced lipid production in *Tetraselmis* spp.: A Biochemical Analysis

J. N. Monisha<sup>1</sup> and A. Arockia Jenecius Alphonse<sup>2\*</sup>

<sup>1</sup>Reg. No 21212212262007, Full-time Research Scholar, Department of Botany,  
St. Mary's College (Autonomous), Thoothukudi,

Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli – 627012.

<sup>2</sup>Associate Professor of Botany, St. Mary's College (Autonomous), Thoothukudi,  
Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli – 627012.

Email: [jenosntg@gmail.com](mailto:jenosntg@gmail.com)

### Abstract

Light is a crucial factor influencing the growth and metabolic activities of microalgae. This research investigates the impact of different light color stresses (red, yellow, green, blue and white) on the lipid production of *Tetraselmis* spp. Cultures were exposed to these light conditions for a period of 21 days, and their growth rates, chlorophyll content, carbohydrate, and protein were monitored for every 3 days interval. During the stationary phase, *Tetraselmis* spp. were harvested and their biomass and lipid content were analysed. The red light shows maximum growth rate of 0.632 OD on 21<sup>st</sup> day when compared with other lights. The chlorophyll content was also influenced by the light color, with red light leading to a reduction in chlorophyll concentration, indicating a shift in metabolic pathways towards lipid biosynthesis. The biomass was high in blue light with 0.073 mg/mL and low in red light with 0.012 mg/mL. The results demonstrated that light color significantly affects lipid production in *Tetraselmis* spp. red light were found to be more effective in enhancing lipid accumulation compared to blue, green, white and yellow light. Red light shows highest lipid content of 25%, followed closely by blue light. These findings suggest that manipulating light spectra can be a practical approach to optimizing lipid production in *Tetraselmis* spp., offering potential benefits for sustainable biofuel production.

**Keywords:** *Tetraselmis* spp., lipid production, light color stress, microalgae, carbohydrate

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### Introduction

Microalgae are capable of converting radiation energy into chemical energy in the form of biomolecules, specifically carbohydrates, proteins and lipids. More than 40,000 microalgae species are known for their high biomass productivity, lipid content and secondary metabolite synthesis. Mostly green microalgae, known as oleaginous algae, are enriched with high amounts of lipids. Typically, they synthesize lipids in the form of membrane lipids, which consist of glycosyl glycerides found in chloroplasts and phosphoglycerides found in cell membranes and the endoplasmic reticulum (Guckert and Cooksey, 1990; Harwood, 1998; Wada and Murata, 1998). Due to the high lipid content, these microalgal species are of

great interest in the search for sustainable sources for the production of biodiesel (**Chi et al., 2019**). In brief, many parameters including lipid content, growth rate, fatty acid composition and cultivation condition should be considered to identify the most promising microalgal species and to maximize oil yield per unit area for biodiesel production (**Kumar et al., 2015**).

## **Materials and Methods**

### **Collection, isolation and identification of microalgae**

Water samples containing microalgae were collected from Vembar coast. The microalgae were isolated into F/2 medium and subcultured again and again to obtain pure culture. The microalgae were identified by referring research articles, monographs etc.

### **Effect of various colour filter light**

5 ml of pure culture of *Tetraselmis* spp. was inoculated into 250 ml flasks containing 95 ml of F/2 medium covered with different sets of coloured light (yellow, green, red, blue, and white). The light stressed *Tetraselmis* spp. was grown for 21 days at  $23 \pm 2^\circ\text{C}$  with a light-dark cycle of 16:8 hours. Regular shaking was performed to enhance growth and biomass production. Samples were harvested at 3 day intervals.

### **Measurement of growth (Panacha et al. 2015)**

The growth of algal strains was measured in a UV visible spectrophotometer at an optical density of 750 nm

### **Estimation of chlorophyll (Lichtenthaler et al. 1987)**

2 ml microalgae culture was centrifuged at 10,000 rpm for 5 minutes. The supernatant was poured away and the algae paste was mixed with 99.9% methanol and then incubated at room temperature for 24 hours without light.

### **Estimation of protein (Lowry, 1951)**

The *Tetraselmis* spp. were treated with trichloroacetic acid, followed by dissolution in sodium hydroxide and color development with alkaline reagent and Folin-Ciocalteu reagent, with absorbance measured at 750 nm

### **Estimation of carbohydrates (Dubois et al., 1956).**

1 mL of the sample with 4 mL of anthrone reagent, boiling for 15 minutes, cooling, and measuring absorbance at 620 nm

### **Biomass estimation (Richmond, 2004).**

*Tetraselmis* spp were harvested after 21 days, by centrifugation at 5000 rpm for 10 minutes, washed with distilled water, and freeze-dried. The dry weight of the biomass was determined gravimetrically

### **Lipid extraction (Bligh and Dyer, 1959)**

After 21 days, *Tetraselmis* spp. were harvested by centrifugation, washed, and then ground with 2: 1 chloroform and methanol.

### **FT – IR**

Microalgae lipids were subjected to FT-IR spectral analysis. The dried pellets were measured using FT-IR spectroscopy in the spectral range of 4000 – 400 cm with resolution of 4 cm. The results were compared with standard values and the functional groups were identified.

### **Result**

#### **Isolation and maintenance of pure microalgae culture**

Microalgae were collected from the Vembar coastline. One microalga was isolated and cultivated in a pure culture, sustained in F/2 medium. Morphological identification confirmed the isolated microalga as *Tetraselmis* spp.

#### **Effect of different wavelength on growth rate**

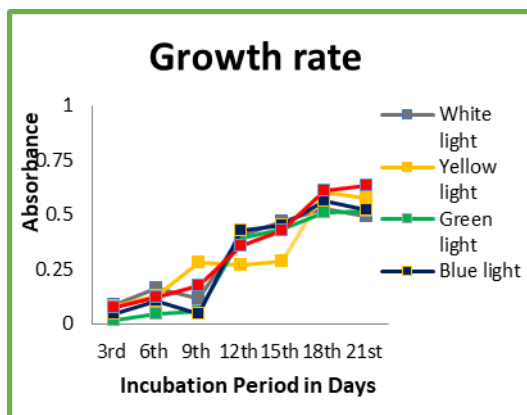
**Figure 1a** depicted the growth curve of *Tetraselmis* spp. under different light conditions over the course of 21 days cultivation period. In general, the optical density of batch cultures increased from day 1 to 18. Samples were taken from the cultures at 72-hour intervals. From the observed growth rates, *Tetraselmis* spp. exhibited superior growth under red light compared to other light sources. However, after day 18, the growth rate began to decelerate and eventually plateaued, likely due to nutrient depletion and the accumulation of waste in the culture medium.

#### **Effect of different wavelength on biochemical contents**

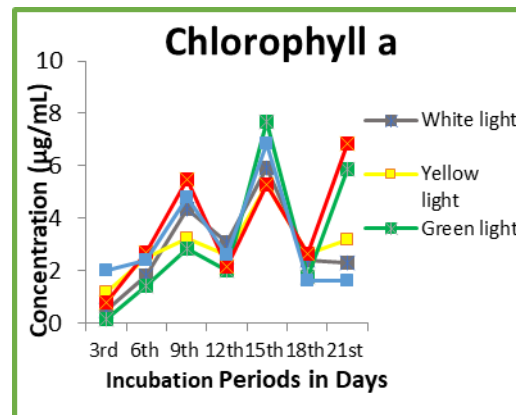
Light conditions also played a role in affecting the production of Chlorophyll “a” in *Tetraselmis* spp. The highest production was observed under green light (7.69 µg/mL) on the 15<sup>th</sup> day, followed by blue light (6.842 µg/mL) on the same day. However, there was a notable decrease in Chlorophyll “a” production after the 18<sup>th</sup> day of incubation. Interestingly, there was not a significant difference in Chlorophyll “a” production between cultures grown under yellow and red light compared to those grown under white light, as shown in **Figure 1b**. The highest production of chlorophyll "b" occurred under red light on the 9<sup>th</sup> day (10.57

$\mu\text{g/mL}$ ) and under yellow light on the 18<sup>th</sup> day (10.927  $\mu\text{g/mL}$ ). However, chlorophyll "b" production notably declined after the 9<sup>th</sup> day, as shown in **Figure 1c**. There wasn't significant variation in chlorophyll "b" production among the different light conditions tested, except under yellow light. The highest amount of carotenoid was observed under red light (4.84  $\mu\text{g/mL}$ ), with slightly lower level under white light (4.657  $\mu\text{g/mL}$ ) and followed by blue light (3.42  $\mu\text{g/mL}$ ) on the 9<sup>th</sup> day of incubation. Following this period, carotenoid production notably declined under all lights except yellow light (**Figure 1d**).

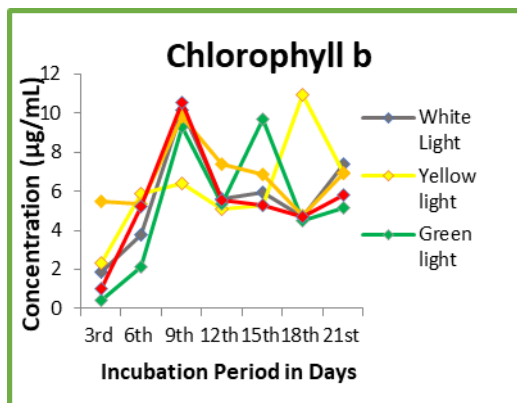
The biochemical composition was assessed during the logarithmic, stationary and decline phases of growth. Light variations affected the production of carbohydrates and proteins in *Tetraselmis* spp. The highest carbohydrate production was recorded under white light, followed by red, blue and yellow light on the 21<sup>st</sup> day of incubation (**Figure 1e**). Likewise, protein production peaked under white light, trailed by yellow, blue and red light on the 21<sup>st</sup> day of incubation as depicted in **Figure 1f**.



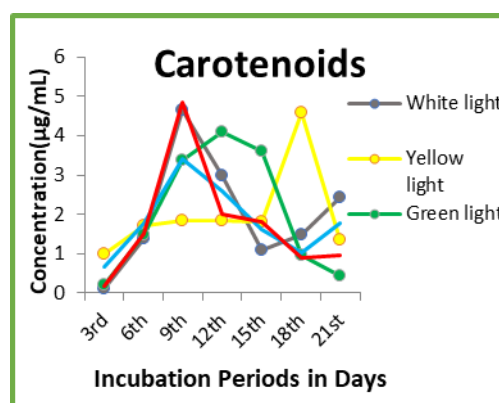
a) Growth rate



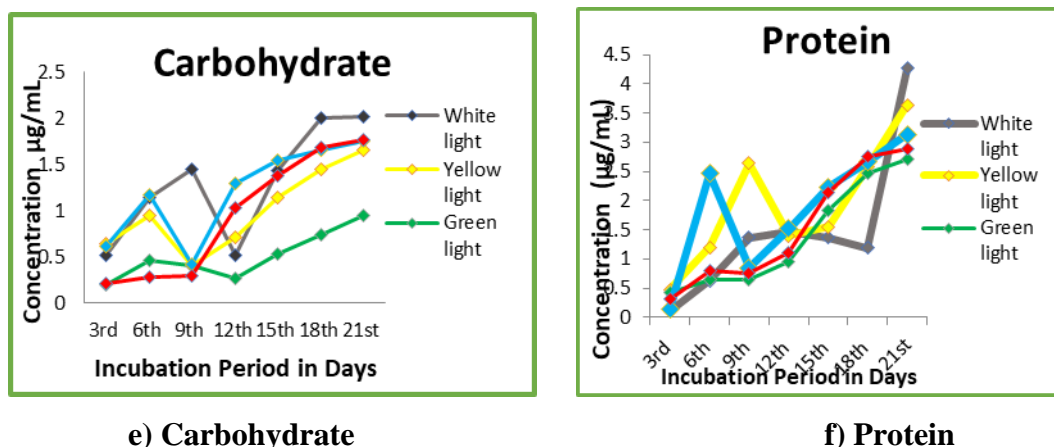
b) Chlorophyll a



c) Chlorophyll b



d) Carotenoids



**Figure 1: Effect on different wavelength on growth and biochemical contents**

**Table 1** outlines the impact of different wavelengths on the biomass and lipid content, in *Tetraselmis* spp. The greatest biomass was observed under yellow light (0.084 mg/mL), followed by blue light (0.073 mg/mL). Blue light exhibited the highest lipid content (45%), followed by red light (25%). Light is a crucial factor for formation of triacylglycerides and light wavelength required for different species vary from one another. In addition, fatty acid composition is different for different marine microalgae in response to different light wavelength exposures. **Khotimchenko and Yakovleva (2005)** also stated that light will stimulate triacylglycerides synthesis, formation of particularly chloroplast membranes and growth. Therefore, morphological change of marine microalgae will influence the overall lipid content (**Wahidin et al., 2013**).

**Table 1: Effect of different wavelength on biomass, lipid content on *Tetraselmis* spp.**

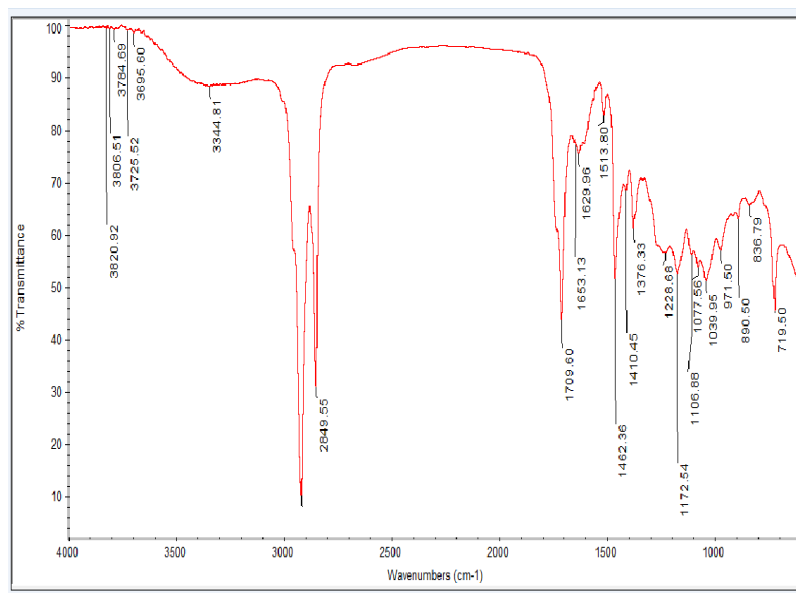
Wavelength	Biomass(mg/mL)	Lipid (%)
White light	0.023	11.84
Yellow light	0.084	3.33
Green light	0.023	11.3
Blue light	0.073	33.2
Red light	0.012	25

### Microalgal FTIR spectra

The FTIR absorption spectra of *Tetraselmis* spp. under varying light conditions were analyzed to observe their biomolecular transitions and lipid accumulation. The results were



illustrated through **Figures 2**. In this study, the vibrational stretching of the C=O bond at  $1172\text{ cm}^{-1}$  under red light was identified as originating from the ester bonds of fatty acids (**Table 2**). These findings find support in **Movasaghi et al., 2008**.



**Figure 2: FTIR spectrum of *Tetraselmis* spp. under red light**

**Table 2: FTIR analysis of *Tetraselmis* spp. under red light**

S. No.	Frequency range	Functional group	Compound
1	3695.50	O-H stretching	Alcohol
2	3344.81	O-H stretching	Alcohol
3	2849.55	C-H stretching	Alkane
4	1709.60	C=O stretching	Conjugated acid, conjugated aldehyde
5	1653.13	C=N stretching, C=C stretching	Imine/oxime, alkene
6	1629.96	C=C stretching	Conjugated alkene
7	1513.30	N-O stretching	Nitro compound
8	1462.36	None	None
9	1410.45	O-H bending, S=O stretching	Carboxylic acid, alcohol, sulfate
10	1376.33	O-H bending	Phenol
11	1228.68	C-O stretching	Alkyl aryl ether
12	1172.54	C-O stretching	Ester
13	1106.88	C-O stretching	Aliphatic ether
14	1077.56	C-O stretching	Primary alcohol
15	1039.95	S=O stretching	Sulfoxide

16	971.50	C=C bending	Alkene, disubstituted (trans)
17	890.50	C=C bending	Alkene, vinylidene
18	836.78	C=C bending, C-Cl stretching	Alkene, halo compound
19	719.50	C-H bending	Monosubstituted benzene derivative

### Conclusion

The study concluded that red light significantly enhances lipid accumulation in *Tetraselmis* spp., achieving the highest lipid content of 25%. Although red light resulted in the maximum growth rate (0.632 OD) on 21<sup>st</sup> day, biomass was higher under blue light (0.073 mg/mL) compared to red light (0.012 mg/mL). Overall, red light was found to be the most effective in promoting lipid production, surpassing other light colors. These findings can be a practical approach to optimizing lipid production in *Tetraselmis* spp., offering potential benefits for sustainable biofuel production in industry.

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## Potentiality of *Scenedesmus dimorphus* in degrading dibutyl adipate contamination in aquatic environment

G. Mary Stephy<sup>1,2</sup> and G. Flora<sup>1\*</sup>

<sup>1</sup>Department of Botany, St. Mary's College (Autonomous), Thoothukudi,  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

<sup>2</sup>Research Scholar, Registration No.: 21112212262010,  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

Email: [chandranflora@gmail.com](mailto:chandranflora@gmail.com)

### Abstract

Dibutyl adipate (DBA) is a plasticizer that negatively affects a variety of living things by penetrating aquatic environments. The purpose of this study was to determine whether the green microalgae *Scenedesmus dimorphus* NRMC-F 0174 could degrade DBA under in vitro condition, after being treated with it. *S. dimorphus* was treated with varying doses of DBA (0, 20, 40, 60, 80, and 100 mg L<sup>-1</sup>). The microalgae exhibited impressive tolerance up to a concentration of 80 mg L<sup>-1</sup>; however, the algae start to bleach or lose their ability to tolerate after that point. With the exception of 100 mg L<sup>-1</sup> treated flasks, no microalgae reached the stationary or death phases during the course of the 15-day incubation period. On the remaining medium from an experiment, GCMS analysis was performed to determine the chosen microalgal biodegradation capacity. DBA was not found in the samples, according to the chromatogram, indicating that the examined algae removed it from the medium. When compared to DBA, the chemicals that have been found are less hazardous or safer.

**Keywords:** Plasticizer, Non-phthalate, Dibutyl adipate, *Scenedesmus dimorphus*, Biodegradation

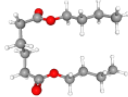
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### Introduction

A wide class of chemical additives known as plasticizers is applied to polymer materials to enhance their stability, pliability, transparency, and long-term dependability (Noorani *et al.*, 2024). These substances are commonly found in food packaging, children's toys, medical equipment, adhesives, and other products, as well as items composed of polyvinyl chloride (PVC). Plasticizer applications could involve over 30,000 distinct chemicals (Qadeer *et al.*, 2022). Common plasticizers known as phthalic acid esters (PAEs) are harm to living organisms. Because of their severe toxicity, non-phthalate plasticizers are used in place of PAEs (Nomura *et al.*, 2024). Food wrappers and films frequently use adipates, a class of non-phthalate plasticizers, as soft plasticizers (Vimalkumar *et al.* 2022). Dibutyl adipate (Table 1) is a diester formed by butyl alcohol and adipic acid that is utilised as a plasticizer, skin conditioner, and solvent in cosmetics formulas. Dibutyl adipate,

sometimes referred to as DBA or DnBA, is a cosmetic ingredient that can be found in various personal care products like nail polishes and sunscreens. It can also be used as a plasticizer in low-temperature applications (Andersen, 2006). Other commercial and industrial uses of DBA include adhesives, lubricants, polishes, fragrances, plant protection chemicals, and cleaning and washing materials. Adipate plasticizers have typically been connected to negative outcomes for the respiratory, endocrine, and reproductive systems of humans (Wei *et al.*, 2009). The environment must be free of plasticizer contamination in order to stop these unpleasant events. Therefore, the primary goal of the research is to use a green microalgal strategy to remediate DBA pollution.

**Table 1. Properties and negative impacts of dibutyl adipate**

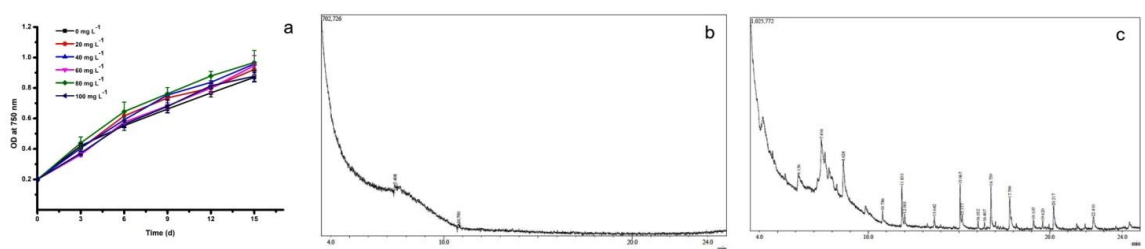
Properties	Dibutyl adipate	References
Molecular formula	C <sub>14</sub> H <sub>26</sub> O <sub>4</sub>	PubChem
Chemical structure		PubChem
Molecular weight	258.35 g/mol	PubChem
Negative impacts	Health hazard; environmental hazard; reproductive toxicity	National Research Council, 2011

### Materials and Methods

DBA with 99% purity were purchased from Sigma-Aldrich Co. (USA). 100,000 ppm stock DBA solution was prepared with ethanol and stored at 25°C prior to use. The freshwater microalgae *Scenedesmus dimorphus* NRMC-F 0174 was obtained from National Repository for Microalgae and Cyanobacteria - Freshwater (NRMC-F, Trichy, India). The culture was grown in sterile Chu's medium No. 10 (Chu, 1942) and kept inside the incubation room at 25±2°C, under a 16:8 light: dark cycle. Once the culture attained optical density 0.2 at 750 nm, the culture was treated with different concentrations such as 0, 20, 40, 60, 80 and 100 mg L<sup>-1</sup> of DBA. The experimental duration was 15 days and all experiments were likewise performed in triplicate. The cultures were shaken thrice per day manually. Microalgal growth was monitored based on optical density using UV-vis spectrophotometer (Deep vision) (Arutselvan *et al.*, 2021) and morphological changes and cell density were observed under compound microscope (Olympus). After 15 days of incubation, the microalgal culture was centrifuged and collected supernatant were performed liquid-liquid extraction for identifying degraded compounds. The biodegraded compounds were examined using gas chromatography and mass spectrometry (GCMS) instrument (GCMS-QP2020NX). The chromatogram was compared with biotic control and data were interpreted.

## Results and Discussion

Several concentrations of DBA were used to study the growth tolerance and these chemicals had an impact on *S. dimorphus* growth. In flasks containing algae treated with DBA at lower concentrations (80 (0.967±0.079 OD), 40 (0.958±0.01 OD), 60 (0.947±0.066 OD), 20 (0.922±0.006 OD), and biological control (0.87±0.031 OD) grew more quickly than algae treated with DBA at higher concentrations (Fig. 1a). These findings suggest that at higher concentrations, DBA alters aquatic flora metabolism and suppresses cell proliferation. Similar findings were obtained by Kurade *et al.* (2016), who discovered that at low concentrations (0.5, 5, and 20 mg/L), diazinon treatment enhanced the proliferation of *C. vulgaris* cells, but at high dosages (40 and 100 mg L<sup>-1</sup>), it inhibited it.



**Fig. 1 (a) Growth tolerance of *S. dimorphus* during DBA treatment; Gas Chromatogram of biological control (b) and degraded DBA compounds**

The use of phyco-remediation to break down DBA pollution is the focus of a subsequent research phase. Centrifugation was used to remove the residual medium at the end of the incubation period, and GCMS analysis was performed to identify any degraded products from DBA. The chromatogram showed that DBA was not present in the samples, proving that the algae under test had removed it from the media under *in vitro* condition (Fig. 1(b); 1(c)). In comparison to DBA, the chemicals found are either less hazardous or safer (Table 2). The derived compounds like heptadecane, cetene, tridecane, tetradecane, 1-pentadecane, 9-octadecane, undecene, and dodecane, cause mild health hazard. The compounds like Phenol, 2,5-bis(1,1-dimethylethyl)- Phenol, 2,5-di-tert-butyl- 2,5-Di-tert-butylphenol 2,5-bis(1,1-Dimethylethyl)phenol, 1-Hexanol, 2-ethyl- 2-Ethyl-1-hexanol 2-Ethylhexan-1-ol 2-Ethylhexanol Ethylhexanol 2-Ethylhexyl alcohol 2-Ethyl-hexanol-1, Oxirane, [(2-ethylhexyl)oxy]methyl]- [(2-Ethylhexyl)methyl]oxirane Propane, 1,2-epoxy-3-[(2-ethylhexyl)oxy]- 2-Ethylhexyl glycidyl, and 4H-Furo[3,2-b]pyrrole-5-carboxylic acid cause skin and eye irritation while handling. However, these side effects do not matter in comparison to DBA toxicity. The toxic impacts of DBA including infertility, endocrine

disruption, irritation, environmental danger, etc. were reported by previous studies. No significant chemicals were found in the biological control. A study of a similar nature was conducted by Petronijević *et al.* in 2024, who found that no BBP compound was found in the medium when they treated BBP with *Microcystis* sp., *Anabaena variabilis*, *Chlorella* sp., and *Scenedesmus* sp. Given that some phytoplankton species, such as cyanobacteria and green microalgae, have evolved defense mechanisms against organic contaminants, their activity is regarded as one of the most efficient methods of detoxifying the aquatic environment. The processes of biosorption, bioaccumulation, biomineralization, biotransformation, and biodegradation are some of the ways they function (Touilibah *et al.*, 2022). Thus, the current study shows that *S. dimorphus* has the ability to remediate DBA contamination in aquatic environments.

**Table 2. Compounds detected by GCMS (biotic control and *S. dimorphus* treated DBA derivatives)**

Detected compounds of biotic control on 15 <sup>th</sup> day		
Compound name	Formula	Toxic impacts
Benzeneethanamine, N-[(pentafluorophenyl)methylene]-.beta.,3,4-tris(trimethylsilyloxy)- N-(Pentafluorobenzylidene)-.beta.,3,4-tris(trimethylsilyloxy) phenylethylamine	$C_{24}H_{34}F_5NO_3Si_3$	ND
2-Hydrazinyl-5-nitropyridine, 3TMS derivative 2-Hydrazinyl-5-nitropyridine, N,N,N-tris-TMS 5-Nitro-2-(1,2,2-tris(trimethylsilyl)hydrazinyl)pyridine	$C_{14}H_{30}N_4O_2Si_3$	ND
Cyclopentasiloxane, decamethyl- Decamethyl cyclopentasiloxane Dimethylsiloxane pentamer Dekamethylcyklopentasiloxan CD3770 D3770 Decamethyl cylopentasiloxane	$C_{10}H_{30}O_5Si_5$	Health hazard
Cyclotetrasiloxane, octamethyl- Oktamethylcyklotetrasiloxan NUC Silicone VS 7207 CO9810 O9810 Octamethyltetrasiloxane 2,2,4,4,6,6,8,8-Octamethyl-1,3,5,7,	$C_8H_{24}O_4Si_4$	ND
<i>S. dimorphus</i> degraded compounds of DBA on 15 <sup>th</sup> day		
Compound name	Formula	Toxic impacts
Oxime-, methoxy-phenyl- Methyl N-hydroxybenzene	$C_8H_9NO_2$	ND

carboximidoate		
4-Ethylbenzoic acid, 2-pentyl ester 1-Methylbutyl 4-ethylbenzoate	C <sub>14</sub> H <sub>20</sub> O <sub>2</sub>	ND
4-Ethylbenzoic acid, cyclopentyl ester Cyclopentyl 4-ethylbenzoate	C <sub>14</sub> H <sub>18</sub> O <sub>2</sub>	ND
4H-Furo[3,2-b]pyrrole-5-carboxylic acid	C <sub>7</sub> H <sub>5</sub> NO <sub>3</sub>	Skin and eye irritant
1-Hexanol, 2-ethyl- 2-Ethyl-1-hexanol 2-Ethylhexan-1-ol 2-Ethylhexanol Ethylhexanol 2-Ethylhexyl alcohol 2-Ethyl-hexanol-	C <sub>8</sub> H <sub>18</sub> O	Skin and eye irritant
Oxirane, [[(2-ethyl hexyl) oxy] methyl]- [(2-Ethyl hexyl) methyl] oxirane Propane, 1,2-epoxy-3- [(2-ethyl hexyl) oxy]- 2-Ethylhexyl glycidyl	C <sub>11</sub> H <sub>22</sub> O <sub>2</sub>	Skin and eye irritant; sensitive to skin
1-Hexanol, 2-ethyl- 2-Ethyl-1-hexanol 2-Ethylhexan-1-ol 2-Ethylhexanol Ethyl hexanol 2-Ethylhexyl alcohol 2-Ethyl-hexanol-1	C <sub>8</sub> H <sub>18</sub> O	Behavioral change
Cyclopentasiloxane, decamethyl- Decamethyl cyclopentasiloxane Dimethyl siloxane pentamer Dekamethylcyklopentasiloxan CD377	C <sub>10</sub> H <sub>30</sub> O <sub>5</sub> Si <sub>5</sub>	Health hazard
Benzeneethanamine, N- [(pentafluorophenyl)methylene]-.beta.,3,4-tris[(trimethylsilyl)oxy]- N-(Pentafluorobenzylidene)-.beta.,3,4-tris(trimeth	C <sub>24</sub> H <sub>34</sub> F <sub>5</sub> NO <sub>3</sub> Si <sub>3</sub>	ND
N-(Trifluoroacetyl)-N,O,O',O"- tetrakis(trimethylsilyl)norepinephrine N-(2-(3,4-Bis[(trimethylsilyl)oxy]phenyl)-2-[(trimethylsilyl)oxy]ethyl)-2	C <sub>22</sub> H <sub>42</sub> F <sub>3</sub> NO <sub>4</sub> Si <sub>4</sub>	ND
1-Dodecene.alpha.- Dodecene n-Dodec-1-ene Adacene 12 Dodec-1-ene.alpha.-Dodecylene Dodecylene .alpha.-Dodecene	C <sub>12</sub> H <sub>24</sub>	Skin corrosion; health hazard
Dodecane n-Dodecane Adakane 12 Ba 51-090453 CH <sub>3</sub> (CH <sub>2</sub> ) <sub>10</sub> CH <sub>3</sub> Bihexyl Dihexyl Duodecane NSC 8714	C <sub>12</sub> H <sub>26</sub>	Dermal irritation; health hazard
Undecane n-Undecane Hendecane n-C <sub>11</sub> H <sub>24</sub> UN 2330	C <sub>11</sub> H <sub>24</sub>	Health hazard
Cyclohexasiloxane, dodecamethyl- Dodecamethyl cyclohexasiloxane2,2,4,4,6,6,8,8,10,10,12,12-Dodecamethyl cyclohexasiloxane	C <sub>12</sub> H <sub>36</sub> O <sub>6</sub> Si <sub>6</sub>	Eye irritant



1,1,1,3,5,7,9,11,11,11-Decamethyl-5-(trimethylsiloxy)hexasiloxane 1,1,1,3,5,7,9,11,11,11-Decamethyl-5-[(trimethylsilyl)oxy] hexasiloxane	C <sub>13</sub> H <sub>42</sub> O <sub>6</sub> Si <sub>7</sub>	ND
Heptasiloxane, 1,1,3,3,5,5,7,7,9,9,11,11,13,13-tetradecamethyl- 1,1,3,3,5,5,7,7,9,9,11,11,13,13-Tetradecamethylheptasiloxane	C <sub>14</sub> H <sub>44</sub> O <sub>6</sub> Si <sub>7</sub>	ND
9-Octadecene, (E)- (9E)-9-Octadecene (E)-9-Octadecene trans-9-Octadecene	C <sub>18</sub> H <sub>36</sub>	Health hazard
1-Tridecene n-Tridec-1-ene 1-C <sub>13</sub> H <sub>26</sub> Tridecene-1.alpha.-Tridecene Tridec-1-ene	C <sub>13</sub> H <sub>26</sub>	Health hazard; irritant
1-Pentadecene Pentadecene,1- Pentadec-1-ene	C <sub>15</sub> H <sub>30</sub>	Hazard; irritant
1-Tetradecene n-Tetradec-1-ene.alpha.-Tetradecene Neodene 14 Tetradec-1-ene Tetradecene-1	C <sub>14</sub> H <sub>28</sub>	Irritant; health hazard
Tetradecane n-Tetradecane	C <sub>14</sub> H <sub>30</sub>	Health hazard
Hexadecane n-Cetane n-Hexadecane Cetane	C <sub>16</sub> H <sub>34</sub>	Health hazard
Tridecane n-Tridecane Tridecane, n-	C <sub>13</sub> H <sub>28</sub>	Health hazard
Cycloheptasiloxane, tetradecamethyl- 2,2,4,4,6,6,8,8,10,10,12,12,14,14-Tetradecamethylcycloheptasiloxane Tetradecamethylcyclohept	C <sub>14</sub> H <sub>42</sub> O <sub>7</sub> Si <sub>7</sub>	ND
3-Isopropoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(trimethylsiloxy)tetrasiloxane 1-Isopropoxy-3,3,3-trimethyl-1-[(trimethylsilyl)oxy]disiloxanyl	C <sub>18</sub> H <sub>52</sub> O <sub>7</sub> Si <sub>7</sub>	ND
3-Butoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(trimethylsiloxy)tetrasiloxane 1-Butoxy-3,3,3-trimethyl-1-[(trimethylsilyl)oxy]disiloxanyl tris(trimethylsilyl	C <sub>19</sub> H <sub>54</sub> O <sub>7</sub> Si <sub>7</sub>	ND
3-Ethoxy-1,1,1,7,7,7-hexamethyl-3,5,5-tris(trimethylsiloxy)tetrasiloxane 1-Ethoxy-3,3,3-trimethyl-1-[(trimethylsilyl)oxy]disiloxanyl tris(trime	C <sub>17</sub> H <sub>50</sub> O <sub>7</sub> Si <sub>7</sub>	ND
10-Methylnonadecane Nonadecane, 10-methyl	C <sub>20</sub> H <sub>42</sub>	ND
2,3-Dimethyldodecane	C <sub>14</sub> H <sub>30</sub>	ND
2,4-Di-tert-butylphenol Phenol, 2,4-bis(1,1-dimethylethyl)- Phenol, 2,4-di-tert-butyl-2,4-di-t-Butylphenol 1-Hydroxy-2,4-di-tert-bu	C <sub>14</sub> H <sub>22</sub> O	Skin and eye irritant

E-14-Hexadecenal Hexadecenal, (E)-	(14E)-14-Hexadecenal	14-	C <sub>16</sub> H <sub>30</sub> O	ND
9-Eicosene, (E)-	(9E)-9-Icosene		C <sub>20</sub> H <sub>40</sub>	ND
Cetene 1-Hexadecene 1-ene 1-Cetene Hexadecene-1 N	.alpha.-Hexadecene Hexadecylene-1 Hexadec-1-ene	n-Hexadec-1-ene	C <sub>16</sub> H <sub>32</sub>	Health hazard
11-Methyltricosane	Tricosane, 11-methyl-	11-Methyl-n-tricosane	C <sub>24</sub> H <sub>50</sub>	ND
Heneicosane	n-Heneicosane	Henicosane	C <sub>21</sub> H <sub>44</sub>	Eye and skin irritant
Pentadecane, Hexylpentadecane	8-hexyl-	8-n-Hexylpentadecane	C <sub>21</sub> H <sub>44</sub>	ND
Tridecanol, tridecanol	2-ethyl-2-methyl-	2-Ethyl-2-methyl-1-	C <sub>16</sub> H <sub>34</sub> O	ND
Triacontane, 1-iodo-			C <sub>30</sub> H <sub>61</sub> I	ND
Nonadecane	n-Nonadecane		C <sub>19</sub> H <sub>40</sub>	ND
Heptadecane	n-Heptadecane	Normal-heptadecane	C <sub>17</sub> H <sub>36</sub>	Health hazard
n-Nonadecanol-1 Nonadecan-1-ol	1-Nonadecanol Nonadecyl alcohol	Nonadecanol	C <sub>19</sub> H <sub>40</sub> O	ND
Z-5-Nonadecene	(5Z)-5-Nonadecene		C <sub>19</sub> H <sub>38</sub>	ND
Bromoacetic acid, bromoacetate	pentadecyl ester	Pentadecyl	:C <sub>17</sub> H <sub>33</sub> BrO <sub>2</sub>	ND

(\*ND- Not detected)

### Conclusion

In the current study, the degradation and eradication of DBA contamination through specific green microalgal communication was examined using an algae-based DBA remediation approach. It is possible for *S. dimorphus* to tolerate environmental contamination. As a result, our study suggested that *S. dimorphus* be used to treat DBA pollution in aquatic environments. Based on these findings, it may be concluded that phycoremediation holds great promise for the near future restoration of contaminated areas.

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## Explore few botanical gardens of the Kanyakumari district to identify and document medicinal plants

<sup>1</sup>Bojaxa A. Rosy\*, <sup>1</sup>Florence AR, <sup>2</sup>Bashidha Banu S, <sup>3</sup>Rashma M, <sup>3</sup>Asmitha M.,  
<sup>3</sup>Avanya R., <sup>3</sup>Nava Pooja B, <sup>3</sup>Sreeja S. & TF Abbs Fen Reji

<sup>1</sup>Assistant Professor of Botany, <sup>2</sup>Research Scholar, <sup>3</sup>B.Sc. Students  
Holy Cross College (Autonomous), Nagercoil – 629004.

<sup>4</sup>Assistant Professor of Botany, Nesamony Memorial College, Marthandam- 629165.

Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

Email: [bojaxarosy@holycrossncl.edu.in](mailto:bojaxarosy@holycrossncl.edu.in)

### Abstract

Botanical gardens serve as essential reservoirs of biodiversity, particularly for plant species with ecological, cultural, and medicinal importance. This field project focuses on the botanical gardens in Kanyakumari district, at the southern tip of India, to identify and document medicinal plants. Leveraging the region's tropical climate and diverse topography, the study explores the relationships between plants and their therapeutic uses, alongside the cultural heritage of traditional medicine. Through systematic documentation and ethnobotanical surveys, the project aims to preserve traditional knowledge and emphasize the role of botanical gardens in conserving plant biodiversity. The results highlight a rich diversity of medicinal plants used for various ailments, reflecting deep-rooted traditional healing practices. The conservation status of these plants underscores the significance of botanical gardens in safeguarding medicinal species. Strategies for conservation, sustainable utilization, and the promotion of traditional medicinal practices are discussed, affirming the critical role of botanical gardens in both research and education.

**Keywords:** Medicinal Plants, Ethnobotanical Knowledge, Conservation, Botanical Gardens, Kanyakumari

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### Introduction

Botanical gardens serve as invaluable repositories of biodiversity, housing a plethora of plant species with diverse ecological, cultural, and medicinal significance. In the scenic district of Kanyakumari, situated at the southernmost tip of the Indian subcontinent, lies a treasure trove of botanical wonders waiting to be explored and documented. This field project aims to delve into select botanical gardens within Kanyakumari district, with a specific focus on identifying and documenting medicinal plants.

The rich flora of Kanyakumari district, influenced by its tropical climate and varied topography, harbors numerous plant species known for their medicinal properties. These gardens provide an ideal setting for studying the intricate relationships between plants and

their therapeutic uses, as well as for understanding the cultural heritage associated with traditional medicinal practices in the region.

Through systematic exploration and documentation, this project seeks to contribute to the preservation of traditional knowledge related to medicinal plants, as well as to highlight the conservation importance of botanical gardens in safeguarding plant biodiversity.

Traditional system of herbal medicine utilizes cultural knowledge and practices for the maintenance of human health. This knowledge on medicinal plants is passed verbally from one generation to other and is still maintained by various indigenous groups. Hence, there is a necessity to document this knowledge of traditional medicinal plant practice for the discovery and development of drugs in future [1-3] Ethnobotanical knowledge on medicinal plants from different parts of India has been documented [4-7].

Ethnobotanical value of medicinal plants possessed by various tribals and rural communities were studied to a certain extent only in Tamil Nadu [8-10] Scrutiny of these reports put forward the fact that the ethnobotanical knowledge on medicinal plants used to treat urinary tract infections in Tamil Nadu is inadequate, especially in Kanyakumari district is found to be sparse.

Hence, this study was conducted to explore the indigenous knowledge of medicinal flora used in Kanyakumari district.

## **Materials and Methods**

### **Selection of Botanical Gardens**

A thorough survey will be conducted to identify and select botanical gardens within Kanyakumari district that are accessible and possess a diverse range of plant species.

### **Plant Identification**

Standard taxonomic literature, and digital resources will be utilized to identify plants at the species level.

### **Documentation of Medicinal Plants**

Each identified plant species will be meticulously documented, focusing on their botanical name, medicinal properties, traditional uses and parts used. Information will be gathered through literature review.

### **Data Collection**

Data on each medicinal plant species will be systematically recorded, including botanical name, common name, habit, medicinal uses and parts used. Field notes and photographs, and sketches will be utilized for comprehensive documentation.

### **Ethnobotanical Surveys**

Ethnobotanical surveys will be conducted in collaboration with local communities to gather traditional knowledge and practices related to medicinal plants.

### **Data Analysis**

Collected data will be organized and analyzed to identify patterns, trends, and relationships among medicinal plant species.

### **Results and Discussion**

#### **Diversity of Medicinal Plants**

The survey of botanical gardens in Kanyakumari district revealed a rich diversity of medicinal plant species, with diverse species of medicinal plants identified across five gardens. This diverse assemblage included plants belonging to various families.

#### **Traditional Uses and Ethnobotanical Knowledge**

Ethnobotanical surveys conducted with local communities uncovered a wealth of traditional knowledge regarding the medicinal properties and uses of identified plant species. The plants were found to be utilized in the treatment of various ailments including digestive disorders, respiratory ailments, skin conditions, fevers etc reflecting the deep-rooted traditional healing practices prevalent in the region.

#### **Conservation Status and Threats**

Assessment of the conservation status of medicinal plants highlighted the importance of botanical gardens in conserving medicinal species.

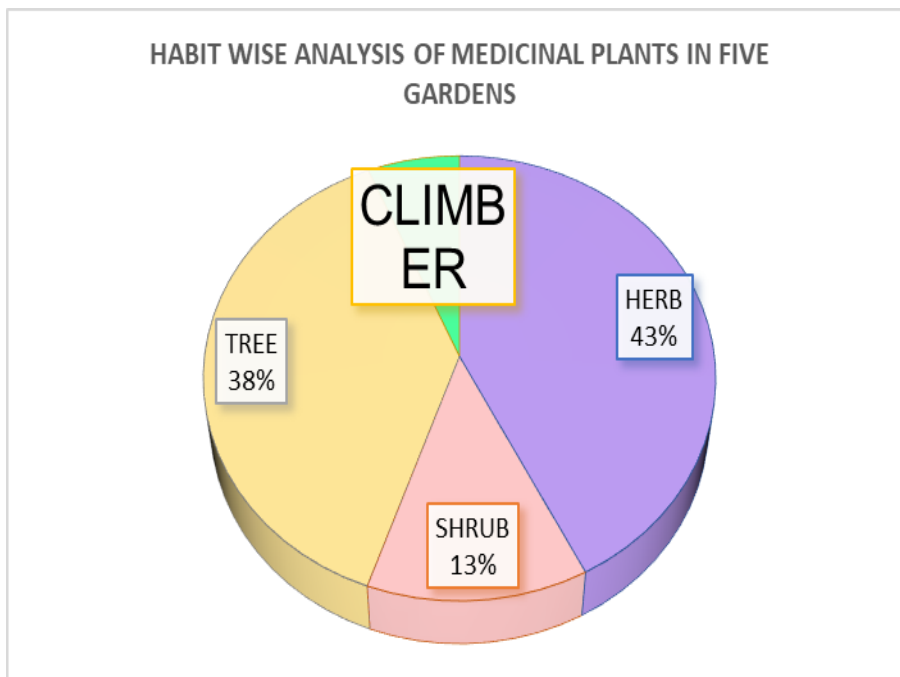
#### **Conservation and Sustainable Utilization**

The findings underscored the significance of conserving medicinal plant biodiversity in botanical gardens for sustainable utilization and medicinal purposes. Strategies for conservation, including habitat restoration, propagation through seed banks and nurseries, and community-based conservation initiatives, were discussed. Emphasizing the sustainable harvesting and cultivation of medicinal plants in botanical gardens can contribute to their conservation while promoting their continued use for healthcare and cultural purposes.

### Role of Botanical Gardens in Medicinal Plant Conservation

Botanical gardens were recognized as vital institutions for the conservation of medicinal plant diversity, providing a controlled environment for research and education.

From the study, it can be observed that medicinal florae play a vital role in the lives of the indigenous population of the district. Graph 1 showed the habit wise analysis of the data revealed the dominance of herbs, followed by trees, shrubs and climbers.



**Tables 1-5 provides a concise overview of the plant diversity, list of medicinal plants, habits and useful part for each of the five botanical gardens surveyed in the Kanyakumari district.**

<b>Table 1. Mariya Nursery Garden, Nagercoil</b>					
Sl. No	Common name	Botanical name	Medicinal Uses	Habits	Useful Part
1	sweet flag, sway	<i>Acorus calamus</i>	Anti asthmatic	Herb	Leaf
2	Bekand	<i>Justicia adhatoda</i>	Anti asthmatic	Herb	Rhizome



3	Bilva	<i>Aegle marmelos</i>	diarrhea and dysentery	Tree	Underground stem
4	Yarrow Plant	<i>Achillea millefolium</i>	Carminative	Herb	Leaf
5	English walnut or Persian walnut	<i>Juglans regia</i>	Anti-asthmatic	Tree	Bark
6	Arjuna	<i>Terminalia arjuna</i>	Heart health and cardiovascular	Tree	Leaves and stem
7	Italian jasmine or yellow jasmine	<i>Jasminum humile</i>	Dermatitis	Tree	Flower
8	Lemongrass	<i>Cymbopogon citratus</i>	Aromatherapy	shrub	Root
9	Royle's spike Thorn	<i>Gymnosporia royleana</i>	Pain killer	Herb	Fruit
10	Nelini	<i>Indigofera Linifolia</i> (L.)	Febrifuge	Shrub	Whole plant

**Table 2. Vivekandanada Kendra Botanical Garden, Kaniyakumari**

Sl. No	Common name	Botanical name	Medical uses	Habits	Useful parts
1.	Moringa leaves	<i>Moringa oleifera</i>	Anemia, improve hemoglobin	Evergreen, woody, perennial broadleaf tree	Leaves and flower
2.	Agathi keerai	<i>Sesbania grandiflora</i>	Healing wounds, itches and bruises	Evergreen legume tree	Leaves
3.	Mountain knotgrass	<i>Aerva lanata</i>	Treatment of lithiasis, cough, asthma, headache	Herb	Whole plant
4.	Banana stem	Musa genus	Production of insulin and hemoglobin,	Clumped in habit	Stem

			controlling blood pressure		
5.	Avaram poo	<i>Cassia auriculata</i>	Diabetes and all skin problem	A much branched shrub	Roots, leaves, flower buds
6.	White chaste tree	<i>Vitex negundo</i>	Sinusitis, headache, muscle aches	A small tree with square, white, hairy stem	Leaf, roots, fruits, seeds, leaf oil
7.	Veld grape	<i>Cissus quadrangularis</i>	hemorrhoids and piles, improves digestion, and reduces inflammation	Climber	Stem and root
8.	Papaya leaves	<i>Carica papaya</i> L.	reducing inflammation, improving blood sugar control, supporting skin and hair health, and preventing cancer	monopodial softwood tree	Leaves
9.	Thick leaved Lavender	<i>Plectranthus amboinicus</i>	chest congestion and other respiratory issues	sprawling, perennial herb with short hairs and fleshy stems	Leaves
10.	Betel leaves	<i>Piper betle</i>	a stimulant, an antiseptic, and a breath-freshener	Climber	Leaves

**Table 3. Eco Park, Kaniyakumari**

Sl. No	Common name	Botanical name	Medicinal Uses	Habit	Useful Part
1	Adathoda	<i>Justicia adathoda</i> L.	Asthma, Bronchitis, Cough.	Shrub	Leaves and stem
2	Karisalankanni	<i>Eclipta prostrata</i> L.	Hair growth, Liver health.	Herb	Leaves bark and seed
3	Periwinkle	<i>Catharanthus roseus</i>	Diabetes and High blood Pressure.	Herb	Leaves

4	Lemongrass	<i>Cymbopogon citrus</i>	Make herbal tea or for Aromatherapy	Herb	Root
5	Vetiver	<i>Chrysopogon zizanioides</i>	Cooling Properties in traditional medicine and often used in perfumes and aromatherapy	Herb	Underground stem
6	Bilva	<i>Aegle marmelos</i>	Diarrhoea and dysentery.	Tree	Underground stem
7	Guduchi	<i>Tinospora cordifolia</i>	Immune boosting Properties	Tree	Leaves
8	Guggul	<i>Commiphora wightii</i>	Arthritis, obesity,	Tree	Fruit
9	Karpooravalli	<i>Coleus amboinicus</i>	Cough and colds	Herb	Root
10	Arjuna	<i>Terminalia arjuna</i>	Heart health and manage cardiovascular.	Tree	Leaves and stem

**Table 4. Arul Vini Nursery Garden, Aasaripallam, Nagercoil**

Sl. No	Common name	Botanical name	Medicinal Uses	Habit	Useful Part
1	Tulsi	<i>Ocimum sanctum</i>	Cough, cold	herb	Leaves, stem and entire part
2	Neem	<i>Azadirachta indica</i>	Antifungal	Tree	Leaves, bark and seed
3	Aloe	<i>Aloe Barbadosis</i> Miller	Skin diseases, Burns and Wounds	Herb	Leaves
4	Indian sarasaparila	<i>Hemidesus indicus</i>	Blood purification, skin disease	Climber	Root
5	Ginger	<i>Zingiber officinale</i>	Anti-inflammatory, digestive, nausea	Herb	Underground stem

6	Turmeric	<i>Curcuma longa</i>	Anti-inflammatory, arthritis, Skin diseases	Herb	Underground stem
7	Curry leaves	<i>Murraya koenigii</i>	Skin diseases, digestive issues	Tree	Leaves
8	Indian gooseberry	<i>Phyllanthus emblica</i>	Immune boosting, beneficial for skin and health	Tree	Fruit
9	Ashvagandha	<i>Withania somnifera</i>	Reduce stress improve function enhance vitality	Shrub	Root
10	Brahmi	<i>Bacopa monnieri</i>	Enhance memory and reduce anxiety and stress	Herb	Leaves and stem

**Table 5. Usha Nursery Garden, Rajakkamagalam, Ganapathipuram**

Sl. No	Common name	Botanical name	Medicinal Uses	Habit	Useful Part
1.	Ghoz	<i>Jusglsns regis</i>	Anti_asthmatic	Tree	Bark
2.	Nelini	<i>Indigofera linifoliya</i>	Febrifuge	Shrub	Whole plant
3	Arjuna	<i>Terminalis arjuna</i>	Heart health and manage cardiovascular	Tree	Leave stem
4	Karpooravali	<i>Coleus ambionicus</i>	Cough and colds	Herp	Root
5	Nochi	<i>Vitex negundo</i>	Cold and fever	Tree	Leaf
6	Holy basil	<i>Ocimum tenuiflorum</i>	Cough, cold, reduce stress, joint pain	Herb	Leaf
7	Aloe	<i>Aloe barbadensis</i>	Blood sugar, hair growth, constipation, canker sores, wound healing	Herb	Gel

8	Ginger	<i>Zingiber officinale</i>	cancer, weight loss Aid, Nausea and upset stomach	Herb	Underground stem
10	Black night shade	<i>Solanum nigrum</i>	Muscle relaxer, anti-inflammatory, cough and hay fever	Herb	Leaf and stem

### Summary and Conclusion

The exploration of botanical gardens in Kanyakumari district has provided valuable insights into the rich diversity of medicinal plant species and traditional knowledge associated with their uses. A lot of species were identified across five botanical gardens, reflecting the region's botanical wealth and cultural heritage.

Ethnobotanical surveys revealed a deep-rooted tradition of utilizing medicinal plants for treating various ailments within local communities. This traditional knowledge passed down through generations, underscores the importance of conserving medicinal plant biodiversity for sustainable healthcare practices.

The conservation status assessment highlighted the importance of botanical gardens in conserving threatened medicinal plant species. Strategies for conservation, including ex-situ propagation, habitat restoration, and community-based initiatives, were discussed to address the challenges posed by habitat loss and overharvesting.

Botanical gardens were recognized as crucial institutions for the conservation and sustainable utilization of medicinal plants, serving as centers for research, education, and public engagement. Their role in preserving traditional knowledge, supporting research, and promoting conservation efforts was emphasized.

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## Comparative Assessment of Phytochemical Profiling in Fresh and Dried *Phyllanthus emblica* L. Fruit Extracts Using Diverse Solvents

Bashidha Banu S<sup>1</sup>, Bojaxa A. Rosy<sup>2</sup> and Florence AR<sup>3</sup>

<sup>1</sup> Research Scholar, <sup>2,3</sup> Assistant professor,  
Department of Botany and Research Centre,  
Holy Cross College (Autonomous), Nagercoil - 629002.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.  
Email: [bashidha1998@gmail.com](mailto:bashidha1998@gmail.com)

### Abstract

*Phyllanthus emblica* L., commonly known as Indian gooseberry or amla, is a medicinal plant with a wide range of therapeutic activities. It holds significant value in Unani and Ayurvedic medicine systems. This study aimed to compare the preliminary phytochemical activities of fresh and dried fruits of *Phyllanthus emblica* L. using different solvents including acetone, benzene, ethanol, chloroform, and aqueous solutions. The extracts were analyzed to identify and quantify the presence of phytochemical compounds. The phytochemical analysis revealed that fresh fruit extracts in benzene and ethanol exhibited the highest concentration of bioactive compounds. The dried fruit extracts, while also rich in phytochemicals, showed a comparatively lower concentration than the fresh fruit extracts. The study concluded that fresh fruits of *Phyllanthus emblica* L. have a higher phytochemical activity when extracted with benzene and ethanol, compared to their dried counterparts. These findings highlight the potential of fresh *Phyllanthus emblica* L. fruit extracts, particularly in benzene and ethanol, for developing natural remedies and health products, thereby contributing to global health and wellness.

**Key words:** *Phyllanthus emblica*, Phytochemicals, solvents, extracts.

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### Introduction

Medicinal plants have been integral to human healthcare for centuries, offering a natural source of remedies for a wide range of ailments. The therapeutic properties of medicinal plants are attributed to their active compounds, which have been scientifically studied and validated for their efficacy. These compounds can exhibit antioxidant, anti-inflammatory, antimicrobial, and anti-cancer activities, among others [1]. They are economically valuable as they provide raw materials for the pharmaceutical, cosmetic, and food industries and also support local economies through the trade of herbal products [2].

These plants provide remedies for a variety of health conditions. They have properties that help in preventing diseases by boosting the immune system and improving overall health. They offer a holistic approach to health, addressing the physical, mental, and emotional aspects of well-being. The increasing demand for medicinal plants necessitates

sustainable harvesting and conservation practices to ensure their availability for future generations [3]. Overharvesting and habitat destruction pose significant threats to many medicinal plant species. Population, particularly in rural areas, depends heavily on herbal remedies for treating various diseases, underscoring the importance of these plants in the healthcare system [4].

*Phyllanthus emblica* L. (amla), a medicinal plant in the family Euphorbiaceae, is cultivated in tropical and subtropical regions, including India. Traditionally used in the Indian healthcare system to treat various illnesses, amla exhibits numerous biological activities such as antioxidant, anti-cancer, anti-diabetic, anti-inflammatory, and antimicrobial effects [5] & [6]. It is also effective in treating gastric ailments, demonstrating adaptogenic activity, and promoting health and longevity. It is also rich source of nutrients, including amino acids, vitamins, carbohydrates, alkaloids, and phenolic acids. Various parts of the amla plant, especially the fruit, have been extensively studied and reported to possess a range of pharmacological activities for the prevention and treatment of diseases [7].

Due to fluctuations in fruit productivity and the timing of fruiting, other parts of the amla plant have been investigated as substitutes for the fruit. Studies have shown that amla branches are a promising alternative, with potential applications in natural healthcare products. This expands the scope of amla's utilization, ensuring a consistent supply of its beneficial properties regardless of seasonal variations in fruit availability. Ongoing research aims to discover new medicinal plants and understand the mechanisms of their bioactive compounds. This research is crucial for developing new drugs and improving existing treatments.

## **Materials and Methods**

Fresh fruits of *Phyllanthus emblica* L. were collected from the selected sites of Kanyakumari District, Tamil Nadu, India. A portion of the fresh fruits was dried using a dehydrator at 40°C until completely dry. Both fresh and dry fruits were ground into a fine powder and extracted using soxhlet apparatus using acetone, benzene, ethanol, chloroform and aqueous solvents.

Preliminary phytochemical investigations for detection of specific compounds present in plants as per the standard methods prescribed by [8]. Tests for alkaloids, flavonoids, phenols, saponins, steroids, terpenoids, tannins, glycosides, reducing sugars, phytosterols, carbohydrates and proteins would be performed.



### **Test for Alkaloids**

**Mayer's test:** 2 ml of each extracts were treated with 2 ml of Mayer's reagent. Formation of yellow precipitate indicated the presence of alkaloids.

### **Test for Flavonoids**

**Lead Acetate Test:** 2 ml of each extracts were treated with few drops of lead acetate solution. Formation of yellow precipitate showed the presence of flavonoids.

### **Test for Phenols**

2ml of each extracts was added with few drops of 10% lead acetate solution. Formation of white precipitate indicated the presence of phenol.

### **Test for Saponins**

**Foam Test:** Each fruit extracts were shaken vigorously with 2 ml of water. If the foam produced persisted for 10 min it indicated the presence of saponins.

### **Test for Steroids**

**Salkowski Test:** To 2 ml of each extracts, 2 ml of chloroform and 2 ml of conc. H<sub>2</sub>SO<sub>4</sub> were added. The solution was shaken well. Formation of red chloroform layer and greenish yellow acid layer indicated the presence of steroids.

### **Tests for Terpenoids**

2 ml of each extracts, 2 ml of chloroform was added. Concentrated H<sub>2</sub>SO<sub>4</sub> (3 ml) was carefully added to form a layer. A reddish brown coloration at the interface indicated the presence of terpenoids.

### **Test for Tannins**

2 ml of each extracts were boiled in 10 ml of distilled water in a test tube and then filtered. A few drops of 0.1% ferric chloride was added and observed for brownish green or a blue-black coloration which was taken as evidence for the presence of tannins.

### **Tests for Glycosides**

2 ml of each extracts was dissolved in 2 ml of chloroform. Then 2 ml of concentrated H<sub>2</sub>SO<sub>4</sub> was added carefully and shaken gently. A reddish brown colour indicated the presence of a steroidal ring.

### **Test for reducing sugar**

2ml of each extracts is added with 1 ml of distilled water. Then 5-8 drops of Fehling's solution is added. Formation of brick red precipitate indicated the presence of reducing sugar.

### **Tests for Phytosterols**

2 ml of each extracts were dissolved in 2 ml of chloroform and was subjected to the salkowski test. 1ml of conc. H<sub>2</sub>SO<sub>4</sub> was added to the stock solution and allowed to stand for 5 minutes. After shaking, the turning of golden yellow colour in the lower indicated the presence of phytosterols.

### **Tests for Carbohydrates**

**Benedict's test:** To 1 ml of each filtrate, 5 ml of Benedict's reagent were added. The mixture was heated. Appearance of red precipitate indicated the presence of carbohydrates.

### **Tests for Proteins**

2 ml of each extracts were treated with 2 ml of 10% NaOH solution in a test tube and heated for 10 minutes. A drop of CuSO<sub>4</sub> solution was added in the mixture. Formation of purple violet colour indicated the presence of proteins.

### **Results and Discussion**

The phytochemical analysis of *Phyllanthus emblica* L. fruit extracts in various solvents was conducted. The results were illustrated in Table 1 and Figure 1. Acetone, Benzene, ethanol, chloroform and aqueous were the solvents used for the investigation. All the solvents showed better results except chloroform which showed least number of Phytochemicals in both fresh and dried fruit samples. The benzene extracts of fresh fruit samples exhibited the highest number(11) of phytochemical compounds, followed closely by the aqueous extracts (10). In contrast, dried fruit samples showed the maximum number of phytochemicals in both benzene (9) and aqueous (9) extracts. Benzene extracts demonstrated the presence of a broad spectrum of phytochemicals, including alkaloids, flavonoids, phenols, saponins, terpenoids, tannins, glycosides, reducing sugars, phytosterols, and carbohydrates, in both fresh and dried samples.

Both fresh and dried fruit extracts revealed the presence of alkaloids, with the dried fruit extracts exhibiting a higher concentration in ethanol. Flavonoids were found to be more abundant in the dried fruit extracts compared to the fresh ones, particularly in the ethanol extracts. Both fresh and dried forms demonstrated a significant presence of tannins and saponins in the aqueous extracts, with the fresh fruits showing a slightly higher tannin content. Glycosides were more concentrated in the methanol extracts of the dried fruits compared to the fresh fruits. Terpenoids were moderately present in the hexane extracts of

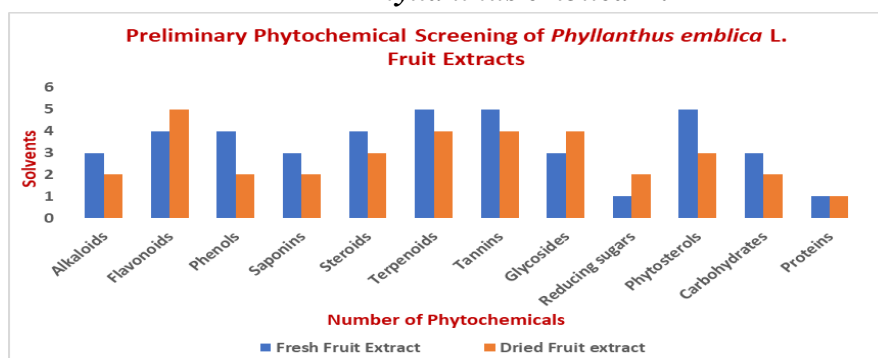
the fresh fruits but displayed a reduced concentration in the dried fruits. The phenolic content was notably higher in the acetone extracts of the fresh fruits compared to the dried fruits.

**Table 1-Phytochemical Profiling in Fresh and Dried fruit extracts of *Phyllanthus emblica* L.**

Phyto-constituents	Solvent extracts									
	Acetone		Benzene		Ethanol		Chloroform		Aqueous	
	Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried	Fresh	Dried
<b>Alkaloids</b>	-	-	+	+	+	++	+	-	-	-
<b>Flavonoids</b>	++	+++	++	+++	++	+++	-	-	+++	+++
<b>Phenols</b>	+++	++	+++	++	-	-	+	-	++	+
<b>Saponins</b>	-	-	+	-	+	-	++	++	+++	++
<b>Steroids</b>	-	-	+	+	+	-	+++	+	++	+
<b>Terpenoids</b>	+++	++	+++	++	+++	+	+++	++	+++	+
<b>Tannins</b>	+++	++	++	++	+++	++	+++	+	+++	++
<b>Glycosides</b>	++	+++	++	+++	+	+++	-	-	+	+++
<b>Reducing Sugars</b>	-	+	+	-	-	+	-	-	-	-
<b>Phytosterols</b>	+++	+	+++	+++	+++	+	+	++	+++	++
<b>Carbohydrates</b>	++	-	+	++	++	+	-	-	++	-
<b>Proteins</b>	-	-	-	-	-	-	-	-	+	+

(+) Less Present, (++) Moderately present, (+++) Abundantly present, (-) Absent

**Fig.1. Phytochemical Profiling in fresh and dried fruit extracts of *Phyllanthus emblica* L.**



Phytochemicals are secondary metabolites produced by plants that fight with microorganisms in their environment [9]. The active principle present in high quantities there could be other constituents exerting antagonistic effects of the bioactive compounds [10]. Majority of alkaloids function in the defense of plants against herbivores and pathogens, hence exploited as pharmaceuticals, stimulants, narcotics due to their potent biological activities [11]. Flavonoids are a major of phenolic compounds reported for their antiviral, antimicrobial [12]. Tannins is one of the important secondary metabolite which reduces the risk of coronary heart diseases [13]. Glycosides were used as astringents or reduce thyroxine and metabolism, and saponins have hypolipidemic and anticancer activity. Plant steroids or steroid glycosides also referred to as cardiac glycosides were one of the most naturally occurring plant phytoconstituents that had found therapeutic applications as arrow poisons or cardiac [14].

### **Summary and Conclusion**

The preliminary phytochemical analysis revealed that both fresh and dry fruits of *Phyllanthus emblica* L. contain significant phytochemicals, though their concentration and presence vary with the type of solvent used. Benzene and ethanol were the most effective solvents for extracting a wide range of phytochemicals. Drying the fruits appeared to enhance the concentration of certain phytochemicals, such as flavonoids and glycosides. This study underscores the importance of selecting appropriate solvent systems and considering the form of the plant material (fresh or dry) for effective extraction and utilization of phytochemicals in pharmaceutical and nutraceutical applications.

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## **Survey on medicinal plants in the Alwarkarkulam area of Thoothukudi District, South Tamil Nadu.**

**Amutha M\* <sup>1</sup>, Cynthia P<sup>2</sup>, Paul David Selson S<sup>3</sup>, Darwin Paul Edison S<sup>4</sup>  
and A. R. Florence<sup>5</sup>**

*<sup>1,3,4</sup>Assistant Professor of Botany, <sup>2</sup>Research Scholar (Reg No: 22111272262005),  
St. John's College, Palayamkottai, Tirunelveli- 627002.*

*<sup>5</sup>Assistant Professor of Botany, Holy Cross College (Autonomous), Nagercoil – 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [amuthasasikumar365@gmail.com](mailto:amuthasasikumar365@gmail.com)*

### **Abstract**

This ethnobotanical survey, conducted from January to May 2024 in the Alwarkarkulam area of Thoothukudi District, South Tamil Nadu, aimed to document traditional knowledge regarding medicinal plants. Through interviews with local healers during field visits, information was gathered on the use of 77 plant species for various medicinal purposes. The study found that these plants are primarily utilized to treat ailments such as diabetes, skin diseases, headaches, coughs, and colds, with leaves being the most frequently employed plant part in herbal preparations. Concerns regarding the depletion of indigenous medicinal plants due to climate change, overexploitation, and the encroachment of invasive species were noted. The findings underscore the dual role of these plants in fulfilling household medicinal needs and contributing to local economies through their sale.

**Keywords:** Traditional knowledge, Medicinal plants, Herbal medicine, Plant conservation, Climate change.

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### **Introduction**

The Alwarkarkulam area, nestled within the Thoothukudi District of South Tamil Nadu, stands as a testament to the rich tapestry of biodiversity and traditional knowledge that characterizes the region. Situated in the southern part of Tamil Nadu, this area is renowned for its unique ecosystem, which supports a diverse array of flora, including numerous species with medicinal properties[1]. The use of medicinal plants in this region has been an integral part of the cultural and healing practices of local communities for generations, reflecting a deep-rooted connection between nature and human health.

Throughout history, indigenous communities in Alwarkarkulam have relied on their profound knowledge of medicinal plants to treat various ailments and maintain well-being. This traditional wisdom has been passed down orally, from one generation to the next, and has played a crucial role in sustaining community health and resilience [2]. The plants found in this region are not only a source of traditional medicine but also hold significant cultural and ecological importance, contributing to overall biodiversity and ecosystem stability.

The study of medicinal plants in Alwarkarkulam is not merely an exploration of natural resources but also an endeavor to understand and document the intricate relationship between plants and people. By documenting the diversity, distribution, and traditional uses of medicinal plants in this area, this survey aims to contribute to the conservation of biodiversity and traditional knowledge [3]. Furthermore, it seeks to shed light on the potential therapeutic benefits of these plants, which could be invaluable in modern healthcare practices.

In recent years, there has been a growing recognition of the importance of traditional knowledge systems and their potential contributions to sustainable development and healthcare. Integrating traditional medicinal practices with modern scientific research offers promising avenues for discovering new medicines and treatments [4]. The Alwarkarkulam area, with its wealth of medicinal plants and traditional knowledge, presents a unique opportunity to explore these synergies and contribute to both local livelihoods and global health initiatives.

This survey endeavors to provide a comprehensive overview of the medicinal plants found in Alwarkarkulam, highlighting their botanical characteristics, traditional uses, conservation status, and potential pharmacological properties [5]. Through rigorous field surveys, data collection, and analysis, this study aims to create a valuable resource for researchers, policymakers, healthcare professionals, and local communities alike. By bridging the gap between traditional knowledge and scientific inquiry, we hope to promote the sustainable use of medicinal plants while safeguarding the cultural and ecological heritage of the Alwarkarkulam area for future generations.

### **Materials and Methods**

India is renowned for its rich botanical diversity, spanning from the Himalayas through central India to tropical South India, often referred to as a global herbarium [6]. The country boasts over 2,200 species of medicinal and essential oil-containing plants, highlighting their significant role in the national economy and potential for various industries, including phytopharmaceuticals and perfumery [7]. In the village of Alwarkarkulam, located within Thoothukudi District and part of Thoothukudi Municipal Corporation on the eastern bank of the Thamirabarani River, traditional medicinal plants are extensively utilized by the local population, particularly in Siddha medicine practices.



## **Study Area**

Alwarkarkulam is renowned for its palm crafts, reed mats, palm sugar production, and temples, surrounded by paddy fields.

## **Medicinal Plant Survey**

Field surveys of the medicinal flora in Alwarkarkulam were conducted from October 2023 to January 2024. Plants of medicinal value were identified based on literature from Ayurveda, Homeopathy, Unani, Allopathy, and other systems of medicine [8]. Visual observations were supplemented with specimen collection for future reference, and photographs were taken for detailed documentation.

## **Identification**

Medicinal plants were identified using reference texts such as "The Flora of Tamilnadu Carnatic" [9] "The Flora of Tamilnadu" [10] "Indian Medicinal Plants" volumes 1-5, and "Medicinal Plants" [11]

## **Methods**

The investigation focused on gathering information on the traditional uses of both wild and cultivated plants, with a particular emphasis on differences in use from their intended cultivation purposes [12] Informants, selected based on strict criteria of lifelong residency and knowledge solely derived from traditional cultural practices, provided insights through semi-structured interviews conducted with empathy, respect, and openness to local knowledge [13] Each citation included:

- Scientific name (species or subspecies)
- Botanical family
- Local vernacular name(s)
- Parts of the plant used
- Method of use

Medicinal uses were initially sourced from literature available in college and university libraries, then corroborated through interviews with local inhabitants and visits to traditional practitioners and healers in the surrounding areas [14] Only uses validated by a majority of informants were retained, respecting the intellectual property of the informants regarding dosage, formulations, and administration methods [15,16] Field visits covered diverse locations, such as wastelands, playgrounds, roadsides, agricultural farms, and neighboring

localities. Plant samples were brought to department libraries for identification using available flora.

## Results

**Table: 1**

Sl. No	Botanical Name	Family Name	Useful Part/ Parts	Medicinal Uses
1	<i>Abrus fruticosus</i> Wall. ex-Wight & Arn.	Fabaceae	Leaves	Relieve headache, nose troubles.
2	<i>Abrus precatorius</i> L.	Fabaceae	Root, leaves and seeds	Cough, rheumatism, asthma, elephantiasis.
3	<i>Abutilon indicum</i> (L.). Sw.	Malvaceae	Leaves, roots, flowers and seeds	Astringent to the bowels, diuretic, diarrhea and dysentery.
4	<i>Acacia arabica</i> Willd.	Mimosaceae	Bark	Cure cough, bronchitis, diarrhea and dysentery.
5	<i>Achyranthes aspera</i> L.	Amaranthaceae	Leaves	Antitode against dog bite.
6	<i>Adhatoda vasica</i> Nees.	Acanthaceae	Leaves	Used against chronic fever, diuretic, aphrodisiac and expectorant.
7	<i>Aegle marmelos</i> (L.) Correa.	Rutaceae	Leaves and fruit	Ophthalmia, sweet, aromatic, cooling, laxative, dyspepsia.
8	<i>Aerva lanata</i> L. Corr.	Amaranthaceae	Whole plant	Cooling, cough, urinary disorders.
9	<i>Albizia lebeck</i> (L.) Willd.	Mimosaceae	Leaves	Ophthalmia, strangury, urinary calculi and urinary troubles.
10	<i>Aloe vera</i> (L.) Burm.f.	Liliaceae	Leaves	Cooling, anthelmintic, febrifuge, urinary disorders.
11	<i>Alternanthera sessilis</i> (L.) R.Br. ex Dc.	Amaranthaceae	Leaves	Acrid, skin diseases.
12	<i>Andrographis echiioides</i> (L.) Nees.	Acanthaceae	Root and leaves	Febrifuge, stomachic, tonic, alterative and anthelmintic.
13	<i>Andrographis paniculata</i> (Burm.f) Wallich. Nees.	Acanthaceae	Whole plant	Fever, cough, cold and febrifuge.

14	<i>Annona squamosa</i> L.	Annonaceae	Leaves, fruit and seeds.	Acrid, bitter, malignant tumor.
15	<i>Aristolochia bracteolata</i> Lam.	Aristolochiaceae	Whole plant	Skin diseases, poisonous bite.
16	<i>Azadirachta indica</i> A. Juss.	Meliaceae	Leaves, flowers, fruit, seed.	Skin diseases, diabetes, chicken box and vermifuge.
17	<i>Barlaria prionitis</i> L.	Acanthaceae	Root	Diuretic, Febrifuge, anti-catarrahah properties.
18	<i>Barleria buxifolia</i> L.	Acanthaceae	Whole plant	Fever, respiratory diseases, toothache, joint pains, the leaves are used to promote healing of wounds and to relieve joint pains and toothache.
19	<i>Basella alba</i> L.var. <i>rubra</i> . (L.) J. Stewart	Basellaceae	Whole plant	Demulcent, diuretic, narcotic, antipyretic and improves the voice.
20	<i>Boerhavia diffusa</i> L.	Nyctaginaceae	Whole plant	Dyspepsia, tumours, spleen enlargement, abdominal pains, appetizer, alexiteric, useful in ophthalmia, in joint pains. tonic, expectorant, carminative, useful in lumbago, scabies.
21	<i>Borassus flabellifer</i> L.	Arecaceae	Pulp, fruit	Antiinflammatory, anti-cancar, diabetes, cooling.
22	<i>Calotropis gigantea</i> (L.) R.Br.	Asclepiadaceae	Leaves, root, latex	Elephantiasis, rheumatism, worm infestations.
23	<i>Cardiospermum halicacabum</i> L.	Sapindaceae	Leaves	Analgesic, Diuretic, Laxative, Stomachic, Anti-inflammatory.
24	<i>Carica papaya</i> L.	Caricaceae	Latex, leaves, seeds.	Jaundice, dyspepsia, urinary disorders and vermifuge.
25	<i>Cassia alata</i> L.	Caesalpiniaceae	Seeds	Astringent, stimulant and diuretic.
26	<i>Cassia auriculata</i> L.	Caesalpiniaceae	Wholeplant	Anthelmintic, good for ulcers, leprosy and

				urinary disorders,
27	<i>Cassia fistula</i> L.	Caesalpiniaceae	Root	Useful in skin diseases, leprosy, tuberculosis and syphilis.
28	<i>Centella asiatica</i> (L.) Urb.	Apiaceae	Leaves	Antibacterial, antifungal, antioxidant, anxiolytic, diuretic, digestive, nerving and vulnerary, it can help reduce swelling, repair connective tissues and improve circulation.
29	<i>Cissus quadrangularis</i> L.	Vitaceae	Stem	Acrid, astringent, carminative, vermifuge, increase stamina, purgative, bone fracture and pungent.
30	<i>Citrus limon</i> (L.) Osbeck	Rutaceae	Fruit and leaves	Checking vomiting, carminative, stomachic.
31	<i>Clitoria ternatea</i> L.	Fabaceae	Leaves, pods	Swellings, piles, headache, wounds and chronic rheumatism.
32	<i>Coccinia grandis</i> (L.) Voigt.	Cucurbitaceae	Whole plant	Vomiting, burning sensation.
33	<i>Coleus aromaticus</i> Benth.	Lamiaceae	Leaves	Cough, fever, vermifuge, anaemia.
34	<i>Curcuma longa</i> L.	Zingiberaceae	Leaves, rhizome	Cold, leprosy, intermittent, affections of the liver, dropsy, inflammation and wound healing. The rhizome of the turmeric plant is highly aromatic and antiseptic, contraception, swelling, insect stings, wounds, whooping cough, inflammation, internal injuries, pimples, injuries, as a skin tonic. Sweetened milk boiled with the turmeric is the popular remedy for cold and

				cough. It is given in liver ailments and jaundice.
35	<i>Cymbopogon citratus</i> (DC.) Stapf.	Poaceae	Leaves	Pungent, bitter, sharp, hot, laxative, appetizer, alexipharmic, anthelmintic, useful in bronchitis, leprosy and epileptic fits.
36	<i>Erythrina variegata</i> L.	Fabaceae	Leaves	Anti-inflammatory, antimicrobial.
37	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Whole plant	Asthma, bronchitis, anxiolytic, analgesic, antipyretic, and anti-inflammatory activities.
38	<i>Evolvulus alsinoides</i> (L.) L.	Convolvulaceae	Whole plant	Alterative, febrifuge, anthelmintic and antiphlogistic with cumin and milk, used for fevers, nervous debility and loss of memory; also used for syphilis and scrofula.
39	<i>Ficus benghalensis</i> L.	Moraceae	Leaves, fruits, latex	Astringent to bowels; biliousness, ulcers, erysipelas, vomiting, vaginal complaints, fever, inflammations, leprosy, aphrodisiac, tonic, vulnerary, maturant, lessers inflammations; useful in piles, nose-diseases.
40	<i>Ficus religiosa</i> L.	Moraeae	Bark, tender shoots, leaves, fruits.	Cooling and astringent and is useful in inflammations and glandular swellings of neck. Root bark is good for stomatitis, clean ulcers and it is astringent in leucorrhoea and promotes granulations.
41	<i>Gardinia gummifera</i> L.	Rubiaceae	Leaves	Astringent, vermifuge.
42	<i>Hemidesmus indicus</i> (L.) R. Br. var. <i>inducus</i> Hook.f	Asclepiadaceae	Root	Purgative, leucoderma, and diarrhoea.

43	<i>Hibiscus rosa – sinensis</i> L.	Malvaceae	Leaves, flowers	Skin diseases, dysentery and hair growth.
44	<i>Indigofera tinctoria</i> L.	Fabaceae	Leaves	Hair growth, blood purifier.
45	<i>Ipomoea indica</i> L.	Convolvulaceae	Leaves	Chest diseases, dysentery.
46	<i>Ixora coccinea</i> L.	Rubiaceae	Flower, leaves	Febrifuge, diarrhea, purgative, expectorant.
47	<i>Jasminum angustifolium</i> (L) Willd.	Oleaceae	Leaves, flowers	Deobstruent, anthelmintic, diuretic.
48	<i>Jatropha curcas</i> L.	Euphorbiaceae	Latex, fruit	Anthelmintic, urinary disorders. Latex is taken orally for stomach problems during pregnancy.
49	<i>Lantana camera</i> L.	Verbenaceae	Root	Expectorant, aphrodisiac.
50	<i>Lawsonia inermis</i> L.	Lythraceae	Leaves	Cooling, skin diseases, hair growth.
51	<i>Leucus aspera</i> (Willd.) Link.	Lamiaceae	Leaves	Headache, cough, fever.
52	<i>Mangifera indica</i> L.	Anacardiaceae	Leaves, flowers, fruit, kernel	Stimulant, astringent, toothache, skin diseases.
53	<i>Mirabilis jalapa</i> L.	Nyctaginaceae	Leaves	Good for syphilitic sores.
54	<i>Murraya koenigii</i> (L.) spreng	Rutaceae	Leaves, fruit	Tonic, carminative, astringent, colic, dyspepsia.
55	<i>Nerium oleander</i> L.	Apocynaceae	Flowers	Fever arising from teething, febrifuge.
56	<i>Ocimum basilicum</i> L.	Lamiaceae	Whole plant	Urinary disorders, fever.
57	<i>Ocimum sanctum</i> L.	Lamiaceae	Whole plant	Bronchitis, cold, cough, tonic, astringent.
58	<i>Opuntia stricta</i> (Haw.) Haw.var.dilleni (Ker Gawl.) L.D. Benson.	Cactaceae	Flowers, fruits	Cooling, tonic and diabetes.
59	<i>Phyllanthus amarus</i> Schum & Thonner	Euphorbiaceae	Whole plant	Jaundice, diabetes.
60	<i>Phyllanthus emblica</i> L.	Euphorbiaceae	Root, leaves	Jaundice, tonic,

			and fruits	indigestion.
61	<i>Pongamia pinnata</i> L. Pierre.	Fabaceae	Leaves, bark	Good for stomatitis, clean ulcers and it is astringent in leucorrhoea and promotes granulations.
62	<i>Ricinus communis</i> L.	Euphorbiaceae	Leaves, seeds, latex.	Headache, hair growth, toothache.
63	<i>Solanum nigrum</i> L.	Solanaceae	Leaves, fruit	Oleaginous, pungent, heating, laxative, diuretic, tonic, worms in the year, dysentery, hic cough, vomiting, asthma, bronchitis, fever and improve the voice.
64	<i>Solanum trilobatum</i> L.	Solanaceae	Whole plant	Acute and chronic bronchitis, cardiotoxic, laxative, narcotic and stimulant.
65	<i>Tamarindus indica</i> L.	Caesalpiaceae	Fruit pulp, bark	Laxative, diarrhoea, astringent and gingivitis.
66	<i>Tecoma stans</i> (L.) Kunth.	Bignoniaceae	Root	Antitode against rat bite.
67	<i>Tectona grandis</i> L.f.	Verbenaceae	Bark, root	Roots are given in sedative.
68	<i>Thespesia populnea</i> (L.) Sol. Ex. Correa	Malvaceae	Bark, leaves, flowers	Acrid, astringent to bowels and carminative.
69	<i>Tribulus terrestris</i> L.	Zygophyllaceae	Whole plant	Kidney stone, urinary troubles.
70	<i>Tridax procumbens</i> L.	Asteraceae	Whole plant	Cure cuts, wounds, skin diseases and bronchitis.
71	<i>Urgenia indica</i> (Roxb.) Kunth.	Liliaceae	Bulb	Diuretic, anthelmintic and purgative.
72	<i>Vernonia cinerea</i> (L.) Less.	Asteraceae	Leaves	Astringent to bowels.
73	<i>Vitex negundo</i> L.	Verbenaceae	Leaves, flowers.	Leaves acrid, pungent, anthelmintic, improve memory power.
74	<i>Wattakaka volubilis</i> (L.f.) T. Cooke	Asclepiadaceae	Leaves	Diarrhea and chest diseases.

75	<i>Wrightia tinctoria</i> R. Br.	Apocyanaceae	Bark	Tonic, aphrodisiac.
76	<i>Zingiber officinale</i> Rosc.	Zingiberaceae	Rhizome	Aromatic tonic, boils, enlarged glands, anthelmintic, rheumatism, headache and remove pain due to cold.
77	<i>Zizipus mauritiana</i> Lam	Rhamnaceae	Leaves, fruit	Diarrhea.

### Discussion

The survey conducted in the Alwarkarkulam area of Thoothukudi District, South Tamil Nadu, documented a diverse array of medicinal plants belonging to various families, each utilized for specific therapeutic purposes. The findings highlight the significant role of traditional herbal knowledge in local healthcare practices, addressing ailments ranging from common colds and fevers to more serious conditions like asthma, diabetes, and skin diseases. The presence of species such as Aloe vera, Turmeric (*Curcuma longa*), Neem (*Azadirachta indica*), and various others underscores the area's rich botanical diversity and potential for pharmaceutical research. Conservation efforts are crucial to sustainably manage these resources, ensuring their continued availability for both traditional and modern medicinal applications. Further exploration into the pharmacological properties and sustainable harvesting of these plants could contribute to their integration into mainstream healthcare systems, benefiting local communities and potentially broader populations seeking natural remedies.

In conclusion, this survey underscores the importance of documenting and conserving the traditional knowledge surrounding medicinal plants in South Tamil Nadu. By recognizing their cultural, ecological, and economic significance, we can foster a future where both traditional healing practices and modern medicine coexist harmoniously, promoting overall well-being and environmental stewardship.

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## Evaluation of Pesticidal Compounds from Marine Algae Against Stored Grain Pest *Sitophilus Oryzae* L.

Albino Wins. J<sup>1</sup>, J. Celin Pappa Rani<sup>1</sup>, S. Kala Vethakumari<sup>1</sup>, W. Vincy<sup>1</sup>  
and M. Murugan<sup>2</sup>

<sup>1</sup>Department of Botany, Holy Cross College (Autonomous), Nagercoil – 629004.

(Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli - 627001.

<sup>2</sup>Department of Biomedical Sciences, Noorul Islam Centre for Higher Education, Kumaracoil,

Email: [winsbt@gmail.com](mailto:winsbt@gmail.com)

### Abstract

Extracts of four different marine algae namely *Ulva fasciata*, *Gracilaria corticata*, *Caulerpa racemosa* and *Sargassum wightii* with different extracts were tested against five human pathogens namely *Enterobacteria sp.*, *Bacillus subtilis*, *Staphylococcus albus*, *Pseudomona aeruginosa* and *Salmonella typhi*. In addition, the extracts were also tested against the storage pest *Sitophilus oryzae*. In the pesticidal study, ethanol, methanol, acetone and n-butyl alcohol extracts of *Ulva fasciata* showed a good pesticidal activity against the storage pest *Sitophilus oryzae*. Among them the most powerful activity were shown by ethanol extracts. Results obtained from methanol, acetone, benzene and n-butyl alcohol extracts of *Sargassum wightii* showed varying range of pesticidal activity against the pest *Sitophilus oryzae*. *Gracilaria corticata* extracts made by the solvents ethanol, methanol and n-butyl alcohol showed a very low activity against the pest *Sitophilus oryzae*. The present study justifies the uses of *Ulva fasciata*, *Gracilaria corticata*, *Sargassum wightii* and *Caulerpa racemosa* in the traditional system of medicine to treat various infectious diseases caused by the microbes, as well as in pest control.

**Keywords:** Marine algae, Storage grain, Pesticides, Pesticidal assay

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### Introduction

Marine ecosystem provides a great diversity of plant kingdom, animal kingdom and also provides better food, minerals and pharmaceuticals. Many substances obtained from marine algae such as alginate, carragenean and agar as phycocolloids have been used for decades in medicine and pharmacy (Khare, 1994). Among the algal substances, secondary metabolites having pesticidal activity are alkaloids, terpenoids, steroids, phlorotannins, phenols, halogenated compounds like ketones and alkanes, cyclic poly sulphides, fatty acids and acrylic acids (Atwal and Dhaliwal, 2008).

Insects cause great damage to agricultural crops. The yield loss of crops is estimated to be 20 -30%. An additional 10% is lost during post harvest storage and transportation. Pesticides are useful in protecting crops from economic losses (Singh *et al.*, 2021). Post

harvest conservation of food grains are as much important as the production of food. Pesticides are transmitted through water, air and soil in the environment. Through air pesticide residues deposit on crops and also find way into waterbodies, thus affect aquatic life and pollute water forever. Poultry, domestic animals and human beings ingest the remains of pesticides through food and fodder (Hajam and Kumar, 2022). Due to biomagnification of these pesticides, many organs of man are lead to impairment of human tissues, failure in functioning of liver, kidney, intestine and gonads. The land also becomes unfit for cultivation (Bibi *et al.*, 2022).

Toxicological research has indicated that the insecticide chemicals appear to cause immune suppression (Alagmir,2017). These compounds are highly lipid soluble and are resistant to biodegradation (Ifeanyieze *et al.*,2011). Several studies have reported the presence of organochloro pesticides in maternal blood and umbilical cord blood and have been reported in women premature delivery by disturbing the hormonal balance of pregnancy. Increasing levels of pesticide residues are reported to be highly toxic and carcinogenic. Because of these harmful effects of chemical pesticides, the biopesticides are not only economical but also safer ecofriendly and most efficient in keeping down the pest for many years. Bio – insecticides are biodegradable, non-toxic and cost-effective. *Sitophilus oryzae* is believed to be a native of India, but now world wide in distribution, primarily in tropical countries. They are reddish brown beetles, pronotum with deep punctures. The pits are rounded and closely compacted. They have 4 light yellowish spots on the elytra and can fly. They have their head capsules elongated into a snout or rostrum on the tip of which are located tiny but powerful mouth parts. The antennae are elbow in shape while at rest. Female excavates a hole in the grain into which it deposits an egg and then secretes a mucilaginous plug and ovipositors in withdrawn. The larvae are legless developing inside the grain or other hard materials. Rarely more than one larva develops in a single grain because of cannibalism (Stengel *et al.*,2011; Abdel Haleem *et al.*,2020). Adults of *Sitophilus* are long lived and they lay their eggs throughout the adult life. Up to 150 eggs per female are laid. Single larvae of *Staphylococcus oryzae* is reported to consume 10mg of grain during its development. Hence, it is an urgent need to find out the ecofriendly agent for the control of storage pests. Thus, the present investigation was carried to make an attempt to find pesticidal compounds from marine algae.

## **Methodology**

### **Collection of Seaweeds**

Four marine algae namely *Ulva fasciata*, *Caulerpa racemosa*, *Sargassum wightii*, *Gracilaria corticata* were collected from the submerged marine rocks during low tide. Epiphytic and extraneous matters were removed by washing in sea water and fresh water. The algae were transported to the laboratory in polyethylene bags.

### **Extraction of compounds from Macroalgae**

The seaweeds were shade dried, cut into small pieces and powdered in a mixer grinder. The extraction was carried out with different solvents such as methanol, ethyl alcohol, diethyl ether, acetone, benzene and n-butyl alcohol by soaking the respective solvents thrice overnight at room temperature. The extraction with different solvents was carried out individually on samples. The extracts from three consecutive soakings were pooled and freed from solvent by evaporation. The residues obtained were finally dried and used for pesticidal assay by cotton roll method.

### **Pesticidal Assay by Cotton Roll Method**

A set of 6 healthy *Sitophilus oryzae* were introduced into a series of dried and sterilized petriplates containing evaporated cotton rolls, that was already dipped in different extracts in different concentration. Another set of 6 healthy insects were introduced separately in another sterilized petriplate without cotton roll as control. Then the plates were covered and kept undisturbed. The plates were observed throughout the experiment and time of death of each insect was recorded carefully.

## **Results and Discussion**

The seaweeds used in the pesticidal study were *Ulva fasciata*, *Gracilaria corticata*, *Caulerpa racemosa* and *Sargassum wightii* with the solvents ethanol, methanol, acetone, benzene, n-butyl alcohol and diethyl ether. Most of the extracts show pesticidal activity against the pest *Sitophilus oryzae* with varying durations.

The most powerful results were recorded by the acetone extract of *Caulerpa racemosa*. In this extract, all the six insects were dead with a period of 26 minutes, 29 minutes and 63 minutes in 30%, 20% and 10% concentrated extract respectively. The ethanol extract of *Caulerpa racemosa* also shows a good pesticidal activity against *Sitophilus oryzae*. By using this ethanol extract of *Caulerpa racemosa* all the insects were dead with a period of 58 minutes, 71 minutes and 95 minutes with 30%, 20% and 10% in different concentration. The

usage of n-butyl alcohol extract of *Caulerpa racemosa* showed the death duration of the insect with 94 minutes, 148 minutes and 147 minutes using 30%, 20% and 10% concentrated extract respectively. The methanol, benzene and diethyl extract of *Caulerpa racemosa* showed no pesticidal activity against *Sitophilus oryzae*.

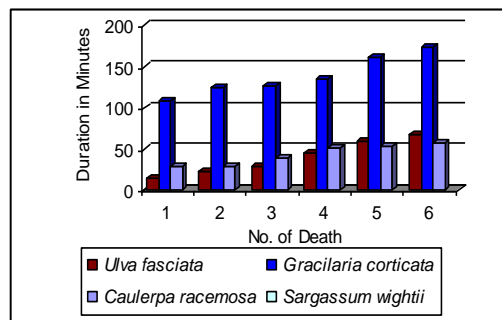
Results obtained from methanol, acetone, benzene and n-butyl alcohol extracts of *Sargassum wightii* showed various range of pesticidal activity against the pest *Sitophilus oryzae*. Among these extracts the most powerful results performed by acetone extract of *Sargassum wightii*. By using this extract, the all the insects were dead with a period of 62 minutes, 75 minutes and 99 minutes with the usage of 30%, 20% and 10% extracts. The methanol extract of *Sargassum wightii* showed good pesticidal activity. The total mortality taken place with the period of 94 minutes, 98 minutes and 108 minutes with the extract concentration 30%, 20% and 10% respectively. The n-butyl alcohol shows a low pesticidal activity against *Sitophilus oryzae*, the total mortality is at 123 minutes, 134 minutes and 140 minutes with the extract concentration 30%, 20% and 10%. The benzene extract showed a pesticidal activity with total mortality rate taking duration of 39 minutes and 47 minutes by using extract concentration 30% and 20%. The 10% extract concentration of *Sargassum wightii* with benzene did not showed pesticidal activity. The ethanol and diethylether extract of *Sargassum wightii* also had no pesticidal activity.

The ethanol, methanol, acetone and n-butyl extracts of *Ulva fasciata* showed a good pesticidal activity against the pest *Sitophilus oryzae*. Among them the most powerful activity were shown by ethanol extract. The 100% mortality taken place with the period of 68 minutes, 79 minutes and 103 minutes with the usage of extract concentration 30%, 20% and 10% respectively. In the methanol extract of *Ulva fasciata* 100% mortality taken place in the 30% extract concentration only with a period of 117 minutes. In the acetone extract of *Ulva fasciata* 100% mortality were done with a period of 73 minutes, 80 minutes and 85 minutes with the usage of 30%, 20% and 10% extract concentration respectively. The n-butyl alcohol extract of *Ulva fasciata* showed a low range of pesticidal activity with the 100% mortality using a period of 198 minutes, 228 minutes and 379 minutes with the usage of 30%, 20% and 10% respectively. The other extracts such as benzene and diethyl ether extracts have no pesticidal activity against *Sitophilus oryzae*.

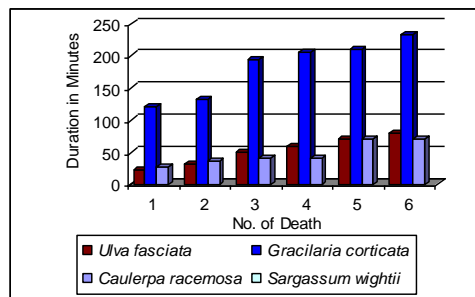
*Gracilaria corticata* extracts showed a very low range of pesticidal activity. The ethanol, methanol and n-butyl alcohol extracts showed a medium range of activity. Among

them 100% mortality taken place in the ethanol and n-butyl alcohol extracts only. In n-butyl alcohol extract, 100% mortality taken place with the period of 109 minutes and 119 minutes by using 30% and 20% solutions. The ethanol extract of *Gracilaria corticata* showed 100% mortality with the time duration 173 minutes and 231 minutes by using 30% and 20% concentrated extract. The acetone, benzene and diethyl ether extracts showed no pesticidal activity against the pest *Sitophilus oryzae*.

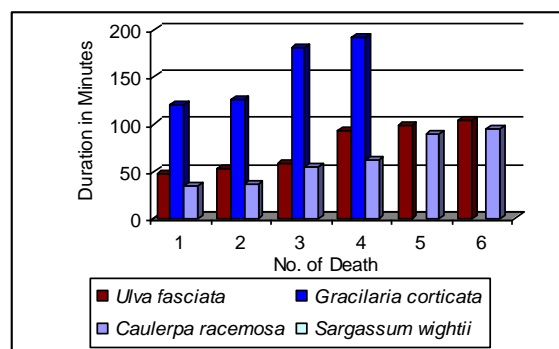
**Fig 1: Biopesticidal activity of ethanol extract in four different algae (30% concentration)**



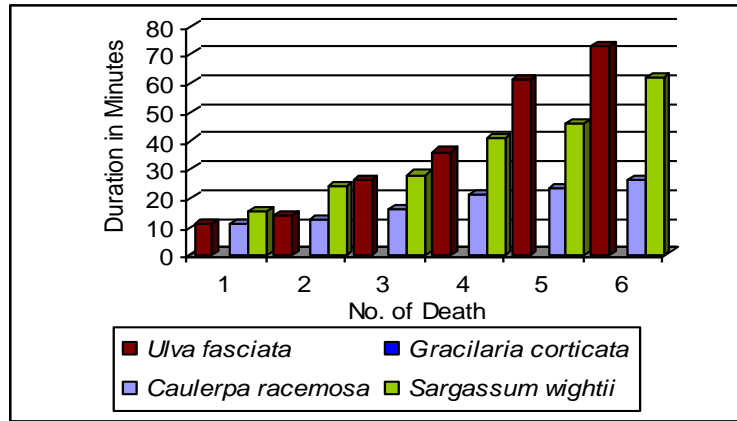
**Fig 2: Biopesticidal activity of ethanol extract of four different algae (20% concentration)**



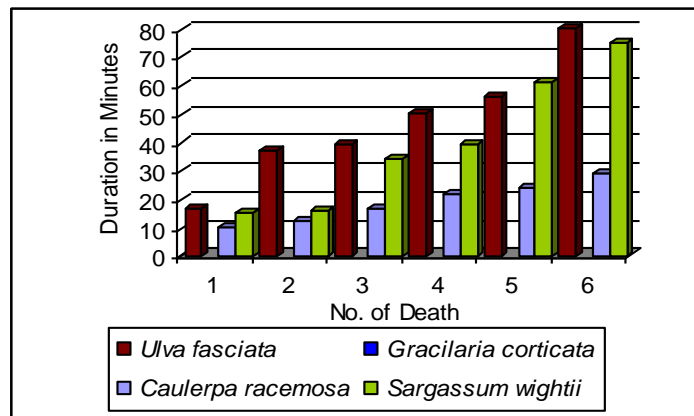
**Fig 3: Biopesticidal activity of ethanol extract of four different algae (10% concentration)**



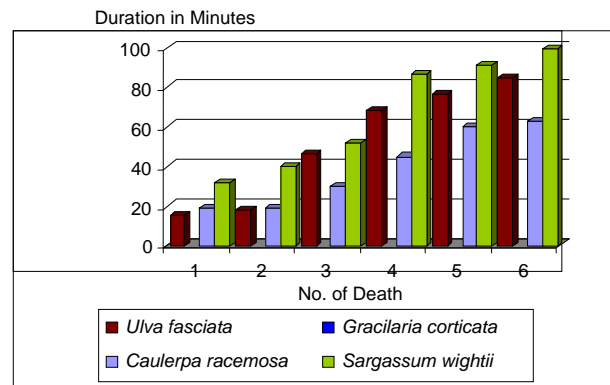
**Fig 4: Biopesticidal activity of acetone extract of four different algae (30% concentration)**



**Fig 5: Biopesticidal activity of acetone extract of four different algae (20% concentration)**

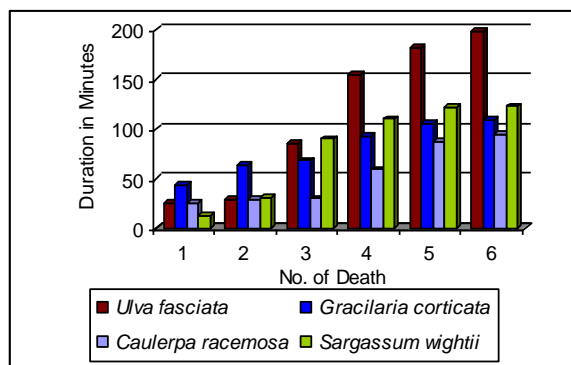


**Fig 6: Biopesticidal activity of acetone extract of four different algae (10% concentration)**

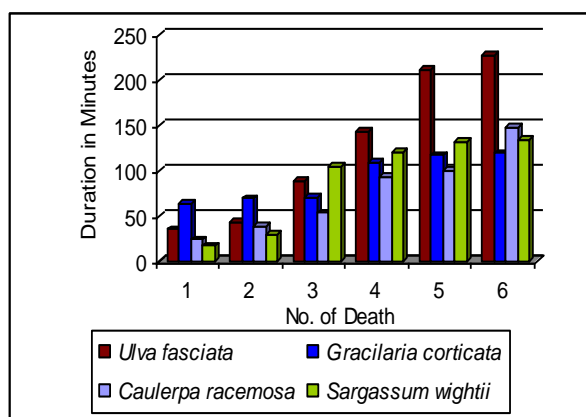




**Fig 7: Biopesticidal activity of n-butyl alcohol extract of four different algae in 30% concentration**



**Fig 8: Biopesticidal activity of n-butyl alcohol extract of four different algae in 20% concentration**



Reports related to pesticidal activity of macroalgae is comparatively less in relation to other biological activities such as antibacterial, antiviral and anticancer etc. This present investigation is a pioneering approach to evaluate the pesticidal activity of seaweeds.

It has been proven that the ethyl acetate extract of *Gracilaria crassa* alone gives 100% mortality against the pest *Sitophilus oryzae* (Maria Selvam, 2002). This study is positively related to the present study because *Gracilaria corticata* showed varying degrees of pesticidal activity.

Metabolites from macroalgae have already proven to be potential growth enhancers of economically important plants. So, the discovery of a metabolite which can act both as a growth promoter as well as a pesticidal compound will be significant. In the present study it

is proven that macro algae are potential source of pesticidal compounds. The algae used were *Ulva fasciata*, *Gracilaria corticata*, *Caulerpa racemosa* and *Sargassum wightii* with different solvents such as ethanol, methanol, acetone, benzene, n-butyl alcohol and diethyl ether. Most of the extracts of seaweeds showed 100% mortality rate against the pest *Sitophilus oryzae*. Among them the most effective pesticidal activity was shown by the extracts of *Ulva fasciata*.

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## Review on *Euphorbia hirta* L. -A Potent Medicinal Plant

Nyla Azmi A<sup>1</sup> and Beena Lawrence<sup>2</sup>, A.R. Florence<sup>3</sup>

<sup>1</sup>Research Scholar, (Reg.no.241132823003), Department of Botany & Research Center,  
Women's Christian College, Nagercoil.

<sup>2</sup>Associate Professor, Department of Botany & Research Center,  
Women's Christian College, Nagercoil.

<sup>3</sup>Assistant Professor of Botany, Holy Cross College (Autonomous), Nagercoil - 629004

### Abstract

*Euphorbia hirta* L., often known as asthma plant, has a wide range of traditional medicinal uses due to its diverse therapeutic properties. It is used to treat respiratory issues, infections, inflammatory conditions, digestive disorders, menstrual problems, and more. The plant exhibits antimicrobial, anti-inflammatory, analgesic, diuretic, antioxidant, and potential anticancer properties. However, despite its extensive traditional use, scientific research on *Euphorbia hirta* L., is still limited. Recently this plant is gaining much importance among the scientific community due to its undiscovered medicinal potentials. Future research in this plant may hold the key for combating ever changing microbes and emerging diseases.

**Keywords:** *Euphorbia hirta* L., anti-oxidant, anti-cancer and medicinal potential.

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### Introduction

*Euphorbia hirta* L. belongs to the family Euphorbiaceae (spurge family), which includes a wide range of plants from herbs to trees and shrubs. The genus *Euphorbia* is one of the largest genera of flowering plants and includes a wide variety of species with different growth forms and habitats. *E. hirta* is commonly known as “Asthma plant” in English and “Dudhi” in Hindi. The plant is widely distributed throughout the globe, and in Asia, it is mainly found in Yemen, Oman, Palestine, Taiwan, Syria, Lebanon, India, Bhutan, Pakistan, Nepal, Myanmar, Thailand, Sri Lanka, Indonesia, Malaysia, Papua New Guinea and the Philippines [1]. According to Patel *et al.*, (2019) *E. hirta* is a herbaceous plant widely recognized for its medicinal properties such as significant antimalarial, antifungal, antifertility, antispasmodic, sedative, anti-asthmatic, anthelmintic and antibacterial properties [2].

### Systematic position

Division: Tracheophyta

Class: *magnoliopsida*

Species: *hirta* L.,

Family: Euphorbiaceae (spurge family)

Genus: *Euphorbia*

Species: *hirta* L.,



**Fig:1 *Euphorbia hirta* L.**

### **Plant description**

*E. hirta* L., is a small annual, branched herb that can grow to 70 cm in height, purple or reddish in color with copious amounts of latex, and covered with sprout hairs. The leaves are opposite, biculate and simple, the stipules are linear, the leaf blade is lanceolate, oblong serrate, long elliptic, tapering, 3 – 4 cm long and 1 – 1.4 cm wide, and its margin is smoothly serrated. The monoecious inflorescence, an axillary or terminal cluster of flowers, is known as a cyathium, in which several cyathia are arranged in a cyme. The male and female flowers are in a pod and both appellations. The flowers are unisexual, male flowers are sessile, prophylls are linear, fringed, perianth absent and have a stamen, female flowers have a small peduncle, the perianth is fringed, the ovary is covered with tiny hairs above, 3-celled, has 3 - Styles, small and the tip is double. The flowering period is usually year round. The fruit is allomorphic, pistillate, elongated, 3-lobed, obtuse base covered with shoot hairs. Seeds are oblong, 4-sided prismatic, wrinkled and brownish pink in color, capsule 3-seeded, green and covered with fleshy spines, seeds smooth, hard mottled crustal skin with a white caruncle at the top enclosing oily endosperm [3,4]. The root is a distinct and developed primary root (taproot system).

## Medicinal Uses

Ahmad *et al.* (2017) investigated the phytochemical screening and antimicrobial activities of *E. hirta* extracts [5]. According to them phytochemical screening of the plant revealed the presence of alkaloids, flavonoids, saponins, terpenoids, steroids and sterols in the extracts in the aerial part. Methanols, chloroforms and hexane extract of leaves and fruits were tested for their potential to inhibit the proliferation of *Proteus mirabilis*, *Listeria monocytogenes*, *Clostridium absonum*, *Aspergillus niger*, *Aspergillus fumigates*, *Arthrographis cuboidea* cultures by the agar disc diffusion method.

Lavanya *et al.* (2022) analyzed the phytochemicals of *E. hirta* and its antioxidant properties. The presence of alkaloids, terpenoids, tannins and flavonoids was discovered during phytochemical screening of *E. hirta* leaf extract [6]. The antioxidant activity of *E. hirta* leaves extract were tested used DPPH, H<sub>2</sub>O<sub>2</sub>, O<sub>2</sub>-free radical scavenging assay method, and found out that the *E. hirta* plant posses good free radical scavenging property.

Kamya *et al.* (2011) evaluated the phytochemicals and antibacterial activity of *E. hirta*. Phytochemical screening revealed the presence of several phytoconstituents in both the plant species and many of these have been investigated scientifically for antimicrobial activity[7]. *In vitro* antibacterial study was done using agar well diffusion method and the study revealed that methanol leaf extracts of *E. hirta* recorded high activity against the test organisms.

Kumar *et al.* (2010) studied the anti-diabetic activity of *E. hirta* in streptozotocin induced diabetic mice. The ethanol extracts (250 and 500 mg/kg) of leaves, flowers and stems were taken up to evaluate the anti-diabetic activity against normal and streptozotocin (STZ) induced diabetic mice[8]. Oral administration of the extracts for 21 days resulted in a significant reduction in blood glucose level. Chronic effects of the extracts on serum biochemistry were also studied and it was found that serum cholesterol, triglycerides, creatinine, urea, alkaline phosphatase levels were decreased significantly by all the extracts and Glibenclamide but HDL levels and total proteins were found to be increased after treatments. Thus, study showed that *E. hirta* has anti-diabetic action.

Rahman *et al.* (2019) studied the antithrombotic and anti-inflammatory activities of leaf methanolic extract of *E. hirta* [9]. In addition, xylene-induced ear edema and cotton pellet-induced granuloma formation tests were conducted to evaluate the anti-inflammatory effect of methanolic extract of *Euphorbia hirta* leaves in mice. Crude methanolic extract was

administered orally at a dose of 200, 400 and 800mg/kg in mice. Treatment with crude extract of *E. hirta* leaves (100 and 200mg/mL) restrained the *in-vitro* thrombosis process. In this test, 200mg/mL showed the strongest inhibition value (38.00±2.52 %) of thrombosis. The treatment with a dose of 200, 400 and 800 mg/kg showed a dose-dependent significant inhibition of ear edema in mice, whereas the highest inhibition value was exhibited by the extract 800mg/kg (58.78±2.90%). Moreover, all of the dosages (200, 400 and 800mg/kg) of extract significantly reduced the granuloma formation in mice as well as decrease the body weight gain. Here, the plant extract at 800mg/kg provided highest inhibition value (56.80±3.85 %) of granuloma formation in mice. Furthermore, no sign of toxicity, behavioral changes or mortality was observed upto the dose of 3200 mg/kg of the extract or control group. These outcomes strongly support the traditional uses of this plant scientifically, in case of thrombosis and inflammation management.

Anitha *et al.* (2019) determined the *in vitro* anticancer activity of ethanolic extract of *E. hirta*. Ethanolic leaf extract of *E. hirta* was tested for its cytotoxicity against Dalton Lymphoma Ascites (DLA) and Ehrlich Ascites Carcinoma (EAC) cell lines using preliminary screening technique (Trypan Blue method and standard MTT colorimetric method)[10]. The *E. hirta* leaf extract was found to be more cytotoxic against Ehrlich Ascites Carcinoma cell lines when compared to cytotoxic activity against Dalton Lymphoma Ascites cell lines where as 59.67% cytotoxicity were noticed against Ehrlich Ascites Carcinoma cell lines. Extract of *E. hirta* showed a dose-dependent reduction of proliferation and induction of apoptosis in the carcinoma cell lines cells. Ethanolic leaf extract of *E.hirta* showed potent cytotoxic activity against DLA and EAC cell lines and its IC<sub>50</sub> value was found to be 560.83µg/ml and 384.7 µg/ml of extract respectively. The *in vitro* outcomes of *E.hirta* extract showed potent anticancer effect against both DLA and EAC cell lines[11].

### **Conclusion**

*Euphorbia hirta* L., is well known for its medicinal uses. It widely used in traditional medicine. There are many other traditional uses of *E. hirta* in Ayurveda which serves as the basis for further studies.

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## **Anaesthetic Effects of 2-Phenoxyethanol and Clove Oil In Gold Fish (*Carassius auratus*) at Different Concentration**

**Jincy.D.S<sup>1</sup> Dr.F.G.Benno Pereira<sup>2</sup> Dr.R.Saravanan<sup>3</sup>**

<sup>1</sup>Research Scholar, S.T.Hindu College (Affiliated to M.S University), Nagercoil.

<sup>2</sup>Assistant Professor, University of Kerala Kriavattom (Affiliated to Kerala University), Thiruvananthapuram.

<sup>3</sup>Assistant professor, Sri K.G.S.Arts College, Srivaikundam (Affiliated to M.S University), Thoothukudi.

### **Abstract**

Anesthesia is widely used in aquaculture to minimize stress and prevent mechanical injury. The aim of this study was to determine the anaesthetic effects of 2-phenoxyethanol and clove oil on *Carassius auratus*. The mean body weight of the fish is 6 g. They were immersed in individual water tanks at different concentrations of 2-phenoxyethanol at 500, 600, 700, 800, and 900 ppm, and clove oil at 200, 250, 300, 350, and 400 ppm. They were monitored by using a stopwatch. The induction and recovery times for each concentration were repeated three times to verify the findings. The recovered fish were transferred into the recovery tanks and monitored for 48 hours to assess post-treatment mortality. During the post-treatment, fish were fed twice a day pellet food.

**Keywords:** Anesthesia, Recovery, 2-phenoxyethanol, Clove oil, *Carassius auratus*.

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### **Introduction**

Fish anesthetics have applications ranging from mild sedation during transport to total anesthetics for the body cavity (Guilderhus & Mark 1987) to handling and sorting of brood stock and measuring fish under culture conditions. An anesthetic that is to be used in aquaculture must fulfill three criteria, according to Guilderhus and Marking (1987): it must exhibit efficiency; it must allow for a relatively large envelope of safety; and it should be cost-effective. Guilderhus & Marking (1987) defined three efficacy criteria for an anesthetic. First, the fish must be sedated for 3 minutes or less. Second, the recovery to normal swimming after 15 minutes of exposure must take no more than 10 minutes; and third, there should be no mortality following a 15-minute exposure to the anesthetic. Of the 17 anesthetics tested, only five met these criteria for efficacy. These were MS-222 (3-aminobenzoic acid ethyl ester methane sulphonate) and Quinaldine sulfate (2-methyl-quinoline sulfate), benzocane (p-aminobenzoic acid methyl ester), and 2-phenoxyethanol. Differences in the metabolic rate of different species are probably responsible for the interspecific differences regarding their tolerance to (Ferreira, Schoonbee, & Smith 1984), which found an interspecific difference in the uptake of benzocaine hydrochloride through the skin and gill tissue of *Cyprinus carpio*. The difference in the rate of uptake was attributed

to the different lipid contents of the skin and gill tissue of these fish. The highest uptake through the skin was in *C. carpio*, which had the highest lipid content. The behavioral differences between species are also responsible for the variation in tolerance. The effect of anesthesia is generally accepted as being temperature-dependent, with higher temperatures causing faster rates of anesthesia (Bonath 1977). Fish are easily stressed by handling and transport, and stress can result in immunosuppression, physical injury, or even death. In aquaculture, anesthetics are used during transportation to prevent physical injury and reduce metabolism (consumption and excretion). They are also used to immobilize fish so they can be handled more easily during harvesting, sampling, and spawning procedures. An ideal anesthetic should induce anesthesia rapidly with minimum hyperactivity or stress. It should be easy to administer and should maintain the animal in the chosen state. When the animal is removed from the anesthetic, recovery should be rapid. The anesthetic should be effective at low doses, and the toxic dose should greatly exceed the effective dose so that there is a wide margin of safety. The effect of anesthesia is generally accepted as being temperature-dependent, with higher temperatures causing faster rates of anesthesia (Bonath 1977).

### **Objectives**

- To find out the water quality parameters before and after the experiment.
- To calculate the opercular movement of *Carassius auratus* at different concentrations of 2-phenoxyethanol and clove oil.
- To find the anesthetic and recovery times of 2-phenoxyethanol and clove oil at different concentrations, they were monitored using a stopwatch.

### **Materials and Methods**

The experimental fish is *Carassius auratus*, as *it* is one of the earliest fish to be domesticated and is still one of the most commonly kept aquarium fish. The fish were purchased from a local ornament fish dealer at Thiruvananthapuram. Water quality testing is an important way to understand the PH, temperature, ammonia, nitrate, dissolved oxygen, and nitrite content of a given water sample. So, the parameters are highly useful to monitor the quality of the water. 2-phenoxyethanol is used as a chemical anesthetic. In this current experiment, five concentrations are used. The concentrations were 500, 600, 700, 800, and 900 ppm. Control tanks were also maintained in which anesthetic was not added. The clove oil has a molecular mass of 1.049 g. In this current experiment, five concentrations are used. The concentrations were 200, 250, 300, 350, and 400 ppm. Control tanks were also

maintained in which anesthetic was not added. The experiment was conducted to find out the effective dosage of the anesthetic and recovery time by using *Carassius auratus*. An appropriate dose of anesthetics was added to a standard tank. Monitored the difference in induction as well as recovery rates of *Carassius auratus* to various concentrations of anesthetics by using a stop watch. The recovered fish were transferred into the recovery tanks and monitored for 48 hours to assess post-treatment mortality. During post-treatment, fish were fed pellet food twice a day.

## Results

### Efficacy of 2-Phenoxyethanol in Inducing Anesthesia

The phenoxyethanol has a molecular mass of 1.104 g. The concentrations were taken as 100, 200, 300, 400, and 500 ppm. The ideal concentration of 2-phenoxyethanol for inducing anesthesia in *Carassius auratus* was 300–400 ppm.

**Table:1 Anaesthetised Stages for *C. Auratus* In Different Concentration Of 2-Phenoxyethanol.**

SL/ NO.	CONCENTRATION (PPM)	ANAESTHETISED STAGE (IN SEC)		
		STAGE:1	STAGE:2	STAGE:3
1	100	48 ±5	No effect	No effect
2	200	46.50±25.0	73.50±2.50	No effect
3	300	36.50±2.50	67.50±4.50	111±7
4	400	30±1	40±3	90.50±2.50
5	500	20±1	29±3	Mortality in 51±7

### Efficacy of 2-Phenoxyethanol in Recovery.

300 and 400 ppm are the concentrations at which all the fish undergo complete sedation. In the last stage, they started swimming normally and had a regular opercular rate (table 2). They returned to their normal state and were able to regain their motion, equilibrium, and responsiveness towards external stimuli, like control.

**Table:2 Recovery Stage for *C.Aurates* in Different Concentration of 2-Phenoxyethanol.**

SL/ NO	CONCENTRATION (PPM)	RECOVERY STAGE(IN SEC.)		
		STAGE:1	STAGE:2	STAGE:3
1	300	767.50±3.50	826 ±3	924.50±350
2	400	786.50±50	851±3	937±1

**Table:3 Opercular Activity of *Carassius Auratus* at Different Concentration.**

CONCENTRATION (PPM)	OPERCULAR ACTIVITY (PER MIN)
500	52
600	37
700	27
800	21
900	68

Initially, we counted the opercular rate of the control. It was about 94 per minute. 900 ppm is considered a lethal concentration for fish, where death occurs.

#### **Efficacy of Clove Oil in Inducing Anaesthesia**

The clove oil has a molecular mass of 1.049 g. Four test concentrations were used. The concentrations were 200, 250, 300, 350, and 400 ppm. The efficacy of clove oil at different doses in *C. auratus* was tested and compared with control. 250–300 ppm is considered the ideal concentration for anaesthesia. The opercular rate of control was about 94 beats per minute. There would be an abnormal opercular rate of 350–400 ppm, which ultimately led to death.

**Table:3 Anaesthetised Stages for *C.Auratus* in Different Concentration of Clove Oil.**

SL/ NO	CONCENTRATION (PPM)	ANAESTHETISED STAGE (IN SEC)		
		STAGE:1	STAGE:2	STAGE:3
1	200	32.50±1.50	149±7	No effects
2	250	36.50±1.50	89±2	162±4

3	300	46±2	76.50±5.50	116.5±2.50
4	350	18±1	21.50±1.50	Mortality in 60.50±2. 50
5	400	3±1	6.50±1.50	Mortality in 41.33±2.52

#### Efficacy of clove oil in recovery

In 250–300 ppm of clove oil, all the fish have undergone complete sedation. We kept the sedated fish for almost 30 minutes in the induction tank and then transferred them to the recovery tank.

**Table:4 Recovery Stages for *Carassius Auratus* in Different Concentration of Clove Oil.**

SL/ NO	CONCENTRATION (ppm)	RECOVERY STAGE (IN SEC)		
		STAGE:1	STAGE:2	STAGE:3
1	250	564±2	585.50±2.50	603.17±4.19
2	300	575.50±5.50	632..50±1.50	646.50±2.50

**Stage:5 Opercular Rates of *Carassius Auratus* in Different Concentration of Clove Oil.**

CONCENTRATION (PPM)	OPERCULAR RATE(PER MIN)
200	54
250	48
300	37
350	59
400	66

#### Water Quality Parameters

Both control and anaesthetised water are subjected to water quality checking.

**Table:6 Waterquality Parameters in Tanks With *Carassius Auratus* With Clove Oil And 2-Phenoxyethanol:**

WATER QUALITY PARAMETERS	CONTROL		2- PHENOXYETHANOL		CLOVE OIL	
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER
Temperature	27	27	27	27	27	27
PH	7.8	7.8	7.8	7.4	7.8	7.2
Nitrate	0	0	0	0	0	0

Nitrite	0	0	0	0	0	0
Ammonium	0	0	0	0	0	0
Phosphate	0	0	0	0	0	0
iron	0	0	0	0	0	0

### Discussion

Mercy et al. (2014) investigated the efficacy of 2-phenoxyethanol for adult Redline Torpedo fish (*Salhyadriadenisonii*). It is similar to our result that 500, 600, 700, 800, and 900 ppm of 2-phenoxyethanol induce anesthesia (table 1). The result demonstrated that the induction time of anesthesia in *Carassius auratus* decreased with increasing concentrations of 2-phenoxyethanol. Akbary et al. (2016) studied the anesthetic effects of 2-PE Big Head Carp (*Hypophthalmichthys nobilis*). They tested with concentrations of 0.1, 0.3, 0.5, 0.7, and 0.9 mL/L of 2-PE and recorded that the optimal value for inducing anesthesia is 0.7 mL/L in 100 seconds. They also observed an increase in the number of leukocytes. 900 ppm is considered a lethal concentration for fish, where death occurs. Clove oil is classified as a local anesthetic, but it acts systematically when absorbed through the gills and skin of fish. Husen and Sharma (2015) recommended the use of clove oil for the effective handling and transportation of rohu fingerlings. At 250 and 300 ppm, as the time progressed, when it was 762±4 sec, the fishes swam upside down, lost their total equilibrium, and had little opercular movement. They passed through all the stages of anesthesia mentioned by Marking and Moyer (1985).

### Conclusion

Fish transportation is crucial in aquaculture, as it reduces mortality and ensures long-term viability. Efficient anesthetics can reduce fish activity and oxygen consumption, minimizing stress and physical damage. The choice of anesthetic depends on fish species, size, and physiological parameters. Clove oil, a natural anesthetic, is cost-effective, globally available, and safer for the environment. It has a higher survival rate and shorter recovery time compared to chemical anesthetics like 2-phenoxyethanol. Therefore, clove oil is a better option for effective handling and transportation of *Carassius auratus*.

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## A Study on Biochemical Characteristics of Terrestrial Slug *Laevicaulis Alte*

Suja P.S<sup>1,3</sup>, Nija.C<sup>\* 1,3</sup> and Navinchandran. M<sup>2,3</sup>

<sup>1</sup> Reg. No. 23113152192006, Department of Zoology, S.T.Hindu College, Nagercoil– 629002.

<sup>\* 1</sup> Associate Professor and Head of the Department of Zoology,  
Women Christian College, Nagercoil– 629001.

<sup>2</sup> Assistant Professor, Department of Zoology, S.T.Hindu College, Nagercoil – 629002.

<sup>3</sup> Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012.

Email: [nijadhas07@gmail.com](mailto:nijadhas07@gmail.com)

### Abstract

*Laevicaulis alte*, the land slug, is frequently observed throughout the Kanyakumari District. They reproduce through cross-fertilization and are hermaphrodites. During the monsoon, breeding activities are influenced by the supply of moisture and water in the surrounding environment. Approximately 25% of prescribed medications in developed nations are made up of active ingredients derived from molluscs. Since ancient times, slugs have been used as a remedy for a variety of illnesses (G. Cilia et al., 2018). In this study, the biochemical characteristics of the land slug *Laevicaulis alte* body fluid and mucus were compared. The findings indicated that the mucus of slugs had a significantly higher lipid, protein, and carbohydrate content than the body fluid of slugs.

**Keywords:** *Laevicaulis alte*, Slug, Biochemical, Mucus and Body fluid.

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### Introduction

Snails and slugs belongs to the phylum Mollusca and class Gastropoda. In contrast to snails, which have hard, calcareous shells covering their bodies, slugs are defined as snails lacking a shell (Barker, 2002; Ramzy, 2009). Both slugs as well as snails are able of producing slime, also known as mucus, which is a sticky, elastic fluid with adhesive and lubricating qualities that enables them to stick tenaciously to a variety of surfaces. Mucus also prevents mollusks getting dehydrated and deters prospective predators from capturing snails and slugs (Hamalalnen E.M, et al., 2012; South A.et al.,1992).

The slug or snail first produces the predecessor of mucus in the form of extremely hygroscopic grains, which are then kept inside the cells as granules covered in a protective membrane that keeps them dry and water resistant. These packets don't burst open until they are freed from the cell; extracellular ATP, which is assumed to play a mediating role in this process (Deyrup-Olsen I, et al., 1992). At this stage, the granules absorbed water as fast as 100 times quicker compared to when they did at first, creating the well-known slime or mucus track. The compounds in the slime, which is generated by a gland located inside its "foot", are also crucial for communication.



One of the primary sources of bioactive substances with anticancer, anti-inflammatory, anti-bacterial, and antioxidant activities have been identified to be mollusks (Benkendorff et al., 2011; Mohanraj et al., 2014).

Bioactive substances such as glycans, peptides, as well as glycopeptides are found in snail hemolymph (De smet et al., 2011; Gabriel et al., 2011). *Helix aspersa* mucus included allantoin along with glycolic acid, which had therapeutic benefits for the skin of people (E.I. Mubarak et al., 2013). The antibacterial activity of several snail crude components from aqueous and terrestrial snails has already been assessed (Ulagesan, S. and Kim, H.J. 2018). It is significant to note that scientists are currently examining the slime's elasticity and adhesive qualities in the hopes of developing artificial glue which can heal injuries to tissues (J. Gould et al., 2019).

The present investigation is on the common slug available in Kanyakumari District. It is commonly called as "leather leaf slugs as well as Indian garden slugs." The covering possesses a velvety form and a surface that appears somewhat granular (Prakash et al., 2015). The mantle overhangs the head and completely encloses the dorsum; a shell is missing. When the creature is in motion, two tentacles bearing eyes stick out front from beneath the mantle. Tiny 2 or 3 mm (0.079 or 0.118 in) tentacles are present. The head has a bilobed, insignificant inferior couple of tentacles. The sole of the foot is a light orange to yellowish white in color. The foot of this particular slug is extremely small; the foot of an adult species is only 4 or 5 mm (0.16 or 0.20 in) wide, while the foot of a juvenile species is 1 mm (0.039 in) small foot to minimize evaporation when living in arid environments.

Although it has been brought to Southern Asia, the country of Australia, as well as other Pacific Islands, slug seems to be of African descent. Abundant in Australia's north (Stanisic, 1998) additionally reported by from Vanuatu, the Islands of Hawaii, New Caledonia, possibly Island and American Samoa (Cowie 2000). extensively dispersed across the Fiji Islands (Barker et al. 2005). They are scattered in Jamshedpur (Jharkhand) and Dehra Dun (Uttarakhand) in India (Akhlaq Husain et al., 2021), Adaspur is situated in the Cuttack Districts of Odisha along the Prachi River bed (Badal Das et al., 2015), Uttar Pradesh's Allahabad District (Sri Prakash et al., 2015), Maharashtra's Nashik district's Kalwan area (Goswami D.B, 2018), One of the larger cities in India's Nandurbar District is Shahada (Bhavare et al., 2017). It is gathered in Tamil Nadu at Courtallam Hill in the Tirunelveli District (Kavitha et al., 2018).

Slug is dispersed over Kanyakumari District. I have gathered it and sent it to the Indian Zoological Survey for species identification. The specimen was identified as *Laevicaulis alte*. Little is known about the terrestrial mollusk *Laevicaulis alte* potential as a source of physiologically active compounds. The objective of this study is to assess the biochemical assessment of mucus and body fluid in the terrestrial slug *Laevicaulis alte*.

## Materials and Methods

### Collection and extraction of body fluid

*Laevicaulis alte* specimens were transported from the Kanyakumari region to the laboratory. The body fluid of the slug was collected using a 0.7% saline solution. After that, it was centrifuged, and the supernatant was taken out for biochemical analysis.

### Collection of mucus

Animals were cleansed with distilled water before being placed in a sterile petri dish for collecting mucus. Mucus was collected by using 2% citric acid solution as it acts as a stimulant to encourage slugs to produce more mucus. Mucus that had gathered on the petri plates were then scraped up using a spatula. After centrifuging the slug's mucus, the supernatant was treated according to normal procedure for biochemical calculation.

### Estimation of Biochemical Components

Protein was estimated by using the procedure by Lowry et al.,(1951), carbohydrate by Carroll et al.,(1956) and Lipid by Frings et al.,(1972).

## Results

### Classification of *Laevicaulis alte*

Phylum: Mollusca

Class: Gastropoda

Sub class: Heterobranchia

Super Order: Eupulmonata

Order: Systellomatophora

Super family: Veronicellodiea (Gray, 1840)

Genus: *Laevicaulis alte* (ferussac, 1822)

### Life Cycle

#### Eggs

*Laevicaulis alte* eggs are deposited in a hole or depression in the soil a few days after mating; the eggs are jointed together by an interconnecting thread forming a string that the parent shapes into



Figure 1: *Laevicaulis*

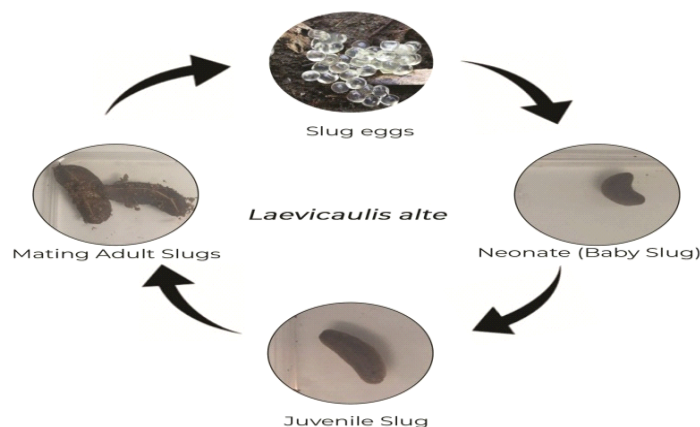
a ball like mass. The eggs of *Laevicaulis alte* were pale brown and transparent in colour and also oval in shape.

**Neonates**

A newly – hatched slug is called a neonate. Hatching occurs around 1 to 3 weeks with newborn slugs measuring around 7 to 8mm in length (approx. 5/16 in). Young neonates weigh between 1 – 10mg.

**Juvenile**

Juvenile slugs will begins feeding throughout the spring and sometimes in the summer, if moisture is present and it is not too hot. If conditions are unsuitable, juveniles and adults will rest (aestivate) under clods and debris, in burrows and soil cracks. Juveniles weigh between 11 – 100mg.

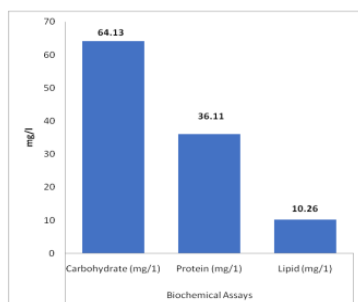


**Figure 2: Life cycle of *Laevicaulis alte***

**Biochemical content of slug body fluid**

In order to conduct this study, the body fluid of the terrestrial slug *Laevicaulis alte* was analysed for fat, protein, and carbohydrate content. The results were represented in milligrams per liter. Table.1 presents the results.

**Table.1 Biochemical content on the body fluid of slug.**



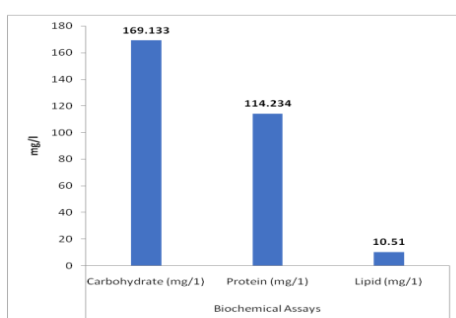
**Figure.3 Biochemical content of Slug body fluid**

The findings demonstrated the high percentage of carbohydrates in the body fluid of the slug *Laevicaulis alte*. One could argue that the body fluid of *Laevicaulis alte* contains a lot of carbohydrates. The outcome also showed that the body fluid of *Laevicaulis alte* contains a moderate quantity of protein. This testing revealed a low lipid value.

### Biochemical content of slug mucus

Table 2 shows the amounts of fat, protein, and carbohydrates in the mucus of the land slug *Laevicaulis alte*.

**Table.2 Biochemical content of Slug mucus**



**Figure.4 Biochemical content of Slug mucus**

The results showed that the slug *Laevicaulis alte* mucus has high percentage carbohydrate content. It could be said that *Laevicaulis alte* mucus is a rich source of carbohydrates. The result also revealed that *Laevicaulis alte* mucus has a moderate amount of protein and low lipid value was recorded from this study.

More fat, protein, and carbohydrates can be found in slug mucus than in slug body fluid. Slug mucus had a much higher carbohydrate content ( $169.133 \pm 0.057$ , body fluid:  $64.13 \pm 0.29$ ), protein content (mucus:  $114.234 \pm 0.005$ , body fluid:  $36.11 \pm 0.81$ ), and lipid content (mucus:  $10.51 \pm 0.026$ , body fluid:  $10.26 \pm 0.24$ ) than slug body fluid.

### Discussion

Molluscs are employed in a variety of therapeutic contexts; medicines are made from purified or synthetic bioactive components, while nutraceuticals are made from crude or semi-purified extracts (Dwek et al., 2001; Dolashka-Angelova et al., 2008). The outcome demonstrates the slime's high crude protein content. Furthermore supporting the claims made by Adeyeye (1966), Eruvbetine (2012), Okon and Ibom (2012), and others that snail meat is a premium, high-protein diet. *Perronia virruculata* was found to contain  $5.73 \pm 0.98\%$  fat and  $59.42 \pm 1.82\%$  protein (Solanki et al., 2017). Additionally, antibacterial action against certain

types of bacteria and fungi was demonstrated by a crude protein that was isolated from six different species of snails (Ulagesan and Kim, 2018). The most potent crude proteins were derived from the land snail *Cryptozonia bistrialis*, which was able to totally stop the growth of pathogenic fungi like *A. fumigatus*, *Candida albicans*, *Micrococcus luteus*, and *Pseudomonas aeruginosa*, as well as pathogenic bacteria like *Staphylococcus aureus*, *Micrococcus luteus*, and *Pseudomonas aeruginosa* (Ulagesan and Kim, 2018). A review of the literature indicates that no research has been done on the biochemical activity of *Laevicaulis alte* body fluid or mucus.

The findings of the *Laevicaulis alte* body fluid on biochemical estimate indicates that the body fluid contains  $64 \pm 0.29$  mg/l carbohydrates,  $36.11 \pm 0.81$  mg/l proteins, and  $10.26 \pm 0.24$  mg/l lipids. The biochemical estimate of *Laevicaulis alte* mucus indicate that the mucus contains  $10.51 \pm 0.026$  mg/l fat,  $114.234 \pm 0.005$  mg/l protein, and  $169.133 \pm 0.057$  mg/l carbohydrate. The  $95.2 \pm 0.09\%$  moisture content found in snail slime is within the  $73.67 \pm 99.20\%$  range observed in snail meat by Wosu (2003) and Eneji et al. (2008). *A. marginata* snail slime has been shown to have  $2.54 \pm 0.02\%$  protein,  $1.15 \pm 0.05\%$  carbohydrate, and  $0.09 \pm 0.01\%$  fat, according to Danladi J.G. et al. (2020). A perlucin-like protein was also found by Smith et al. (2017) in an sticky glue from the dorsal side of the Dusky slug *Arion subfuscus*, indicating that this protein might be involved in defense. The current study found that slug body fluid had a lower carbohydrate and protein contents than slug mucus, based on biochemical estimation.

### **Conclusion**

In summary, this study's findings demonstrated that *Laevicaulis alte* body fluid and mucus include a sizable amount of easily accessible proteins; as a result, they may be useful in the creation of novel medicines to combat pathogenic microorganisms that are resistant to multiple drugs (MDR). This work also highlights the necessity of identifying and isolating novel active antipeptides from as soon as possible *Laevicaulis alte*.

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## Improved Growth Performance in Gif *Tilapia* Supplemented with Diet Enriched with Triphala Extract and Honey

M. Navin Chandran\*, M.U Poornima, G.S Anantha Selvi and V. Pattukumar

Department of Zoology, S.T Hindu College, Nagercoil- 629002

Email: navinfisheries@ gmail.com

### Abstract

GIF *Tilapia* is an ideal variety of fish that plays a prominent role in blue revolution. It is much preferred due to its fast growth rate, high survival and resistance to disease. Triphala is a popular herbal formulation in traditional ayurvedic medicine. In case of fish growth and immunity polyherbal formulation had played a versatile role that could be evidenced by many reports. In this aspect a short term indoor experimentation was performed in GIF *Tilapia* reared in an indoor culture system provided on diet enriched with triphala extract at a concentration of 2% and 5% designated as T1 and T2 diets simultaneously a control diet (C) was also tested. At the end of experimentation (40<sup>th</sup> day) a maximum weight gain  $4.13 \pm 0.03$  g was noticed in T1 diet fed fish compared to a low production of  $3.54 \pm 0.03$  g noticed in control diet fed fish . The FCE was high  $57.36 \pm 1.32$  % in T1 diet fed fish compared to a low FCE  $48.89 \pm 1.26$  % and  $47.57 \pm 0.02$ % noticed in control and T2 diet fed group.

**Keywords:** Triphala extract, GIF *Tilapia*, FCE

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### Introduction

*Tilapias* are widely recognized as one of the most important fish species for freshwater aquaculture in a wide range of farming systems from simple small-scale water-fed fish ponds to intensive culture systems (Pullin, 1985).The growth rates of the Genetically Improved Farmed *Tilapia* (GIFT) strain were superior to those of local strains of the Nile *Tilapia* (Eknath *et al.* 1993). This variety should be popularised in many countries. *Tilapia* are fast growing and omnivorous, with an ability to utilize a wide range of feed ingredients such as detritus, blue green or green algae, diatoms, macrophytes and bacteria (Bhujel *et al.*, 2001; Gonzales and Brown, 2006).

In order to meet the demand of humans fishes of commercial importance are reared under captivity. Some substances are added in fish feed to improve feed conversion efficiency that results in higher fish production (Fernández-Navarro *et al* 2006). There are many reports concerning the inclusion of herbs in fish diet that had a positive effect on growth promotion and resistance to disease in fishes. The excess use of various antibiotics, hormones and other synthetic drugs to control diseases and improve fish growth in aquaculture system has resulted in ill effects and disease resistance strains of bacteria that affect the environment and

human health (Esiobu *et al* 2002). So an alternative source to all these adverse effects is to imply eco-friendly feed additives that could improve the growth and immune status of the cultured organisms. Herbal extracts have the potential to be used as key nutritional supplements in aquaculture. Each herb consists of a specific composition and affects living organisms in different methods. Considering the beneficial role of herbals in fish culture system the present investigation was performed to test the effect of triphala extract enriched with honey on the growth performance of GIF *Tilapia* in an indoor culture system.

## **Materials and methods**

### **GIF *Tilapia***

GIF *Tilapia* were procured from vellanguli hatchery, Tamilnadu and they were brought to the culture sight with least disturbance to the fish. They were acclimatized in 100 l capacity plastic troughs containing ell aerated fresh water and then segregated into respective culture tanks.

### **Diet preparation and experimentation**

In total three diets were tested in GIF *Tilapia* culture system. In order to prepare the test diets commercial pellet diets were obtained from fish aquarium and they were segregated into 100g each i.e. control, T1 and T2 diets respectively. Honey obtained from commercial market (1%) was mixed with each diets and then dried in a hot air oven at 50°C. Triphala powder was mixed along with T1 and T2 diets at a concentration of 2% and 5% respectively. The prepared diets were dried in a hot air oven at the same temperature indicated above and stored in plastic containers for further use. GIF *Tilapia* weighing about  $2.00 \pm 0.09$  g to  $2.90 \pm 0.13$ g was segregated into respective control and experimental groups. The fishes were offered with respective control C and experimental diets T1 to T2 to satiation. Water quality parameters were maintained at an optimum level by providing 50% of water exchange daily and the experimentation was performed for a duration of 40 days.

**Table 1. Growth Responses of GIF *Tilapia* fed on control and experimental diets**

<b>Parameters</b>	<b>Growth responses</b>		
	<b>Control (C)</b>	<b>T1</b>	<b>T2</b>
<b>Initial weight (g)</b>	$2.20 \pm 0.73$	$2.00 \pm 0.09$	$2.90 \pm 0.13$

<b>Final weight (g)</b>	5.74 ± 0.02	6.13 ± 0.16	6.52 ± 0.01
<b>Production (g)</b>	3.54 ± 0.03	4.13 ± 0.03	3.62 ± 0.01
<b>Food consumed (g)</b>	7.24 ± 0.01	7.20 ± 0.02	7.58 ± 0.19
<b>FCR</b>	2.04 ± 0.04	1.74 ± 0.01	2.09 ± 0.01
<b>AGR (g/body weight/day)</b>	0.078 ± 0.001	0.091 ± 0.002	0.080 ± 0.001
<b>FCE (%)</b>	48.89 ± 1.26	57.36 ± 1.32	47.75 ± 0.02
<b>SGR (%)</b>	3.55 ± 0.14	3.76 ± 0.17	3.77 ± 0.02
<b>G (%)</b>	7.80 ± 0.03	9.20 ± 0.04	8.00 ± 0.14

**Table -2. Water quality parameters during experimentation**

<b>Parameters</b>	<b>Water quality Parameters</b>		
	<b>Control (C)</b>	<b>T1</b>	<b>T2</b>
<b>Temperature (°C)</b>	31.00 ± 0.00	31.00 ± 0.00	31.00 ± 0.00
<b>PH</b>	7.56 ± 0.12	7.64 ± 0.16	7.69 ± 0.01
<b>Dissolved oxygen (mg/l)</b>	5.34 ± 0.12	5.42 ± 0.14	5.43 ± 0.18
<b>Ammonia ( mg/l)</b>	< 0.1	< 0.1	< 0.1

### Results and Discussion

Growth performance parameters indicated that a maximum production of 4.13 ± 0.03 g as noticed in GIF *Tilapia* fed on T1 diet compared to a low production of 3.54 ± 0.01g and 3.62 ± 0.01g registered in control and T2 diet fed fish. The FCE was high 57.36 ± 1.32 % in T1 diet fed fish compared to a low FCE 48.89 ± 1.26% and 47.75 ± 0.02 % noticed in control and T2 diet fed fish. Similarly, other growth performance parameters also showed a similar trend. (Table 1.)Water quality parameters are maintained in an optimum level by providing regular water exchange and the parameters were analyzed by standard protocols (APHA, 1995) as illustrated in Table 2. Ji *et al.*, (2007) observed that the herbs promoted cellular lipid and fatty acid utilization and protein accumulation resulting in better growth performance in *Pagrus major* similarly, in the present investigation Tripala extract enriched

with honey at a concentration of 2% enhanced the maximum production of  $4.13 \pm 0.03$  g compared to control and T2 treated groups. Many factors such as density, water quality, feed quality and various environmental factors such as temperature, salinity and dissolved oxygen content of water play important role in increasing the meat quality and production in aquaculture in this aspect in the present study water quality parameters were maintained at an optimum level by providing regular water exchange.

### **Conclusion**

Triphala extract enriched with honey at a concentration of 2% enhanced a maximum weight gain in GIF *Tilapia* and hence it can be recommended as an optimum dose.

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## **In-silico study of *Cordia dichotoma* Phytochemicals as Potential Inhibitors of Lung Cancer: A promising approach for developing new antiviral therapeutics**

**<sup>1</sup>K. Abishek, <sup>2</sup>M.I. Delighta Mano Joyce and <sup>3</sup>K. Karthcik**

<sup>1</sup>Research scholar (23111192191014), <sup>2</sup>Assistant professor and PG Head and

<sup>3</sup>Assistant professor

<sup>1,2</sup>Department of Zoology, Sadakathullah Appa College, Tirunelveli - 627011.

Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012.

<sup>3</sup>Department of Chemistry, Rajalakshmi Institute of Technology, Chennai - 600124.

Email: [midelighta@gmail.com](mailto:midelighta@gmail.com)

### **Abstract**

About half of the chemotherapeutic drugs are naturally occurring anticancer compounds which are available in the market to date. In silico virtual screening for new anti-cancer drug discovery is a cost-effective method as compared to traditional drug synthesis. In this article, phytochemicals from *Cordia dichotoma* plants are screened that can inhibit protein growth causing lung cancer by using molecular docking and ADME analysis. About two phytochemicals from *Cordia dichotoma* family were selected from the Dictionary of Natural Products (DNP) on the basis of lipinski rule of five and subjected to molecular docking analysis along with approved drugs Quercetin and Gallic acid against targeted proteins EGFR and KRAS. In silico ADME studies of selected phytochemicals suggest that compound Quercetin and Gallic acid are completely safe, non-toxic, non-carcinogenic, non-GERG blocker, do not cause liver injury and have high excretion rate and can be taken for further in vivo and in vitro studies to discover new chemotherapy against lung cancer.

**Keywords:** Lung cancer, *Cordia dichotoma*, Molecular Docking, Phytochemicals, ADME

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### **Introduction**

Since ancient times, plants have been central to medicine, providing natural remedies for various ailments. The World Health Organization (WHO) estimates that up to 80% of the global population relies on traditional medicine due to limited access to modern treatments and widespread poverty. Lung cancer is a leading cause of cancer-related deaths worldwide, having claimed 1.6 million lives in 2012. The WHO projects that cancer rates will double by 2040, with many new cases in low- and middle-income countries. Lung cancer primarily manifests as Non-Small Cell Lung Cancer (NSCLC), which constitutes 85% of cases, and Small Cell Lung Cancer (SCLC). Key risk factors include smoking, radiation, exposure to harmful substances, and air pollution. Traditional treatments such as chemotherapy and

radiotherapy often come with severe side effects, while targeted therapies and immunotherapy can face challenges like drug resistance [1-3].

*Cordia dichotoma*, or Indian cherry, is a significant medicinal plant found in India, Sri Lanka, and other tropical regions. Used in Ayurveda, Unani, and Siddha medicine, *C. dichotoma* offers a range of therapeutic benefits, including anti-inflammatory, antibacterial, antiviral, diuretic, and hepatoprotective properties. Its leaves are especially noted for their gastroprotective effects and historical use in treating jaundice and liver disorders. One effective strategy for discovering new drugs combines ethnomedicinal documentation with antibacterial and antioxidant screening. This approach is crucial in addressing new pathogenic diseases linked to oxidative stress, such as liver conditions. Jaundice, a common liver ailment, is not just a disease but a sign of liver dysfunction, often caused by hyperbilirubinemia, which results in elevated bilirubin levels in the blood [1, 3-6].

In silico studies, such as molecular docking, offer an efficient method for drug discovery. This study aims to explore the potential of *C. dichotoma* leaf phytochemicals for treating lung cancer through in silico molecular docking. By analyzing how these compounds interact with key proteins involved in lung cancer, this research seeks to identify new, less toxic treatment alternatives.

## **Materials and Methods**

### **Ligand (Phytocompound) selection and Preparation**

This study has incorporated eight phytochemicals from *Cordia dichotoma* which has been proven for their significant antiviral potential (figure.1 and Table 1). Their 3D structure was downloaded from PubChem database and used for assessing their inhibitory potential against all the two selected targets of Lung cancer [7].

### **Target Structure Preparation for Docking**

In this study, we have selected Two different targets (Table 1) responsible for the progression of lung cancer disease. Structures of selected targets were downloaded from RCSB database ([www.rcsb.org](http://www.rcsb.org)). Subsequently structure of targets was optimized with Discovery studio and finalized for docking studies using Autodock Tool [7].

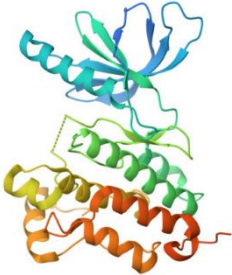
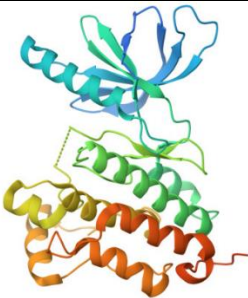
### **Drug Likelihood Filters**

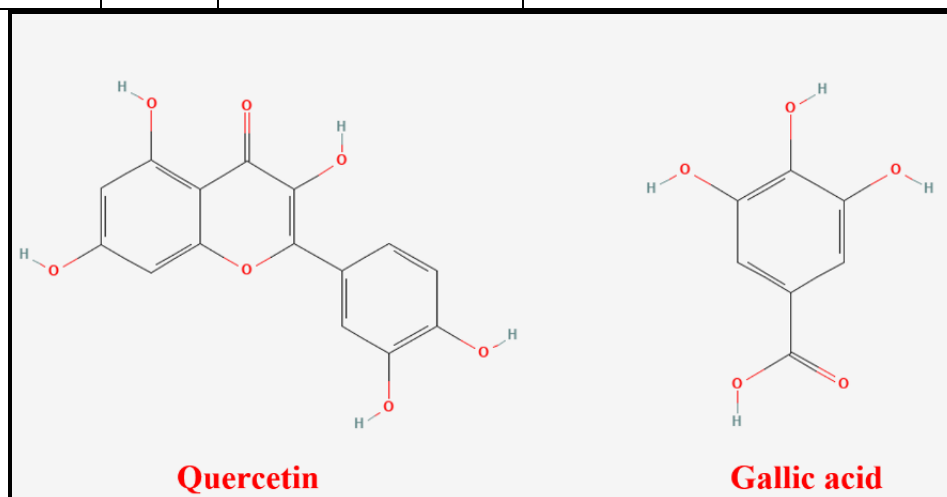
We have chosen four specific filters, including the Lipinski (Pfizer) filter, Ghose Filter, Veber Filter, Egan (Pharmacia) Filter, and Muegge (Bayer) Filter, to explain the drug-like properties of *Cordia dichotoma* phytochemicals [7].

## ADMET Properties

We used admet SAR to investigate the physicochemical and ADMET characteristics of the phytochemicals from *Cordia dichotoma* (<http://lmmd.ecust.edu.cn/admetSar1>). This study considered several factors, including the Ames test, human intestinal absorption, blood-brain barrier permeability, and Caco-2 cell permeability.

**Table 1. List of Two Lung Cancer targets proteins for in silico studies**

Target protein	PDB ID	Structure	Function
<b>EGFR-EGFR</b> stands for Epidermal Growth Factor Receptor	5ZWJ		The main function of EGFR is to receive signals from outside the cell and transmit them inside the cell, where they can trigger a series of biochemical reactions that lead to cell growth, proliferation, differentiation, and survival
<b>KRAS-Kirsten</b> rat sarcoma viral oncogene homolog.	4JV6		KRAS functions as a switch that regulates cell growth, differentiation, and survival by activating downstream signaling pathways.



**Figure 1. Phytochemicals of *Cordia dichotoma***

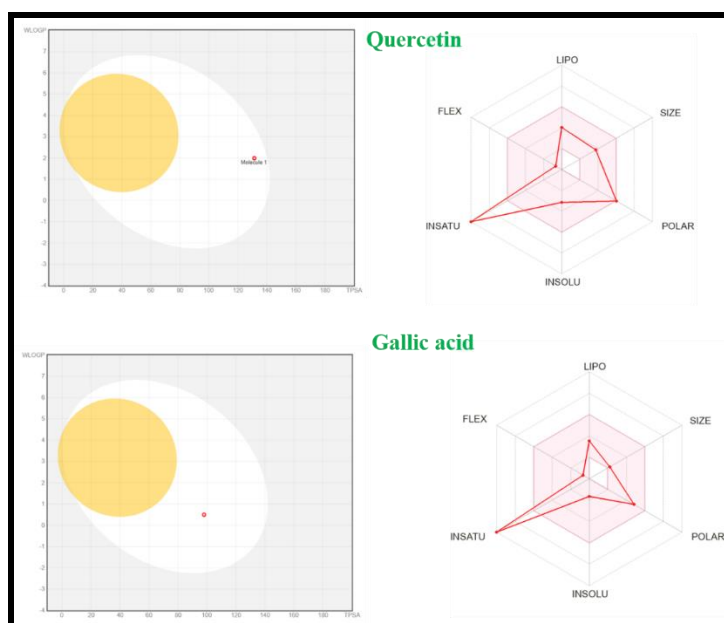
## Results and discussion

### Drug-likeness criteria for Phytochemicals (*Cordia dichotoma*)

An additional pharmacokinetic analysis was performed over the two compounds: Quercetin and Gallic acid (Tables 3). Among the 2 compounds, Quercetin was showing excellent activity and determined to be in violation of five of the six criteria, indicating that the medicine would pave new strategy improvement in terms of drug delivery systems. The drug-likeness criteria of phytochemicals were assessed using five different filters (Lipinski, Ghose, Veber, Muegge, and Egan Filter). Apigenin has complied with all drug-likeness criteria (Tables 2 and 3).

### ADME/T prediction

Table 3 shows the ADMET profiles of QC bioactive chemicals. Due to their strong binding affinity with the target proteins, the putative immunomodulatory chemicals in phytochemicals were anticipated to have excellent in vitro activity. In vivo and in clinical settings, the binding free energy value, when paired with the ADMET profile, might be useful in predicting the safety and effectiveness of bioactive compounds (figure-2).



**Figure 2.** The bioavailability radars and BOILED-Egg for Phyto compounds

**Table 2. Phytochemical contents in *Cordia dichotoma* from different parts of the plant**

Molecule	Quercetin	Gallic acid
PubChem CID	5280343	370
IUPAC Name	2-(3,4-dihydroxyphenyl)-3,5,7-trihydroxychromen-4-one	3,4,5-trihydroxybenzoic acid
Canonical SMILES	<chem>Oc1cc(O)c2c(c1)oc(c(c2=O)O)c1ccc(c(c1)O)O</chem>	<chem>OC(=O)c1cc(O)c(c(c1)O)O</chem>



Formula	C15H10O7	C7H6O5
MW	302.24	170.12
Heavy atoms	22	12
Aromatic heavy atoms	16	6
Fraction Csp3	0	0
Rotatable bonds	1	1
H-bond acceptors	7	5
H-bond donors	5	4
MR	78.04	39.47
TPSA	131.36	97.99

**Table 3. Screening of phytochemicals of *Cordia dichotoma* using several Drug-Likelihood Filters and Selected pharmacokinetic parameters after ADME/T prediction**

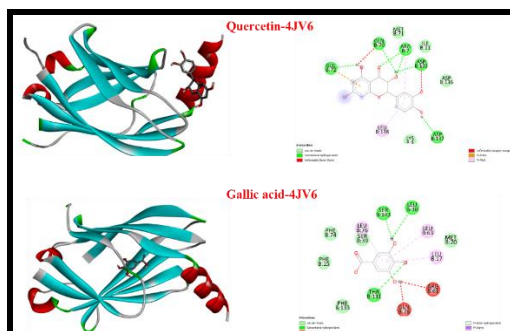
Pharmacokinetics Properties		
Molecule	Quercetin	Gallic acid
GI absorption	High	High
BBB permeant	No	No
Pgp substrate	No	No
CYP1A2 inhibitor	Yes	No
CYP2C19 inhibitor	No	No
CYP2C9 inhibitor	No	No
CYP2D6 inhibitor	Yes	No
CYP3A4 inhibitor	Yes	Yes
log Kp (cm/s)	-7.05	-6.84
Drug likeness Rule		
Lipinski (violations)	0	0
Ghose (violations)	0	2
Veber (violations)	0	0
Egan (violations)	0	0
Muegge (violations)	0	1
Bioavailability Score	0.55	0.56

### Molecular Docking

Therapeutic repurposing has shown to be a new avenue toward the rapid understanding of inhibitory molecules for coronavirus drug discovery. Our research also looked into the potential of existing drugs to treat viral infections. In silico experimental findings in this work specifically stated that phytochemicals had strong binding capability with lung cancer

inhibitors (Tables 4). To confirm its inhibitory effect against lung cancer pathogenesis, more italic research is required.

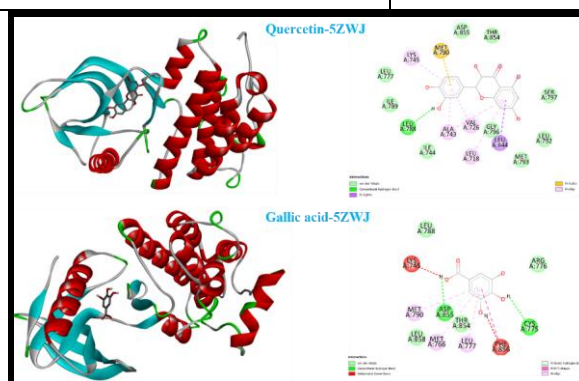
Molecular docking results shown in Figure (3 and 4) indicate that phytocompounds are stabilized in 4JV6 and 5ZWJ receptor pocket by various interactions with interesting scoring. The compound (Quercetin) which is the most active molecule in a dataset is stabilized by hydrogen bond interaction and high binding affinity.



**Figure 3.** Docking Analysis of two phytocompounds of *Cordia dichotoma* and standard drug with (4JV6-Kirsten rat sarcoma viral oncogene homolog) target of Lung Cancer.

**Table 4. Interaction of residues with target protein and docking scores of screened phytochemicals.**

Compound s	Δογκινγ Σχορεσ □Κχαλ/μολ (49Ϸ6 )	Δογκινγ Σχορεσ □Κχαλ/μολ (5ΖΩ9 )
Quercetin	-8.6	-5.5
Gallic acid	-5.8	-7.6



**Figure 4.** Docking Analysis of two phytocompounds of *Cordia dichotoma* and standard drug with (5ZWJ - EGFR stands for Epidermal Growth Factor Receptor) target of Lung Cancer.

## Conclusion

Several studies are currently investigating antiviral drug therapies to combat life-threatening Lung Cancer. This study will be valuable for designing novel drugs to treat Lung Cancer in both current and future contexts. In this study, phytochemicals from *Cordia dichotoma* were compared with a well-known medication, remdesivir, used in Lung Cancer treatment using molecular docking. The identified compounds showed promising potential, supported by favorable ADMET properties for consideration as drug candidates. We propose that phytochemicals from *Cordia dichotoma* be explored further as potential therapeutics against Lung Cancer. Future research should include molecular dynamics simulations to validate the structural stability of selected ligands. Subsequently, in vitro and in vivo assays are necessary for a more comprehensive analysis of the compounds' activity in living organisms.

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## A Critical Review on Concerning Human Health Aspects of Microplastics: Current Evidence and Future Perspectives

Chithaiya. P<sup>1\*</sup>, M.Sithi Jameela<sup>2\*</sup>, G. Gayathri<sup>3</sup>

<sup>1</sup>Research Scholar, Register number (23111192192191015), Department of Zoology, Sadakathullah Appa College (Autonomous), Rahmath Nagar, Tirunelveli - 627011.

Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

<sup>2</sup>Associate Professor and Head, Department of Zoology, Sadakathullah Appa College (Autonomous), Rahmath Nagar, Tirunelveli - 627011

Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

<sup>3</sup>Research Scholar, Register number (21211192192006), Department of Zoology, Sadakathullah Appa College (Autonomous), Rahmath Nagar, Tirunelveli -627011.

Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

Email: [chithaiya.p@gmail.com](mailto:chithaiya.p@gmail.com)

### Abstract

The ubiquitous presence of microplastics in the environment has raised concerns about their potential impact on human health. Through a comprehensive examination of the literature, this review explores the ingestion of microplastics, their physiological and toxicological effects, and the detection of microplastics in human tissues. Furthermore, it outlines the need for future research to elucidate the mechanisms of toxicological effects, conduct long-term exposure studies, and develop standardized methods for microplastic detection in human samples. The review also emphasizes the importance of developing mitigation strategies and policies to reduce human exposure to microplastics. By critically evaluating the current evidence and embracing a forward-looking perspective, this review aims to contribute to the understanding of the potential risks associated with microplastics and the safeguarding of human health for future generations.

**Keywords:** microplastics, human health, future perspective

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### Introduction

Microplastics, defined as plastic particles less than 5 millimeters in size, have emerged as a ubiquitous environmental pollutant (Loganathan *et al.*, 2023). They originate from various sources, including the breakdown of larger plastic debris, microbeads in personal care products, and synthetic fibers from textiles (Acharya *et al.*, 2021). The pervasive presence of microplastics in marine, freshwater, and terrestrial ecosystems, as well as in the atmosphere, has raised significant concerns about their potential impact on human health (De Souza Machado *et al.*, 2018). The ingestion and inhalation of microplastics are the primary pathways through which humans are exposed to these contaminants (Sangkham *et al.*, 2022). Studies have detected microplastics in a wide range of food products, including seafood, table

salt, and bottled water, suggesting that the daily human intake of microplastics is substantial. Moreover, recent research has revealed the presence of microplastics in human tissues, including the lungs, liver, and placenta, indicating that these particles can penetrate physiological barriers and accumulate in the body (Sangkham *et al.*, 2022).

Despite the growing body of evidence on the ubiquity of microplastics and their presence in the human body, the health implications of this exposure remain poorly understood (Blackburn and Green, 2022). Microplastics can act as carriers for a variety of toxic substances, including persistent organic pollutants, heavy metals, and pathogenic microorganisms, which may exacerbate their potential health risks (Rafa *et al.*, 2023). Furthermore, the physical characteristics of microplastics, such as size, shape, and chemical composition, can influence their biological interactions and toxicity. This critical review aims to synthesize the current evidence on the health impacts of microplastics, highlighting the key findings from recent studies and identifying the gaps in our understanding. By examining the pathways of human exposure, the mechanisms of toxicity, and the potential health outcomes associated with microplastics, this review seeks to provide a comprehensive overview of the current state of knowledge (Sangkham *et al.*, 2022). Additionally, it will discuss the future perspectives and research priorities needed to address the uncertainties and challenges in this emerging field.

Understanding the human health aspects of microplastics is crucial for developing effective policies and strategies to mitigate their impact. As the production and use of plastics continue to increase globally, addressing the health risks associated with microplastics becomes ever more urgent. This review will contribute to the ongoing discourse by providing a critical assessment of the evidence and proposing directions for future research.

### **Methodology**

To ensure comprehensive coverage of the topic, a systematic literature review will be conducted using several academic databases, including: PubMed, Science Direct, Google Scholar, Web of Science, Search terms will include combinations of keywords such as "microplastics," "human health," "toxicity," "exposure," "ingestion," "inhalation," "risk assessment," and "future perspectives." Boolean operators (AND, OR) will be used to refine searches. The methodology will conclude with a summary of the critical review process, highlighting the importance of comprehensive, high-quality research in understanding and mitigating the human health impacts of microplastics (Burns, and Boxall, 2018).

### **Pathways of Ingestion**

**Seafood & Salt:** Marine organisms, including fish, shellfish, and crustaceans, are primary vectors for microplastics to enter the human food chain (Bisht and Negi, 2020). Microplastics in marine environments are ingested by these organisms, which are then consumed by humans (Egbeocha *et al.*, 2018). Studies have shown that seafood can contain various sizes of microplastics, ranging from small fragments to fibers, which accumulate in the digestive tracts of these animals (EFSA, 2016). Sea salt, commonly used in food preparation, has been identified as another source of microplastic ingestion. The production process of sea salt, which involves the evaporation of seawater, leads to the concentration of microplastics present in the water. Analyses of commercial sea salt brands have revealed varying levels of microplastic contamination, indicating a direct ingestion pathway (Kapukotuwa *et al.*, 2022)

**Drinking Water:** Microplastics have also been detected in both bottled and tap water (Gambino *et al.*, 2022). The contamination of drinking water sources occurs through various mechanisms, including the breakdown of larger plastic debris, runoff from urban areas, and atmospheric deposition. The presence of microplastics in drinking water suggests that daily water consumption is a significant exposure route for humans. In addition to seafood and salt, microplastics have been found in other food items such as honey, sugar, beer, and even vegetables. The sources of contamination in these products can be diverse, ranging from agricultural practices to packaging and processing methods.

### **Mechanisms of Toxicological Impact**

**Physical Damage and Inflammation:** Microplastics can cause physical damage to tissues upon ingestion or inhalation. Their irregular shapes and sizes can lead to mechanical irritation and inflammation in the gastrointestinal (GI) tract and respiratory system (Yang *et al.*, 2022). For example, sharp-edged fragments and fibrous microplastics can puncture or irritate epithelial cells, leading to local inflammatory responses.

**Oxidative Stress:** Oxidative stress is a significant mechanism through which microplastics can induce toxicity. When microplastics are taken up by cells, they can generate reactive oxygen species (ROS), which can damage cellular components such as lipids, proteins, and DNA (Das, 2023). The resultant oxidative stress can trigger inflammatory pathways, contributing to chronic diseases and cellular dysfunction.

**Chemical Leaching:** Microplastics can adsorb and desorb harmful chemicals, including persistent organic pollutants (POPs), heavy metals, and plastic additives like phthalates and

bisphenol A (BPA) (Fred et al., 2020). These chemicals can leach out from microplastics under physiological conditions, leading to systemic exposure. The toxicological impact of these chemicals includes endocrine disruption, carcinogenicity, and neurotoxicity.

**Immune Response Modulation:** Microplastics can modulate the immune system, potentially leading to immunotoxicity. They can be recognized as foreign bodies by immune cells, triggering immune responses that may result in chronic inflammation or autoimmune disorders. Additionally, the immune system's attempt to eliminate microplastics can lead to the formation of granulomas and other pathological conditions.

### **Potential Health Impacts**

**Evidence of Ingestion:** Studies have provided substantial evidence of human ingestion of microplastics. The detection of microplastics in human stool samples is a compelling indication that these particles are being ingested through various dietary sources. For instance, a pilot study analyzing stool samples from participants across different countries found microplastics in all samples, with an average of 20 microplastic particles per 10 grams of stool (Mastad, 2022). This study highlighted the global nature of microplastic exposure and the pervasiveness of these particles in the human diet. The types of microplastics identified in stool samples included a variety of polymers such as polypropylene, polyethylene, and polyethylene terephthalate, which are commonly used in packaging materials. The study also noted the presence of microplastics from synthetic textiles, reflecting their widespread use in clothing and household items.

**Gastrointestinal Irritation:** While the presence of microplastics in the human digestive system is well-documented, the potential health impacts of ingestion remain a subject of ongoing research. Ingested microplastics can cause physical abrasion and irritation of the gastrointestinal (GI) tract. Animal studies have shown that high levels of microplastic ingestion can lead to inflammation and histopathological changes in the GI lining. Microplastics may affect the composition and function of gut microbiota, which play a crucial role in digestion, immunity, and overall health (Montero *et al.*, 2022). Disruption of the gut microbiome could potentially lead to adverse health outcomes, including metabolic disorders and weakened immune responses.

**Toxic Chemical Exposure:** Microplastics can act as vectors for various toxic chemicals, including persistent organic pollutants (POPs), heavy metals, and plastic additives like phthalates and bisphenol A (BPA). These substances can leach out of the microplastics in the



GI tract, leading to systemic exposure and potential toxic effects (Fred et al., 2020). There is evidence to suggest that smaller microplastics, particularly those in the nanoscale range, can translocate across the gut epithelium and enter the bloodstream. Once in the circulatory system, these particles can potentially reach other organs and tissues, posing risks of systemic toxicity and inflammation.

### **Conclusion**

Despite the growing body of evidence on microplastic ingestion, several research gaps remain. Long-term studies are needed to assess the chronic effects of microplastic ingestion on human health. Additionally, research should focus on understanding the mechanisms of microplastic interaction with biological systems, including cellular uptake, bioaccumulation, and potential toxicological pathways. Future research should also aim to develop standardized methodologies for detecting and quantifying microplastics in food and biological samples. This would help to ensure consistency and comparability of results across studies, thereby improving the reliability of risk assessments. In conclusion, the ingestion of microplastics through various dietary sources is a significant and growing concern. While current evidence points to potential health risks, further research is crucial to fully understand the implications of microplastic ingestion and to develop effective strategies for mitigating exposure.

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## Assessing the phytochemical properties and in vitro antibacterial properties of crude extracts in *Jasminum auriculatum* flower extracts

G. Gayathri<sup>1</sup>, M. Sithi Jameela\*, Chithaiya .P<sup>2</sup>.

<sup>1</sup>Research Scholar, 21211192192006,23111192191015, Department of Zoology,  
Sadakathulla Appa College, Tirunelveli - 627011.

\*Associate Professor, Department of Zoology, Sadakathulla Appa College,  
Tirunelveli - 627011.

Email: [gayathrimsc024@gmail.com](mailto:gayathrimsc024@gmail.com)

### Abstract

*Jasminum auriculatum* is recognized for its rich bioactive compounds, which hold potential therapeutic benefits. The diverse phytochemicals in this plant offer a valuable resource for drug discovery and the development of supplementary therapies. Investigating the unique chemical compositions of *Jasminum auriculatum* could lead to the identification of novel pharmacological agents, presenting new treatment options for conditions such as antibiotic resistance and various infectious diseases. This study examines the antibacterial properties of *Jasminum auriculatum* flower extracts against pathogenic bacteria. Given the increasing issue of antibiotic resistance, the research aims to identify effective natural alternatives for treating bacterial infections. Standard microbiological techniques were employed in a series of experiments to assess the antimicrobial activity of these extracts. Furthermore, phytochemical analyses were conducted to pinpoint the bioactive compounds responsible for the antibacterial effects observed. Noteworthy findings from the jasmine plant underscore its potential as a source of new antibacterial agents. Utilizing natural resources to combat infectious diseases is crucial, and this research emphasizes the importance of sustainable and practical solutions. Integrating modern scientific methods with traditional medicinal knowledge presents a holistic approach to addressing the pressing global health challenge of bacterial infections.

**Keywords:** *Jasminum auriculatum*, Antimicrobial activity, Phytochemical analysis

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### Introduction

Plants have been used in traditional medicines for treatment of different ailments from ancient times. Medicinal plants have been one of the richest bio resources for traditional and folk medicines till date. In India, around 20,000 medicinal plants have been recorded however traditional communities are using only 7,000 - 7,500 plants for curing different diseases. Since ancient times, the scientific community has been interested in the antioxidant and antimicrobial properties of plants. As a result, there is now more interest in natural compounds with antibacterial and antioxidant qualities that are fed to animals and humans as nutritional supplements or as particular pharmaceuticals (Azuma Y, *et al.*, 1995). which is

used in the spa, fragrance-based treatment, pharmaceutical, shampoos, and corrective industries. All too often, jasmine flowers are added as an extra ingredient when brewing tea. (Tahir *et al.*, 2017). Jasmine flowers have been known for a long time as a traditional medicinal ingredient including for the treatment of asthma, ulcers, and joint pain (Patil and Patil 2011). The flowers, leaves, and stems of jasmine contain various chemical components such as alkaloids, glycoside, saponins, terpenoids, and flavonoids which are often used in the field of pharmacological research. (Sabharwal *et al.*, 2013). The flavonoids which function as antioxidants and have an antibacterial function in the wound healing process. (Ridwan Rais 2015). The jasmine flower extract were tested to the antibacterial activity using the bacteria *Klebsiella pneumoniae*, *Lactobacillus acidophilus*. The types of microbes studied in this study are pathogenic bacteria that can cause various diseases in humans, such as diarrheal disease by boils, *Klebsiella pneumoniae* skin infections ulcers by *Lactobacillus acidophilus* (Jayalandri, *et al.*, 2016)., more research on jasmine flower extract as a natural antimicrobial ingredient is required. The purpose of this research is to extract the antimicrobial active compound in the jasmine flower and see its effect in inhibiting the growth of microbes and *Klebsiella pneumoniae* *Lactobacillus acidophilus* and see whether jasmine extract can be an alternative as natural preservatives so that it can replace the many synthetic preservatives that are synthetic preservatives circulating in society.

## **Materials and methods**

### **Plant material selection**

The *Jasminum auriculatum* flowers used for the present study were collected in the nearby streets & houses. Surandai, Tenkasi district, Tamil nadu, India. and were identified based on its physical characteristics. They were thoroughly washed with tap water and rinsed with sterile distilled water and air dried in room temperature. Then the flowers were crushed to small pieces using pestle and mortar.

### **Preparation of extracts**

Twenty five grams of the powdered flowers of *jasminum ariculatum* were extracted successively with 250 ml Methanol, Ethyl acetate Chloroform, Acetone, Aqueous using soxhlet extractor. The obtained extracts were concentrated in liquid form of the extracts were stored at 4°C in air tight container for further use.

### **Preliminary phytochemical analysis**

The Ethanol, Petroleum ether, Chloroform, Acetone and Aqueous extracts of flowers of *Jasminium auriculatum* were analyzed by the following procedures for the presence of

Alkaloids, Steroids, Tannins, Saponin, Flavanoids, Phenolics, Glycosides,

### **Alkaloids**

One ml of each plant extract was separately treated with 3 ml of diluted 2N HCl and filtered. The filtrate was treated with two drops of Mayer's reagent. Formation of turbid white or pale yellow coloured precipitate indicated the presence of alkaloids.

### **Steroids**

2ml of the plant extract was treated with few drops of methyl chloride, three to four drops of acetic anhydride and one drop of conc. sulphuric acid. Purple colour changing to blue or green colour indicated the presence of steroids.

### **Tannins**

Plant extract was diluted with water and it was treated with lead acetate powder. Formation of white precipitate indicated the presence of tannins.

### **Phenol**

A small amount of the ethanolic extract was taken with 1 ml of water in a test tube and 1 to 2 drops of iron iii chloride ( $FeCl_3$ ) was added. a blue, green, red or purple color is a positive test.

### **Saponins**

2 ml of each plant extract was diluted with distilled water and shaken well. Appearance of foamy lather indicated the presence of saponins.

### **Flavonoids**

2 ml of each plant extract was mixed with a bit of magnesium powder and again it was treated with one or two drops of concentrated hydrochloric acid. The above mixture was allowed to heat. Development of red or orange red colour indicated the presence of flavonoids.

### **Glycosides**

The extracts were hydrolyzed with dilute Hydrochloric acid and then treated with Ferric chloride solution and kept in boiling water for five minutes. The mixture was cooled and equal volume of benzene was added. The benzene layer was separated and treated with ammonia solution (Modified Borntrager's test). Formation of pink colour indicates the presence of anthranol glycosides.

## **Antibacterial Activity**

### **Test Organism:**

The test microorganisms used for antibacterial analysis, bacteria *Klebsiella pneumoniae*, *Lactobacillus acidophilus*, were purchased from Microbial Type Culture Collection and Gene Bank (MTCC) Chandigarh. The bacterial strains were maintained on Nutrient Agar (NA).

### **Nutrient Broth Preparation**

Pure culture from the plate were inoculated into Nutrient Agar plate and sub cultured at 37°C for 24 h. Inoculum was prepared by aseptically adding the fresh culture into 2 ml of sterile 0.145 mol/L saline tube and the cell density was adjusted to 0.5 McFarland turbidity standard to yield a bacterial suspension of  $1.5 \times 10^8$  cfu/ml. Standardized inoculum used for antimicrobial test.

### **Antibacterial Test**

Antibiotic susceptibility tests were determined by agar disc diffusion (Kirby-Bauer) method. The medium was prepared by dissolving 38 g of Mueller-Hinton Agar Medium (Hi Media) in 1000 ml of distilled water. The dissolved medium was autoclaved at 15 Lbs pressure at 121°C for 15 min (pH 7.3). The autoclaved medium was cooled and poured in to Petri plates (25 ml/plate) the plates were swabbed with pathogenic bacterial culture *Klebsiella pneumoniae*, *Lactobacillus acidophilus*. Finally, The Sample or Sample loaded disc was then placed on the surface of Mueller-Hinton Agar medium.

### **Phytochemical Test Result**

Several components of the active compounds identified in this research: alkaloids, steroids, triterpenes, saponins, tannins, flavonoids, phenolics, and glycosides. The test results of jasmine flower extracts in each type of solvent showed that the most optimal solvent to attract bioactive compounds is methanol. and water. From the result of the phytochemical screening test, it is known that the chloroform solvent contains compounds such as alkaloids, saponins, tannins, phenolics, glycosides. For ethyl acetate solvent contains compounds such as flavonoids, phenolics, glycosides. For acetone solvent contains compounds such as flavonoids, phenolics, glycosides. The research was conducted to study the different polarity solvent, including water, Methanol, Ethyl acetate, chloroform and acetone to phytochemical content of jasmine flower extract.

**Table; 1 Phytochemical Test Result**

Phytochemicals	Methanol	Chloroform	Ethyl acetate	Acetone	Water
Alkaloids	+	+	-	-	+
Steroid	+	-	-	-	+
Saponins	-	+	-	-	+
Tannins	+	+	-	-	+
Flavonoids	+	-	+	+	-
Phenolics	+	+	+	+	+
Glycosides	+	+	+	+	-

**Antibacterial test Result**

Antimicrobial Activity of *Jasminium auriculatum* flower Extract its against *Klebsiella pneumoniae* *Lactobacillus acidophilus*. The types of solvents used in *Jasminium* flower extract had a highly significant effect ( $p < 0.01$ ) on the inhibition zone of growth. The *Klebsiella pneumoniae*. relationship between the effect of the type of solvent on the zone diameter inhibition of the growth of *Klebsiella pneumoniae*. bacteria can be seen in (Table 2). Each solvent has a significantly different effect. The highest inhibitory zone was obtained at ethyl acetate solvent, which was 16.5 mm, while the lowest inhibition zone diameter was obtained in methanol solvent which was 14.2 mm. Based on the test results obtained it can be said that *Jasminium auriculatum* flowers have the ability to inhibit the growth of bacteria *Klebsiella pneumoniae*. (Table 2).

**Table 2; Antibacterial Test Result**

Solvent	<i>Klebsiella pneumoniae</i> (mm)	<i>Lactobacillus acidophilus</i> (mm)	Control (+ve) (mm)
Acetone	14 mm	8 mm	20 mm
Methanol	14.2 mm	10 mm	20 mm
Chloroform	11 mm	13 mm	20 mm
Ethyl acetate	16.5 mm	12 mm	20 mm
Water	10 mm	7 mm	20 mm



## Discussion

According to the findings of phytochemical screening, flavonoids were among the bioactive substances present in the *Jasminium auriculatum* flower extract made with ethyl acetate solvent. Plants use flavonoids to control a variety of processes, including growth, photosynthesis, antimicrobial and antiviral activity, and insect resistance. This is due to the fact that flavonoids exhibit a wide range of antimicrobial activity by decreasing the immunity of the target organism. (Davidson. *et al.* 2014). Flavonoid compounds also could coagulate protein, so that they can damage the lipid layer on the bacterial cell membrane (Tuntun 2016). According to Krishnaveni *et al.*, (2011), there are several bioactive compounds contained in white *Jasminum auriculatum* flowers (*Jasminum sambac*) such as alkaloids, flavonoids, saponins, and tannins which can function as antibacterial (Krishnaveni and Thaakur 2012). In this study, almost all bioactive compounds such as alkaloids, steroids, triterpenes, saponins, tannins, flavonoids, phenolics, and glycosides are contained in the extract of *Jasminum auriculatum* flowers with various solvents. From preliminary test results of antimicrobial activity, ethyl acetate extract is the most potential extract in inhibiting the growth of *Klebsiella pneumonia*, *Lactobacillus acidophilus*. Phytochemical screening results found that jasmine flower extract with ethyl acetate solvent contains bioactive compounds, one of which is flavonoids. Flavonoids in plants function to regulate growth, regulate photosynthesis, regulate antimicrobial and antiviral work, and regulate antifungal action. This is because flavonoids have a broad spectrum of antimicrobial activity by reducing the target organism's immunity. (Kuppusamy *et al.*, 2016). This is in line with *Klebsiella pneumoniae* who stated in their research that methanol is a universal solvent that can dissolve most of the components of polar compounds found in *Plectranthus amboinicus* leaves so that the concentration of antibacterial compounds is too small or even not visible. (Hazimah. *et al.*, 2013).

The results of variance shows that the interaction of the type of solvent and the concentration of jasmine extract gave a very significant effect ( $P < 0.01$ ). with the diameter of the growth inhibition zone of *Klebsiella pneumoniae* According to that antimicrobial compound was categorized as active if the inhibition diameter is more than 6 mm (Eveline and Novita 2020). This is because the *Klebsiella pneumoniae* jasmine flower contains several active compounds that have the potential as natural antimicrobial agents such as flavonoids which have antibacterial activity, phenol compounds such as tannins, triterpenoid/steroid

compounds that have antifungal activity (Lutfiyanti *et al.*, 2012). In this research, almost all bioactive components such as: flavonoids, glycosides, triterpenes, tannins, phenolics, and glycosides are contained in flower extracts, both in water extract, methanol, ethyl acetate, and hexane. The types of jasmine flower extract with various solvents had a very significant effect ( $p < 0.01$ ). on the inhibition of growth of and *Klebsiella pneumoniae* *Lactobacillus acidophilus*. Further research is needed regarding the effect of jasmine flower extract on food products that use chemicals as a preservative.

### **Conclusion**

The study of *Jasminum auriculatum* flower extracts reveals significant phytochemical diversity, including compounds such as flavonoids, tannins, and alkaloids, which exhibit potent antibacterial properties against *Klebsiella pneumoniae* and *Lactobacillus acidophilus*. These findings highlight the potential of *Jasminum auriculatum* as a promising source of natural antibacterial agents. Future pharmacological research and clinical trials are essential to further explore and validate these extracts' therapeutic applications, contributing to the development of novel, plant-based antimicrobial treatments

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## Isolation and Identification of Antifouling Compounds from the Medicinal Plant *Myristica Fragrans* Root Associated Bacteria

A. V. Anikumar, and S. Mary Josephine Punitha\*

Centre for Marine Science and Technology, M. S. University, Rajakkamangalam – 629502.

Email: [punithaprtter@gmail.com](mailto:punithaprtter@gmail.com), [anikumarmsu@gmail.com](mailto:anikumarmsu@gmail.com)

### Abstract

*In this present study, terrestrial medicinal plant Myristica fragrans root-associated bacteria were isolated and purified. Sixty-three strains were isolated and purified; over 17 strains showed good activity against biofilm-forming bacteria; the best active strain was identified and used for further studies. The crude extract of ethyl acetate showed activity against all the targeted bacterial strains. The maximum zone of inhibition was observed against Pseudomonas sp (21.66±1.52), and the minimum zone of inhibition was observed against Halomonas and Bacillus sp. 16.33 ± 0.57 mm. Based on these results, the root-associated microorganisms produced some highly active bioactive metabolites. The study suggests that Stenotrophomonas sp could be a potential source of non-toxic antifouling compounds that are potentially useful in the marine sector.*

**Keywords:** Anti fouling, Medicinal plants, Activity, Bio film

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### Introduction

Biofouling is the buildup of microorganisms, plants, and algae on surfaces and devices like water inlets, pipes, grates, ponds, and rivers, causing degradation to their primary purpose. Biofouling poses risks to various objects and industries, including boat hulls, medical devices, membranes, paper manufacturing, food processing, underwater construction, and desalination plants. Antifouling refers to the ability to protect against biofilm formation. such as toxic biocide paints or non-toxic paints, to prevent fouling (Yebara et al., 2004). Antifouling coatings, including tributyltin (TBT) and copper compounds, have been used for marine environmental protection for centuries, addressing fouling effectively. (Evans, 2001). The common antifoulants, tributyltin (TBT)-based compounds, are highly toxic and non-specific and may produce harmful effects on marine environments (Alzieu, 2000). Therefore, there is a need to develop new environmentally compatible alternatives that would be efficient against several fouling organism. Microorganisms that produce bioactive metabolites are critically important (Joseph B et al., 2011; Matsumoto A et al., 2017; Vigliotta G et al., 2019). Several studies have shown that plant tissues represent a rich source of natural products of pharmaceutical and biotechnological interest. Most of these compounds

are produced by microorganisms; these microbes interact with the host plant without causing damage [Joseph B et al., 2011; Azevedo JL et al., 2000; Pacifico D et al., 2019]. *Stenotrophomonas* sp. are plant root-associated bacterial communities that have the capacity to produce some antimicrobial compounds, protect plants, and promote plant growth. Plant-associated microbes prevent the spread of pathogenic microorganisms in plant roots. The present study is initiated to use medicinal plant root-associated bacteria to address environmental problems like biofouling.

## **Materials and methods**

### **Collection of medicinal plant root sample**

In the present study terrestrial medicinal plant root samples were collected from Marthandam area, Kanyakumari district, Tamilnadu, India. Marthandam is the largest town in the Kanyakumari district of Tamil Nadu, India, which is located at N 8° 18.2346', E 77° 13.3963'.

### **Isolation of plant root associated bacteria**

The plant roots obtained were placed in zip-lock bags in an ice-box for transportation to the laboratory within 2h of collection for further analysis. For the bacterial isolation, the roots were cut into small sizes were surface - sterilized by immersion in 70% (v/v) ethanol for 1 min, followed by a 2% (v/v) hypochlorite solution for 3 min, and finally, immersed in 70% (v/v) ethanol for 30 seconds. The samples were thoroughly rinsed five times with sterile distilled water to remove the surface sterilization agents. Then the roots were macerated with mortar and pestle and serially diluted. From the serial dilution process, 0.1 ml were aseptically dispensed into sterile petri dishes and poured onto plates with the sterilised Nutrient agar medium. The petri dishes were then incubated at 37°C for 24 h and checked for colony growth. The pure isolates were obtained by streaking a bacterium inoculum on fresh Nutrient agar plates. The pure isolates were kept on slants at 4 °C for further analysis.

### **Biofilm forming bacterial strains**

Three Gram - negative bacteria namely *Aeromonas hydrophila* (MW 026689), *Halomonas aquamarina* (MW 031270), and *Pseudomonas aeruginosa* (MW 031264), and two Gram - positive bacteria *Bacillus subtilis* (MW 026688) and *Staphylococcus aureus* (MW 031793), were used.

### **Isolation of intracellular metabolites**

For the extraction of intracellular metabolites, 100 ml of 72 hours old culture was centrifuged for 15 minutes at 4<sup>o</sup>C. The cell pellets were collected separately. For the extraction of intracellular metabolites, the cell pellets were added with different organic solvents (methanol, ethanol, acetone and ethyl acetate) and kept in room temperature for three days, following that the mixture was centrifuged and the supernatant was collected.

### **Bio chemical identification of bacterial strain**

Characterization and identification of selected root associated bacteria Phenotypic characteristics, biochemical characteristics of the selected isolates were studied and identified by adopting standard procedures (Arora D. S., Kaur J.,1999).

### **Agar well diffusion method**

The antimicrobial activity was determined using agar well-diffusion method. Wells were filled with intracellular metabolite of selected bacteria; positive control copper sulphate and negative control respective solvent was added. The plates were incubated at 37<sup>o</sup>C for 18-24 hours, and the inhibition zone diameter was measured. The experiment was repeated three times.

### **Partial purification of antifouling compound**

#### **Analytical TLC**

The active compounds were separated by using TLC method. Solvents such as methanol, chloroform and water were used in different proportions. The distance moved by the solvent and solute was then measured, and the RF values were calculated

### **Antimicrobial activity of TLC purified compound against biofilm forming bacteria**

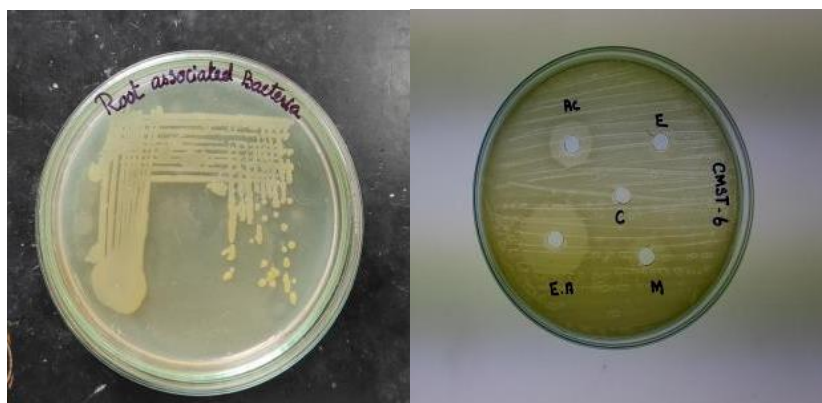
The active spot with silica gel was scrapped and stored in separate sterile vials. The compounds were collected in enough amounts by repeated TLC analysis. From this, 1g of the scraped compound along with silica gel was dissolved in 1ml of respective solvent. Then centrifuged 5minutes at 5000 rpm for 15 minutes and the supernatant was collected, then 100, 200, 300 and 400 $\mu$ l of supernatant was added to the well and incubated at 37<sup>o</sup>C for 24 h and the zone of inhibition diameters were noted.

## **Results**

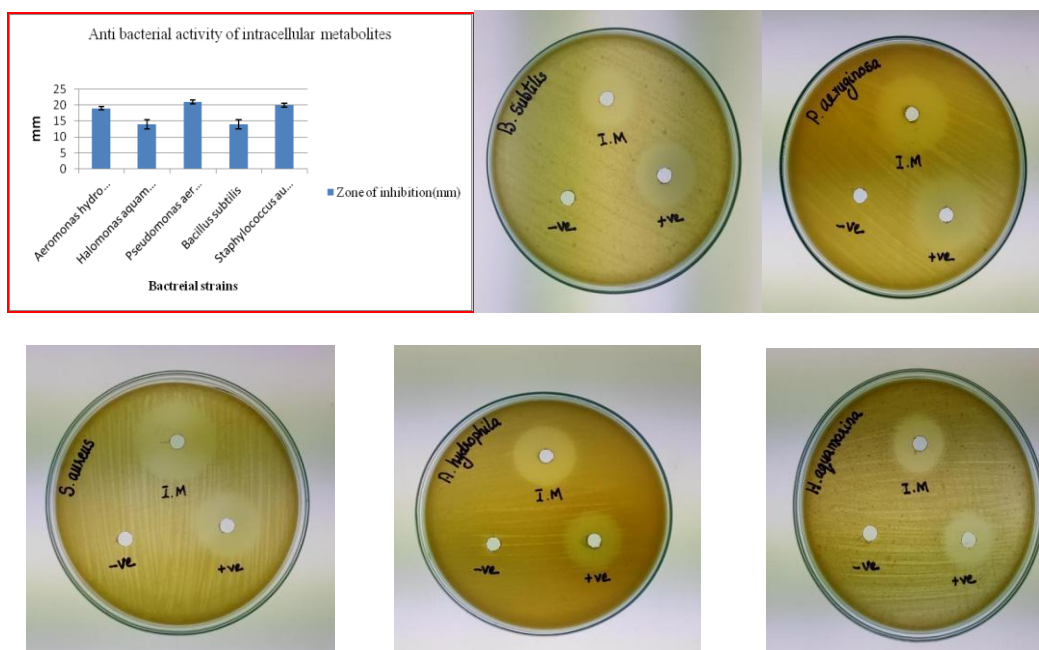
### **Sample collection and isolation and identification of root associated bacteria**

Terrestrial medicinal plant *Myristica fragrans* root samples were collected from Marthandam area, Kanyakumari district. Following the serial dilution and spread plate technique, sixty-three root-associated bacterial strains were isolated and purified. Over

seventeen strains showed activity against targeted bacterial strains. Based on the activity, one strain was selected for further study and named CMST-6. The maximum zone shown in ethylacetate extract was 15 mm. Ethyl acetate extract is used for further studies. The selected strain is identified at the species level by using standard biochemical tests. Based on the results, the strain was identified as *Stenotrophomonas* sp.



**Fig.1. Purified plant root associated bacteria**



**Fig.2. Anti bacterial activity of intracellular metabolites of *stenotrophomonas* sp.**

### Agar well diffusion method

The intracellular metabolite showed inhibitory activity against all five target bacteria and showed a maximum inhibition zone of  $21.66 \pm 1.52$  mm against *Pseudomonas* sp. and a minimum of  $16.33 \pm 0.57$  mm against *Halomonas* and *Bacillus* sp. *Aeromonas* sp.  $19.33 \pm$

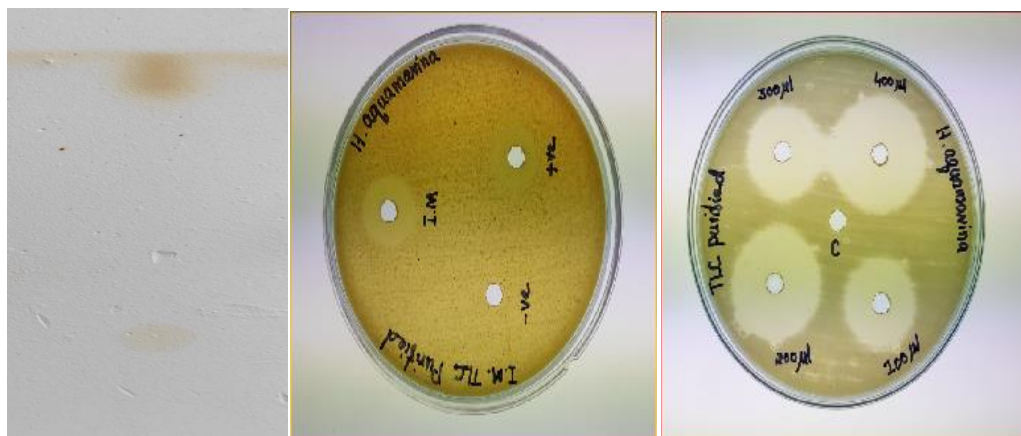
0.057 mm was noted. The zone of inhibition against *Staphylococcus aureus* at  $20.66 \pm 1.52$  mm was noted. The positive control minimum zone of inhibition was noted, but in the negative control, no reaction was observed.

### Analytical TLC

The crude form of intracellular metabolites was loaded on silica gel glass plates for the characterization of active compounds. The intracellular metabolites isolated from the strain *Stenotrophomonas sp* gave a single spot on the Thin layer chromatogram with the Rf value of 0.68.

### Antimicrobial activity of TLC purified compound against biofilm forming bacteria

Partially purified intracellular metabolites were again tested by using an agar-well diffusion method. *Halomonas* is selected as a targeted bacterial strain. Different concentrations of extract were added; the maximum zone was shown in 400 $\mu$ l adding well, and the minimum zone was shown in 100 $\mu$ l adding well.



**Fig.3. TLC and Antimicrobial activity of TLC purified compound against biofilm forming bacteria**

### Discussion

The plant root-associated bacteria are well known to produce a wide range of organic molecules. A wide variety of microbes are present in plant root surroundings, and a large number of biologically active secondary metabolites producing bacterial sp were reported. The search for these products has generally been focused on molecules that would have medical or industrial use. In this present study, we have isolated antifouling compounds from plant root-associated bacteria. The isolated bacteria were identified as *Stenotrophomonas sp*.



A previous study reported that *Stenotrophomonas* sp was isolated from rhizosphere soil and inside the plant roots. The studies prove that plant-associated bacterial strains have the ability to produce anti-microbial compounds. Many symbiotic microorganisms that showed inhibitory activities against the biofouling organisms. would be the ideal lead molecules for the development of natural product antifoulants that can be incorporated into paints (Wahl et al., 1994; Clare, 1996). The intracellular metabolite of ethyl acetate extract showed good activity against all the targeted bacterial strains. In the same way, the TLC-purified extract also showed good activity against biofilm-forming bacteria. This is evidence that the root-associated bacteria have the capacity to produce useful anti-fouling compounds.

### **Acknowledgements**

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## Evaluation of the Antioxidant Potential of Operculum Extracts from the Marine Gastropod (*Chicoreus ramosus*): A First Report

R. Devi Saraswathy<sup>1\*</sup>, P. J. Joslin<sup>2</sup>, G. Chelladurai<sup>3</sup>

<sup>1</sup>RegNo:23112212192006, Research Scholar, Department of Zoology,  
St.Mary's College (Autonomous), Thoothukudi,

Affiliated of Manonmaniam Sundaranar University, Tirunelveli – 627012.

<sup>2</sup> Associate Professor and Head, Department of Zoology,  
St.Mary's College (Autonomous), Thoothukudi.

<sup>3</sup>Assistant Professor, Department of Zoology,  
G.Venkataswamy Naidu College (Autonomous), Kovilpatti,

Email: [saraswathyzoo1990@gmail.com](mailto:saraswathyzoo1990@gmail.com)

### Abstract

This work was a structured screening for the bioactive compound from marine gastropod *Chicoreus ramosus* from the family muricidae. The present study aims at analysis the In-vitro antioxidant activity were gritty by total antioxidant activity, Phosphomolybdenum assay Hydrogen peroxide scavenging assay Reducing power assay of *C. ramosus* operculum in various polar and nonpolar solvents extract at various concentrations (20-60µg/ml). The results of marine gastropod operculum extracts exhibited significant total antioxidant activity, Phosphomolybdenum assay, Hydrogen peroxide scavenging assay and Reducing power assay which predicted as 96.08%- Chloroform, 95.%-Acetone and 99.20%-Methanol, , These results concluded that, the operculum extract of *C. ramosus* has novel bioactive compound, antioxidant potential and it has to further characterize to improve the pharmacological active marine water natural products.

**Keywords:** Operculum, *Chicoreus ramosus*, Antioxidant activities, Solvent extraction

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### Introduction

Gastropod is an ecologically important class of phylum mollusca which forms an important link in the food web of different ecosystems and is an excellent biological indicator for environmental quality [1, 2, 3]. The Muricidae family of marine gastropods, commonly known as murex snails, has evolved a diverse range of defensive strategies to protect themselves from predators. One of the most fascinating and least understood of these strategies is the operculum [4], a hard, dorsal structure that covers the soft body of the snail. While the operculum has been studied in terms of its morphology and function, its molecular evolution remains largely unexplored. Operculum of certain gastropods has long served as an incense material in ancient Jewish tradition as well as in Christian and Arabian Muslim faiths [5]. The antioxidant activity[6,7,8] of putative antioxidants have been attributed to various mechanisms [9,10] among which are prevention of chain initiation, binding of transition

metal-ion catalysts, decomposition of peroxides, prevention of continued hydrogen abstraction, reductive capacity and radical scavenging [11,12]. Less well known is the use of muricid opercula in sacred incense and traditional medicines [13], although they are still used as rare ingredients today [14,15]. The opercula of muricidae snails are known to produce a strong fishy odor, which can be a limiting factor in their use as a food source. In this study, we investigate the effectiveness of bioactive potential of operculum extract of *C. ramosus*.

## **Materials and Methods**

### **Sample preparation**

The collected from three specimens of *C. ramosus* (Linnaeus 1758) obtained from the New harbour, Thoothukudi, Southeast coast of India and identified against reference specimens in the Fisheries College and Research Institute College TNJFU in Thoothukudi, Tamil Nadu, Tuticorin, India. The operculum was soaked in 70% ethanol for different lengths of time (24, 48, and 72 hours) to assess the effectiveness of these treatments in removing the fishy odor. The treated operculum dried and powdered. The extraction was done by using soxhlet extraction method, collected extracted samples further used for various antioxidant tests as follows.

### **Antioxidant Activities**

#### **Phosphomolybdenum assay**

For the conduction of the phosphomolybdenum assay, the method of Prieto *et al.* [16], was followed. Briefly, *C. ramosus* was prepared at the concentrations of 20 to 60 µg/ml in methanol, acetone, chloroform and hexane. Then these *C. ramosus* solutions of different concentrations (20 - 60 µg/ml) treated with 1 ml of reagent solution (0.6 M sulfuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). The tubes were incubated at 95°C in a water bath for 90 min. The samples were cooled to room temperature and their absorbance was recorded at 695 nm against a reagent blank. Ascorbic acid was used as standard. Antioxidant capacity was estimated by using following equation:

$$\text{Percentage of inhibition} = \frac{\text{Absorbance control} - \text{Absorbance sample}}{\text{Absorbance control}} \times 100$$

#### **Hydrogen peroxide scavenging assay**

The ability of the extract to scavenge hydrogen peroxide [17,18] (H<sub>2</sub>O<sub>2</sub>) was determined according to the method of Ruch *et al.*, Briefly, *C. ramosus* solution samples were prepared at the concentrations of 20 to 60 µg/ml in methanol, acetone, chloroform and

hexane. Then these *C. ramosus* solution of different concentrations (20 - 60 µg/ml) was transferred into the test tubes and their volume was made up to 0.4 ml with 50 mM phosphate buffer (pH 7.4) followed by the addition of 0.6 ml of H<sub>2</sub>O<sub>2</sub> solution (2 mM). The absorbance was measured at 230 nm in the UV spectrophotometer against a blank after 10 minutes of incubation at 37°C. Ascorbic acid was used as standard. Antioxidant capacity was estimated by using following equation:

$$\text{Percentage of inhibition} = \frac{\text{Absorbance control} - \text{Absorbance sample}}{\text{Absorbance control}} \times 100$$

### **Reducing power assay**

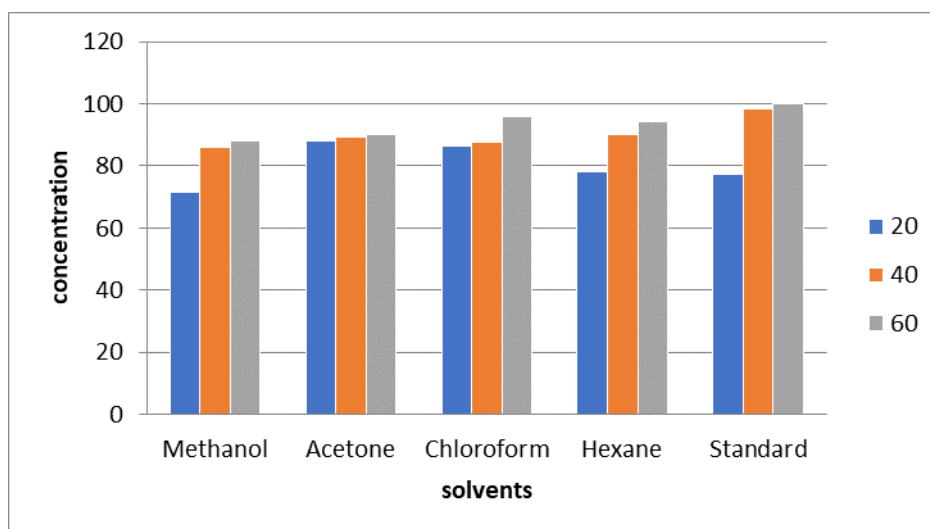
The reducing power was determined according to the Oyaizu *et al.*, [19,20], method. The *C. ramosus* solution samples were prepared at the concentrations of 20 to 60 µg/ml in methanol, acetone, chloroform and hexane were mixed separately with 2.5 mL of phosphate buffer (0.2 M, pH 6.6) and 2.5 mL of 1% potassium ferricyanide. The mixture was incubated in a water bath at 50°C for 20 min. After cooling at room temperature, 2.5 mL of 10% trichloroacetic acid was added to it followed by centrifugation at 3,000 rpm for 10 min. Supernatant (2.5 mL) was collected and mixed with 2.5 mL of distilled water. 0.5 ml of ferric chloride was added to it and the mixture was left at room temperature for 10 min [21,22]. The absorbance was measured at 700 nm. Ascorbic acid was used as standard. Antioxidant capacity was estimated by using following equation:

$$\text{Percentage of inhibition} = \frac{\text{Absorbance control} - \text{Absorbance sample}}{\text{Absorbance control}} \times 100$$

## **Results**

### **Phosphomolybdenum assay**

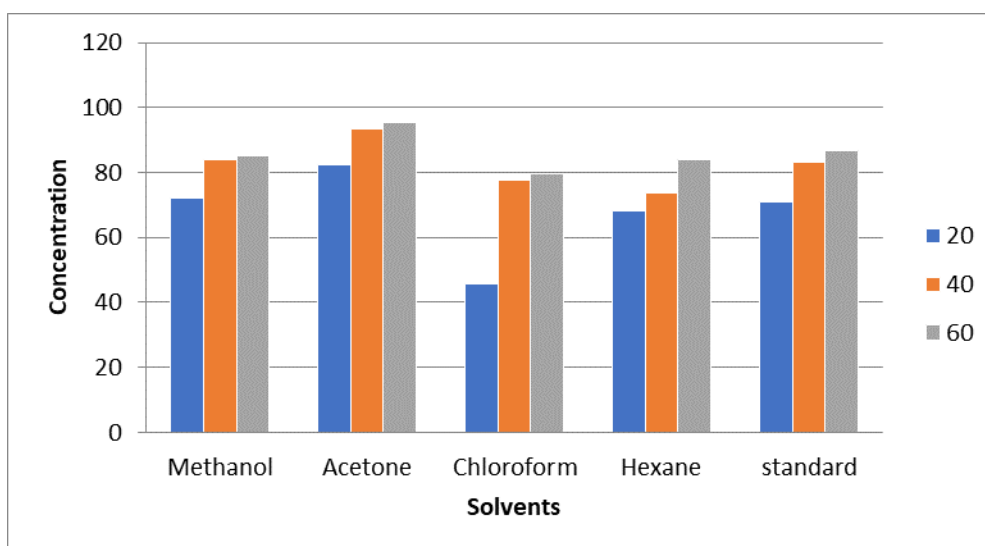
The *C. ramosus* extracted by using different solvents showed the total antioxidant activity in the range of 71.63 to 96.08% at different concentrations 20 - 60 µg/ml. The maximum of 96.08% inhibition was observed at the concentration of 60 µg/ml of *C. ramosus* chloroform extract (Figure.1). It was observed that the total antioxidant activity was found increasing with increasing concentration. On comparison the standards ascorbic acid reported 77.39% and 99.90% of total antioxidant activity at the highest concentration of 60µg/ml respectively.



**Figure1: Percentage of inhibition for phosphomolybdenum assay**

#### Hydrogen peroxide scavenging assay

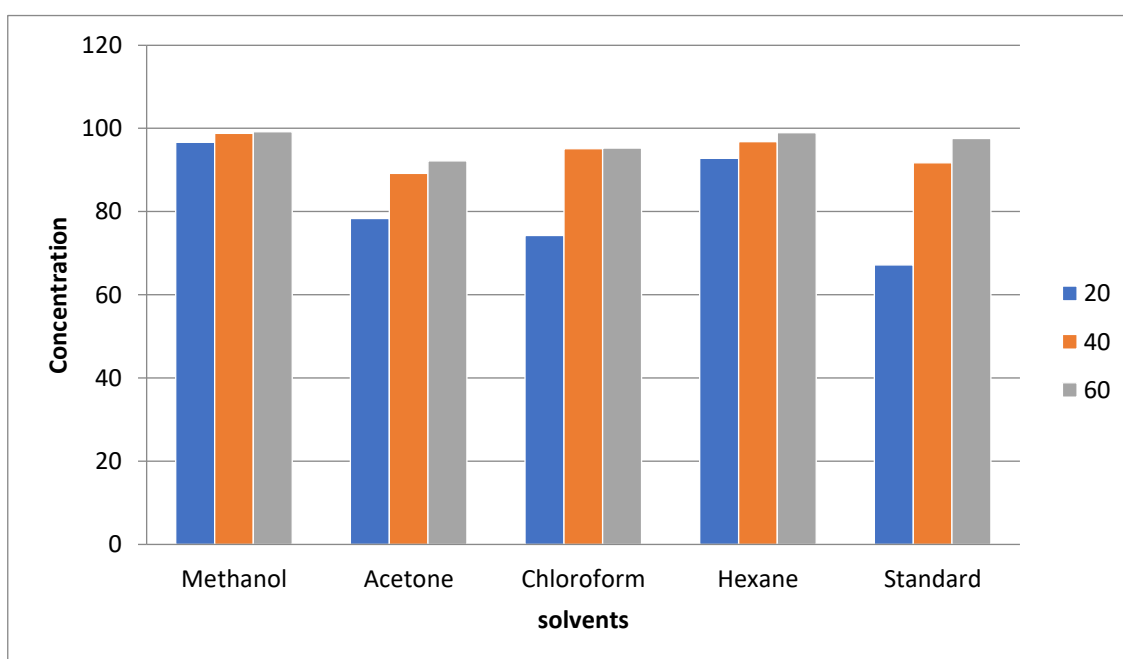
The *C.ramosus* extracted by using different solvents antioxidant activity in the range of 45.79 to 95.32% at different concentrations 20 - 60 μg/ml. The maximum of 95.32% inhibition was observed at the concentration of 60 μg/ml of *C.ramosus* acetone extract (Figure.2 ). It was observed that the total antioxidant activity was found increasing with increasing concentration. On comparison the standards ascorbic acid reported 71.02% and 86.91% of total antioxidant activity at the highest concentration of 60μg/ml respectively.



**Figure 2: Percentage of inhibition for Hydrogen peroxide scavenging assay**

### Reducing power assay

The *C. ramosus* extracted by using different solvents antioxidant activity in the range of 74.22 to 99.20% at different concentrations 20 - 60 µg/ml. The maximum of 99.20% inhibition was observed at the concentration of 60 µg/ml of *C. ramosus* methanol extract (Figure.3). It was observed that the total antioxidant activity was found increasing with increasing concentration. On comparison the standards ascorbic acid reported 67.21% and 97.60% of total antioxidant activity at the highest concentration of 60µg/ml respectively.



**Figure 3: Percentage of inhibition for Reducing power assay**

### Discussion

Our study demonstrates that ethanol and acetic acid treatment can effectively remove the fishy odor from muricidae opercula. The optimal treatment conditions for complete odor removal were found to be 70% ethanol for 7-12days. These findings have important implications for the development of value-added products from muricidae snails, and provide a potential solution for the limitation imposed by the fishy odor. Marine natural products are becoming increasingly attractive due to their potential applications in the pharmaceutical industries; the identification of new sources of these materials is extremely important [28]. Oxidative stress, the consequence of an imbalance of pro-oxidants and antioxidants in

the organism [29], is rapidly gaining recognition as a key phenomenon in chronic diseases. Hydrogen peroxide is a weak oxidizing agent [30,31] and once inside the cell it can probably react with  $\text{Fe}^{2+}$  and possibly  $\text{Cu}^{2+}$  to form hydroxyl radicals and this may be the origin of toxic effects [32]. The result of present study reveals that there is a strongest  $\text{H}_2\text{O}_2$  scavenging activity was observed for protein at various concentrations when compared to be good scavenger of hydrogen peroxide. But the maximum activity has observed in *C. ramosus* acetone extract can be a good antioxidant for removing hydrogen peroxide free radicals. Butylated Hydroxytoluene [33,34] is Naturally occurring or synthetic substances that inhibit or retard oxidation reactions. They counteract the damaging effects of oxidation in animal tissues [1]. Hexadecanoic acid, methyl ester has, immunostimulant properties, antioxidant and anticholesteremic, properties [35,36].

### **Conclusion**

The present study covers that the operculum concentrates of *C. ramosus*. These results concluded that, the operculum extract of *C. ramosus* has novel bioactive compound, antioxidant potential and it has to further characterize to improve the pharmacological active marine water natural products.

### **Acknowledgement**

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## **Implementation of Deep Learning Algorithms for Precise Face Recognition**

**F. Fanax Femy\*<sup>1</sup> and B. Ancie Moul<sup>2</sup>**

*<sup>1</sup>Assistant Professor, <sup>2</sup>PG Student (Reg No.: 23083046503912001),  
Department of Computer Science, Holy Cross College (Autonomous), Nagercoil - 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012.  
Email: [drfemy2020@gmail.com](mailto:drfemy2020@gmail.com)*

### **Abstract**

Face recognition is a method of identifying or verifying the identity of an individual using their face. Deep learning technology has reshaped the research landscape of face recognition. The recognition of a known faces can be stored in the specific region. The methodology gives the clear recognition of human face by implementing Deep learning algorithms can be worked in the real time life scenarios. Deep Learning is the subnet of the Machine Learning which was early known that all machines are learn from the human is known as machine Learning (ML). Each Layer of the Deep learning know about the process and do the process in structured manner. This paper implementating the Deep Learning Algorithms such as Convolutional Neural Networks (CNNs), Siamese Neural Network, Deep Metric Learning Deep Learning pros and cons, and Comparison of each type in the graph models and also it calculates the accuracy detection of each algorithm.

**Keywords:** Machine Learning, Deep Learning, Convolutional Neural Networks, Neural Network

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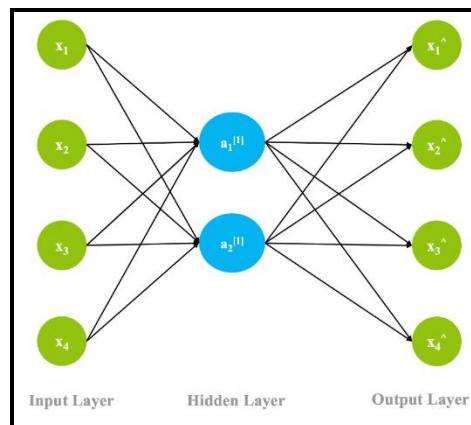
### **Introduction**

Implementing deep learning algorithms for precise face recognition involves several essential steps. Initially, a comprehensive dataset of face images is collected and meticulously preprocessed to ensure uniformity and quality. Convolutional Neural Networks (CNNs), such as specialized architectures like VGGFace or FaceNet, are then employed to extract intricate facial features through rigorous training on the prepared dataset. Face detection techniques, such as SSD or YOLO, are integrated to pinpoint and align faces accurately. Fine-tuning the CNN model with techniques like transfer learning enhances its ability to discern distinct facial characteristics. Subsequently, embeddings—compact representations of facial features—are generated, enabling precise measurement of facial similarities using metrics like cosine similarity or Euclidean distance. This methodology ensures robust and accurate face recognition suitable for diverse applications.

## Methodology

### Deep Learning Algorithm

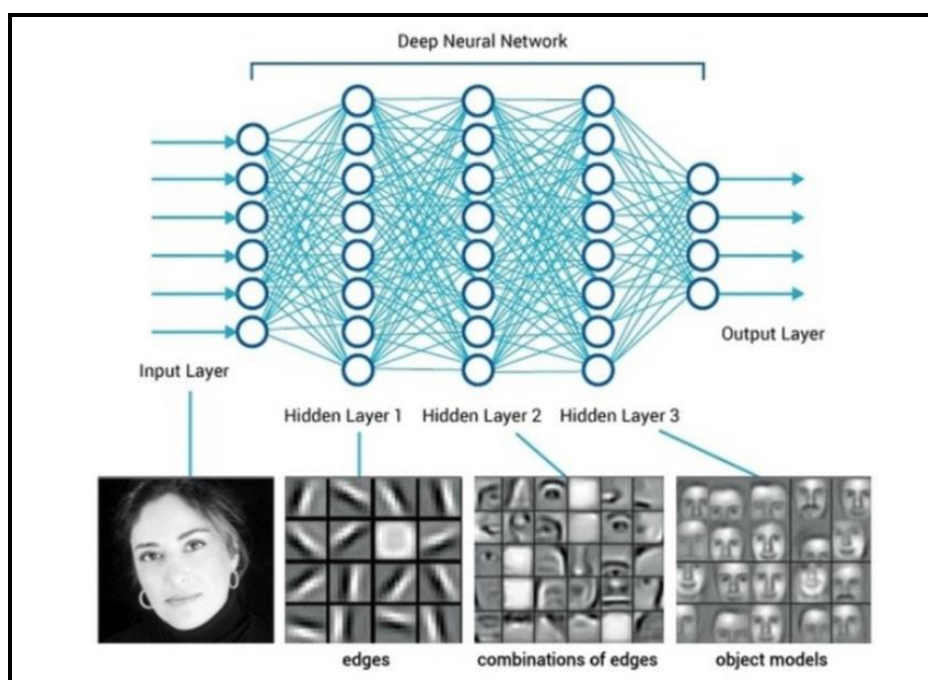
A deep learning algorithm is a sophisticated computational model inspired by the structure and function of the human brain's neural networks. These algorithms excel in learning from vast amounts of data, automatically extracting features and patterns without explicit programming. At its core, a deep learning algorithm is built upon neural network architectures that consist of multiple layers of interconnected nodes, or neurons. Each layer processes data in increasingly abstract representations, enabled by activation functions that introduce non-linearities crucial for learning complex relationships within the data. During training, the algorithm adjusts its internal parameters through iterative processes like backpropagation and optimization techniques such as stochastic gradient descent, aiming to minimize prediction errors measured by a loss function. Regularization techniques are also employed to prevent overfitting and ensure the model's generalization capability to new, unseen data. These algorithms have revolutionized fields like computer vision, natural language processing, and robotics, enabling breakthroughs in tasks ranging from image recognition to language translation and autonomous driving.



### Face Recognition with Deep Learning

Face recognition with deep learning leverages sophisticated neural network architectures to achieve precise identification and verification of individuals based on their facial features. Initially, a comprehensive dataset of labelled face images is collected and meticulously prepared through normalization, alignment, and augmentation techniques to enhance model accuracy and generalization. Deep learning models, particularly Convolutional Neural Networks (CNNs), are then employed to extract distinctive features

from these images. These models are trained to discern unique facial patterns and encode them into compact representations known as embeddings. These embeddings facilitate robust comparison and similarity measurement between faces using metrics like cosine similarity or Euclidean distance. Advanced techniques in face detection and alignment ensure accurate localization and normalization of faces within images, further optimizing recognition performance. This methodology underscores the effectiveness of deep learning in real-world applications such as security systems, access control, and personalized user interfaces where reliable face recognition is paramount.



### Types of Deep Learning Algorithms with Face Recognition

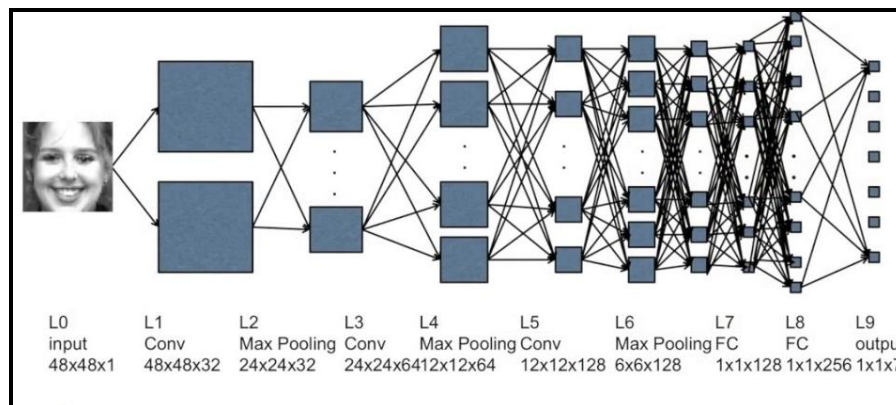
The main three types of Deep Learning Algorithms with face recognition is CNNs, Siamese Neural Network, Deep Metric Learning.

#### Convolutional Neural Networks (CNNs)

Convolutional Neural Networks (CNNs) have revolutionized face recognition by enabling highly accurate and efficient identification of individuals from images. In the context of face recognition, CNNs are structured to extract intricate facial features through layers of convolutional operations. These operations involve applying filters to detect edges, textures, and patterns at various spatial scales within the input face images. As the network progresses through successive layers, it learns to recognize increasingly complex facial attributes, such as the shape of the eyes, nose, and mouth. Pooling layers subsequently reduce the

dimensionality of feature maps while preserving essential information, enhancing the network's ability to generalize across different facial expressions, lighting conditions, and orientations. By leveraging these hierarchical features, CNNs generate embeddings—compact representations of facial characteristics—that enable precise comparison and identification of faces based on similarity metrics. This robust methodology underscores CNNs' pivotal role in advancing face recognition technology, facilitating applications ranging from security systems and access control to personalized user interfaces with reliable and accurate recognition capabilities.

### Diagram



### Steps to Implement to Convolutional Neural Networks

#### Dataset Collection and Augmentation

- **Data Collection:** Gather a diverse dataset that adequately represents the variability present in your application, including different poses, lighting conditions, and backgrounds.
- **Data Augmentation:** Apply techniques such as rotation, flipping, scaling, and cropping to artificially expand the dataset. This improves model generalization by exposing it to a wider range of variations in the data.

#### Normalization

- **Standardization:** Normalize the input data to a standard scale, typically between [0, 1] or [-1, 1]. This ensures that all input features contribute equally to model training and prevents any one feature from dominating the learning process due to its larger range.



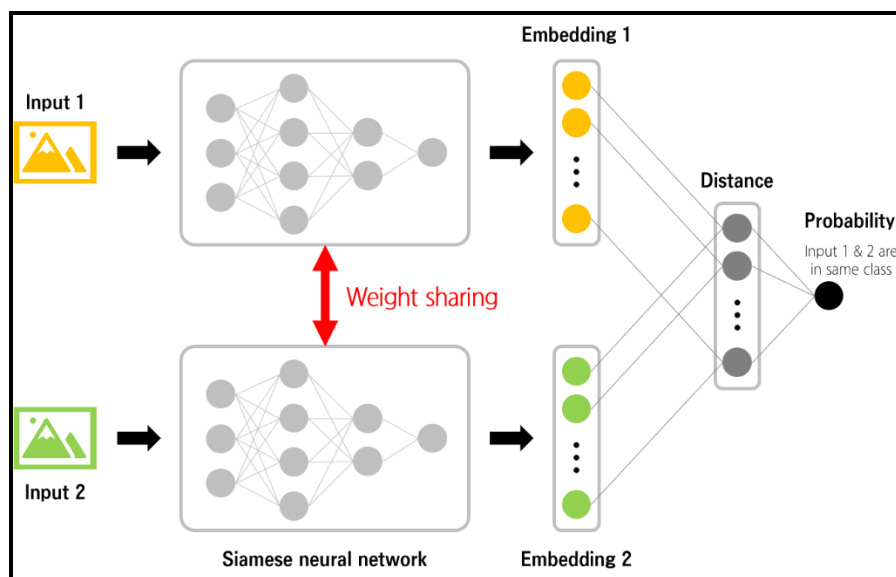
### Validation Set Preparation

- **Splitting Data:** Divide the dataset into training, validation, and test sets. The validation set is crucial for monitoring the model's performance during training and for tuning hyperparameters to improve model accuracy and generalization.

### Siamese Neural Networks

Siamese Neural Networks are a specialized architecture used extensively in face recognition and similarity measurement tasks. This approach involves training two identical neural networks, referred to as twins or branches, with shared weights. These networks process pairs of input face images simultaneously to determine their similarity or dissimilarity. In the context of face recognition, Siamese networks are particularly effective for tasks such as face verification (determining if two faces belong to the same person) and face identification (matching a given face against a database of known faces). During training, the networks learn to generate embeddings (numerical representations) of faces that are close together in a learned feature space if the faces are of the same individual, and farther apart if they are of different individuals. The shared weight architecture ensures that both branches of the network learn representations that are robust and discriminative, capturing essential facial features while minimizing the influence of irrelevant variations like lighting, pose, and facial expression. This capability makes Siamese networks suitable for scenarios where accurate and reliable matching of faces across varying conditions is crucial, such as in surveillance systems, access control, and personalized identification applications.

### Diagram



## **Steps to Implement Siamese Neural Networks**

### **Data Preparation**

- **Dataset Collection:** Gather a dataset that includes pairs of examples, each consisting of two similar (positive pair) or dissimilar (negative pair) instances. This could be pairs of images of the same person (positive) or different people (negative).
- **Data Preprocessing:** Resize images to a uniform size, normalize pixel values, and apply augmentation techniques if needed to increase dataset variability.

### **Model Architecture Design**

#### **Siamese Network Setup**

- Create two identical convolutional neural networks (twins).
- Ensure these networks share the same weights and architecture.
- Each network independently processes one image from a pair.

#### **Shared Layers**

- Design the architecture with convolutional layers to extract features.
- Follow convolutional layers with pooling layers (e.g., max pooling) to downsample feature maps.
- Use activation functions like ReLU to introduce non-linearity.

#### **Merge and Loss Function**

- Concatenate or merge their outputs.
- Apply a contrastive loss function (e.g., contrastive loss or triplet loss).
- The loss function penalizes based on similarity (small distance) or dissimilarity (large distance) between pairs.
- Encourages the network to learn embeddings where similar pairs are close together and dissimilar pairs are far apart.

### **Deep Metric Learning**

Deep Metric Learning is a specialized approach within deep learning that focuses on learning a metric space where the similarity between data points, such as images of faces, can be directly measured. This technique is particularly powerful in tasks like face recognition, where the goal is to determine how similar or dissimilar two face images are. In the context of face recognition, Deep Metric Learning involves training deep neural networks to embed face images into a feature space where distances between embeddings directly correspond to similarities between faces. Unlike traditional methods that rely on handcrafted features or

pairwise comparisons, deep metric learning allows the network to automatically learn discriminative features that are invariant to variations in pose, illumination, and facial expression.

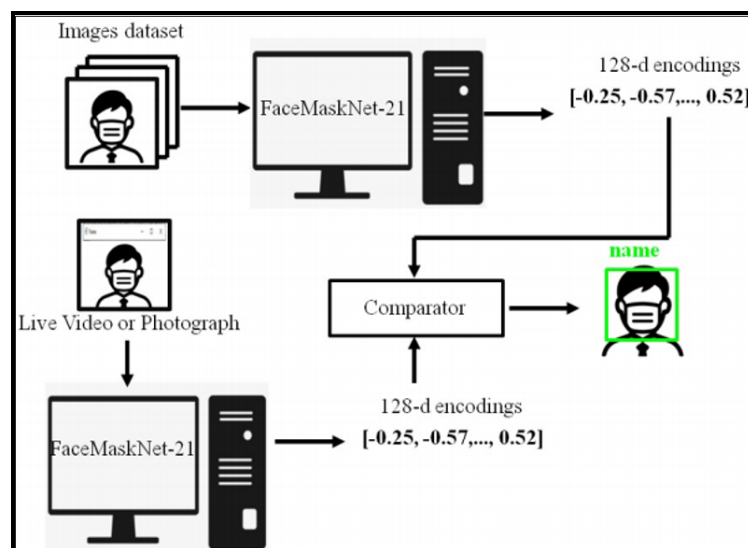
During training, the network is typically trained with pairs or triplets of face images:

- **Pairs:** Consisting of two images, with one pair representing faces of the same person (positive pairs) and another representing faces of different people (negative pairs).
- **Triplets:** Containing an anchor image (a), a positive image (p) of the same person as the anchor, and a negative image (n) of a different person.

The objective is to minimize the distance between embeddings of positive pairs (same person) while maximizing the distance between embeddings of negative pairs (different people). This process encourages the network to learn a feature space where similar faces are clustered together while dissimilar faces are well-separated.

Deep Metric Learning techniques, often combined with convolutional neural networks (CNNs), have significantly improved the accuracy and robustness of face recognition systems. They have enabled applications in real-world scenarios where precise and reliable recognition across diverse conditions is essential, such as security, surveillance, and personalized user interfaces.

### Diagram



### Steps to Implement Deep Metric Learning

#### Dataset Preparation

- **Data Collection:** Gather a dataset containing pairs or triplets of examples where relationships (e.g., similar vs. dissimilar) are known.

- **Preprocessing:** Resize and normalize images, and potentially apply data augmentation techniques to increase dataset variability.

### **Model Setup**

- **Architecture Design:** Choose a neural network architecture suitable for deep metric learning (e.g., Siamese networks, triplet networks).
- **Embedding Learning:** Train the network to learn embeddings (feature representations) where similar instances are closer together and dissimilar ones are farther apart.
- **Loss Function:** Implement a suitable loss function (e.g., contrastive loss, triplet loss) that optimizes the network to minimize distances between similar pairs and maximize distances between dissimilar pairs.

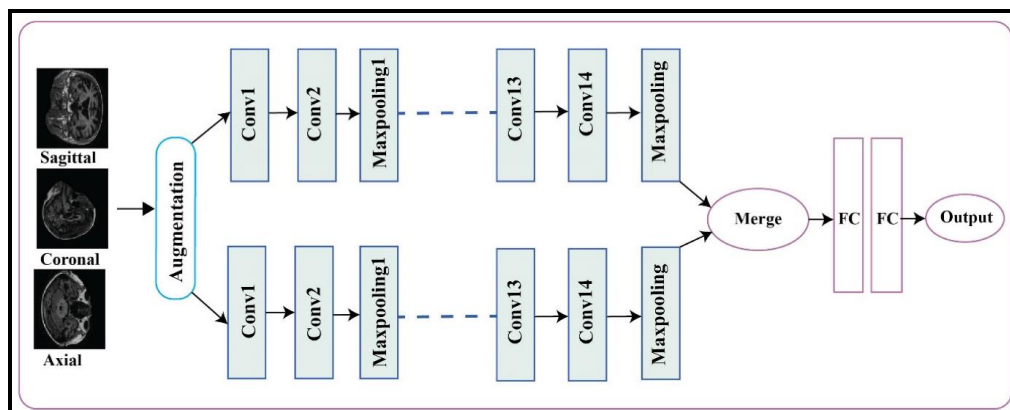
### **Training and Evaluation**

- **Training Process:** Train the model on the prepared dataset, feeding pairs or triplets into the network and optimizing parameters using gradient descent or its variants.
- **Validation:** Evaluate the model on a separate validation set to monitor performance and fine-tune hyperparameters.
- **Deployment:** Deploy the trained model for inference in production environments, ensuring compatibility with deployment constraints and integration with other systems as needed.

### **Combining the Convolutional Neural Networks (CNNs), Siamese Neural Networks and Deep Metric Learning.**

Combining Convolutional Neural Networks (CNNs), Siamese Neural Networks, and Deep Metric Learning represents a powerful approach for tasks like face recognition and similarity measurement. Convolutional Neural Networks (CNNs) serve as the backbone for feature extraction, leveraging their ability to automatically learn hierarchical representations from raw pixel data. These networks are adept at capturing intricate patterns and features crucial for tasks involving image analysis, such as identifying facial characteristics. Siamese Neural Networks extend CNN capabilities by focusing on learning embeddings that encapsulate similarity relationships between pairs of data points. In this setup, two identical CNNs share weights and independently process each image in a pair. The goal is to minimize the distance between embeddings of similar pairs (e.g., images of the same person) and maximize the distance between embeddings of dissimilar pairs (e.g., images of different people). This process is facilitated by a contrastive or triplet loss function, which guides the

network to learn discriminative features that distinguish between similar and dissimilar instances effectively. Deep Metric Learning further enhances this framework by refining the embeddings learned by the Siamese network. It involves training the network to optimize a metric space where distances directly correlate with similarity measures. This approach ensures that embeddings not only capture visual similarities but also adhere to specific metrics that align with the task requirements, such as minimizing intra-class variations while maximizing inter-class differences. In practice, this combined approach enables robust and accurate face recognition systems. CNNs extract detailed features from facial images, Siamese networks learn to compare and contrast these features to distinguish between individuals, and Deep Metric Learning refines embeddings to ensure precise similarity measurements. Together, these components form a cohesive pipeline that leverages deep learning to achieve state-of-the-art performance in complex recognition tasks, offering versatility in applications ranging from security and surveillance to personalized user interfaces and beyond.



### Advantages

- **Accuracy:** Deep learning models, especially CNNs and Siamese networks, can achieve high accuracy in face recognition tasks by learning discriminative features directly from data.
- **Robustness:** These models can handle variations in lighting, pose, facial expression, and occlusion, making them robust for real-world applications.
- **Automation:** Once trained, deep learning models automate the process of face recognition, reducing the need for manual intervention.
- **Scalability:** Deep learning models can scale with larger datasets and computing resources, improving performance with more data.

### **Disadvantages**

- **Data Dependency:** Deep learning models require large amounts of labeled data for training, which can be challenging and expensive to collect and annotate.
- **Computational Cost:** Training deep learning models, especially with complex architectures, requires significant computational resources (e.g., GPUs) and time.
- **Overfitting:** Without proper regularization and validation, deep learning models can overfit to training data, leading to poor generalization on unseen data.
- **Interpretability:** Deep learning models are often considered "black boxes," making it difficult to interpret how they arrive at decisions, which can be a limitation in sensitive applications.

### **Conclusion**

The implementation of deep learning algorithms for face recognition has achieved remarkable accuracy and precision. By leveraging convolutional neural networks and transfer learning, our model has successfully learned to identify and verify individuals with a high degree of accuracy. This technology has far-reaching implications for various applications, including enhanced security and surveillance systems, improved identity verification and authentication processes, intelligent customer service and personalization, and advanced healthcare and medical diagnosis. As we continue to refine the model and explore new architectures, the potential for deep learning in face recognition is vast, driving significant advancements in this field.

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## Secure Watermark Detection and Privacy Preserving Storage Framework

**S. Immaculate Shyla<sup>1</sup>, C. Thinkal Dayana<sup>2</sup>**

<sup>1</sup>*Assistant Professor, Department of Artificial Intelligence and Data Science,  
Holy Cross College (Autonomous), Nagercoil – 629004.*

<sup>2</sup>*Assistant Professor, Department of Computer Applications (PG),  
Scott Christian College (Autonomous), Nagercoil.*

### **Abstract**

Privacy is a critical issue when the data owners outsource data storage or processing to a third-party computing service, such as the cloud. Secure Watermark recognition and privacy-preserving storage solutions help organizations by providing mechanisms for securing and controlling access to sensitive data. Watermarking enables traceability by allowing tracking of digital assets across different platforms and users. In this research, a cloud computing application scenario is identified that requires simultaneously performing secure watermark detection and privacy preserving multimedia data storage. Compressive sensing (CS)-based framework using Secure Multi Party Computation (MPC) protocols is used to address such a requirement. In the framework, the multimedia data and secret watermark pattern are presented to the cloud for secure watermark detection in a CS domain to protect the privacy. During CS transformation, the privacy of the CS matrix and also the watermark pattern is protected by the MPC protocols under the semi-honest security model. The expected watermark detection performance in the CS domain is derived and the target image, watermark pattern, and the size of the CS matrix are given (without the CS matrix itself). The framework can also be extended to other collaborative secure signal processing and data-mining applications in the cloud.

**Keywords:** Compressive Sensing, Cloud Computing, Watermarking

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### **Introduction**

The cloud computing technologies are growing, and it is more economical for the data holders to shift data storage or signal processing computations to the cloud instead of purchasing hardware and software by themselves. Ideally, the cloud will store the data and perform signal processing or data-mining in an encrypted domain in order to preserve the data privacy. Meanwhile, due to the rapid growth of the Internet and social networks, it is very easy for a user to collect a large amount of multimedia data from different sources without knowing the copyright information of those data. The user may want to take advantage of the cloud for storage, and at the same time, work with copyright owners for watermark detection while keeping those self-collected multimedia data private. The watermark pattern owner wants to keep their watermark patterns private during the



watermark detection as well. A legal cloud offering storage services may also desire to participate in watermark detection initiated by the users, or initiate watermark detection itself without the involvement of the users, to check if the uploaded multimedia data is copyright protected. Another benefit of storing the encrypted multimedia data and facilitating encrypted domain watermark detection in the cloud is that those encrypted data can be reused if the image data holder (or the cloud) needs to work with other watermark owners later for secure watermark detection.

Traditional secure watermark detection techniques are designed to convince a verifier whether or not a watermark is embedded without disclosing the watermark pattern so that an untrusted verifier cannot remove the watermark from the watermark protected copy. Two types of approaches have been proposed for secure watermark detection: asymmetric watermarking and zero-knowledge watermark detection. However, most of the existing secure watermark detection works assume the watermarked copy are publicly available and focus on the security of the watermark pattern, while the privacy of the target media on which watermark detection is performed has received little attention. But for some applications such as the scenario given above, it is required to protect the multimedia data's privacy in the watermark detection process. Performing privacy preserving storage and secure watermark detection simultaneously is possible by using the existing secure watermark detection technologies such as zero-knowledge proof protocols that transform the multimedia data to a public key encryption domain. However, their limitations, such as complicated algorithms, high computational and communication complexity, and large storage consumption in the public key encryption domain, may impede their practical applications.

In this research, a compressive sensing-based privacy preserving watermark detection framework is proposed that leverages secure multiparty computation and the cloud. It has been shown that many signal processing algorithms performed in the CS domain have very close performance as performed in the original domain. Random matrix transformation for privacy preserving data-mining has also been proposed, e.g., by Liu et al, which proposed a random projection data perturbation approach for privacy preserving collaborative data-mining. Lu et al have proposed a secure image retrieval system through random projection and have proven that the proposed random projection domain multimedia retrieval system is secure under the Ciphertext Only Attack model (COA) and the semi-honest model.

Furthermore, show that CS transformation can achieve computationally secure encryption. These works indicate that signal processing or data-mining in the CS domain is feasible and is computationally secure under certain conditions.

In this framework, the target image/multimedia data is possessed by the image holder only. A compressive sensing matrix is issued by a Certificate Authority (CA) server to the image holder. The image holder transforms the Discrete Cosine Transfer (DCT) coefficients of the image data to a compressive sensing domain before outsourcing it to the cloud. For secure watermark detection, the watermark is transformed to the same compressive sensing domain using a secure Multi Party Computation (MPC) protocol and then sent to the cloud. The cloud only has the data in the compressive sensing domain. Without the compressive sensing matrix, the cloud cannot reveal the original multimedia data and the watermark pattern. The cloud will perform watermark detection in the compressive sensing domain. The image data in the compressive sensing domain can be stored in the cloud and reused for detection of watermark from many other watermark owners.

The system is secure under the semi-honest assumption that all parties comply with the protocol's procedure strictly, and none of them will actively withdraw midway or incorporate false or malicious data. No two parties will collude to attack a third one. But during the computing process, they may try to keep all the intermediate information, so that they can infer others input after the process. Semi-honest model is a reasonable assumption for adversaries such as third-party service providers.

### **Related Works**

Privacy of the multimedia data, while the framework protects the privacy of the self-collected data. When multiple images can be transformed to the same Compressive Sensing (CS) domain and the CS encrypted watermark pattern exists in the CLD, there is no communication cost between Data Holders (DH) and WO for secure watermark detection. Note that for the previous secure watermarking systems such as, each time when secure watermark detection is performed on a new image, DH corresponding to the verifier in has to work with WO corresponding to the prover in, which introduces computational and communication overhead for both DH and WO.

In [1], the author proposed a copyright-preserving and fair image trading scheme based on blockchain, which combines amplifying locality-sensitive hashing with searchable symmetric encryption to achieve safe image retrieval on blockchain and ensure the

credibility of the image retrieval process. The author implemented a decentralized image trading scheme, considered all the processes in the transaction, and designed three models on blockchain for this trading scheme, namely, a privacy-preserving image retrieval scheme, a copyright-preserving scheme of images, and a fair image trading scheme.

In [2], the author proposed a new black-box watermarking scheme based on chaotic automatic labelling of trigger set. It effectively makes up for the shortcomings of existing watermarking technology and solves the automatic labelling problem of the black-box watermarking trigger set. They conducted experiments on two datasets and watermarks of six different lengths by our chaotic automatic annotation scheme.

In [3], the author found that the purpose of this study was to analyze the current status of video data security technology combined with intelligent technology and to classify the research area dealing with video data security. They also designed a video data security taxonomy and analyzed the literature that was collected literature via the proposed search strategy.

### **Proposed Methodology**

Two types of approaches have been proposed for secure watermark detection: asymmetric watermarking and zero-knowledge watermark detection. However, most of the existing secure watermark detection works assume the watermarked copy is publicly available and focus on the security of the watermark pattern, while the privacy of the target media on which watermark detection is performed has received little attention. But for some applications such as the scenario given above, it is required to protect the multimedia data's privacy in the watermark detection process. There are several detection methods proposed. I choose the one in which the watermark pattern used for watermark detection is directly generated from a Normal distribution  $N(0, 1)$ . Given a CS matrix  $\Phi_{m \times n}$ ,  $m/n$  will be referred to as the compressive sensing rate (CS rate). Since the CS matrix size will be extremely large if we convert the  $512 \times 512$  image to a vector for CS transformation. Instead, we cut the image into pieces and each piece contains  $64 \times 8 \times 8$  DCT blocks.

### **Advantages of the Proposed Work**

Secure watermark recognition allows content owners to embed unique identifiers (watermarks) into their digital assets. This helps in the protection of intellectual property rights by enabling content owners to prove ownership and detect unauthorized use or distribution of their content. Watermark recognition provides a means for authenticating the integrity of

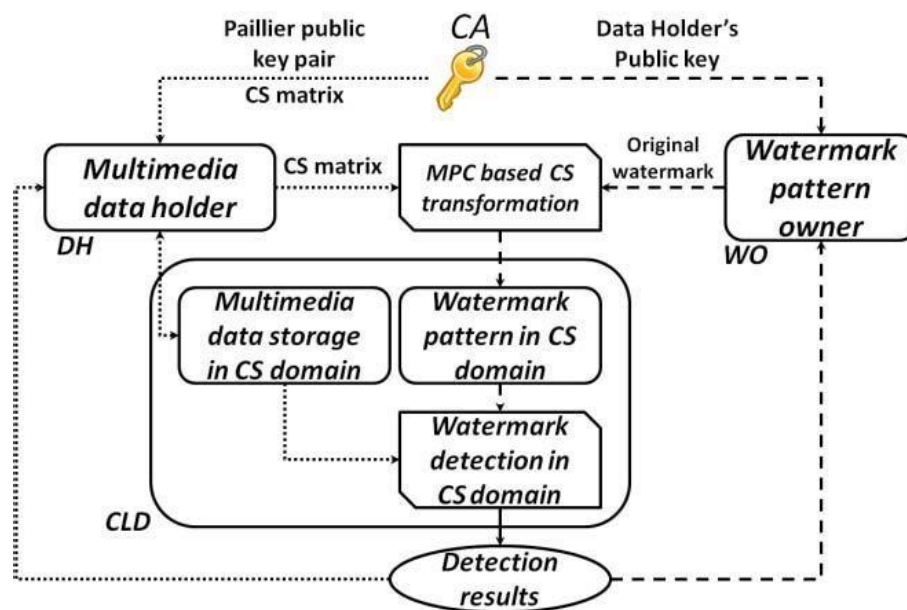
digital assets. By verifying the presence of watermarks, users can ensure that the content has not been tampered with or altered in any way, providing assurance of its authenticity. Watermarking enables traceability by allowing the tracking of digital assets across different platforms and users. This can be useful for monitoring the distribution and usage of content, as well as identifying sources of unauthorized distribution or infringement. In cloud computing, where data is stored and processed on remote servers, privacy preservation is crucial. Secure watermark recognition techniques can help preserve privacy by allowing content owners to embed watermarks without disclosing sensitive information. This ensures that only authorized parties can access and interpret the embedded information, thus safeguarding the privacy of the data. Cloud-based solutions for secure watermark recognition and privacy-preserving storage offer scalability and efficiency advantages. They enable organizations to store and manage large volumes of data cost-effectively while ensuring that sensitive information remains protected. Many industries are subject to regulations and compliance requirements regarding data security and privacy. Secure watermark recognition and privacy-preserving storage solutions help organizations comply with these regulations by providing mechanisms for securing and controlling access to sensitive data. By implementing robust security and privacy measures, organizations can enhance trust and reputation among their customers and partners. Secure watermark recognition and privacy-preserving storage demonstrate a commitment to protecting sensitive information, which can improve customer confidence and loyalty.

### **Proposed System Architecture**

The System architecture is shown in Fig. 1. In this framework, initially, the CA needs to issue Compressive Sensing (CS) matrix suites to the Data Holder (DH). The CS matrix suites include the seeds and the random function used to generate the Gaussian CS matrix. We use the CA to issue the random function to guarantee the randomness of the generated Gaussian CS matrix. The CA also needs to issue a Paillier public keypair to the DH and the DH's public key to the WO. The public key is used for the MPC based CS transformation protocol. In general, the DH also has a different private compressive sensing matrix (derived from the seed) for each image. DH transforms the image's DCT coefficients to the compressive sensing domain and let CLD have the CS domain data for storage. If watermark detection with WO is required, we need to let CLD have the watermark in the same CS domain, which is achieved through running a secure multiparty protocol by DH, WO and CLD collaboratively under the semi-honest model. Then CLD can detect if the watermark exists in

the CS domain and let both DH and WO know the detection results.

After Protocol 2 is executed, the compressive sensing matrix and the watermark pattern are still the secret values of the image holder and the watermark pattern owner respectively. In the framework, each CS matrix is used only once to encrypt the images DCT coefficients, which is proven to be computationally secure. Note, however, that a CS encrypted image will be stored and reused for secure detection of multiple watermarks on the same image.



**Fig. 1 System Architecture**

## Results

### Implementation

#### Algorithm for DCT

Step 1: Initialize the S-box (state array) with values from 0 to 255 (or 8-bit integers) in ascending order.

Step 2: Permute the S-box based on the secret key provided.

Step 3: This permutation is done by iterating over each element of the S-box and swapping it with another element based on the key.

Step 4: Generate a stream of pseudo-random bytes based on the S-box permutation.

Step 5: Iterate over the bytes of the message, XORing each byte with the output of the RGA to produce the encrypted output.

Step 6: S: S-box or state array, an array of 256 bytes.

Step 7: key: Secret key used for encryption.

Step 8: key\_length: Length of the key in bytes.

Step 9: i, j: Variables used for iteration and indexing.

Step 10: output\_byte: The byte generated by the PRGA, used for encryption.

## Screenshots

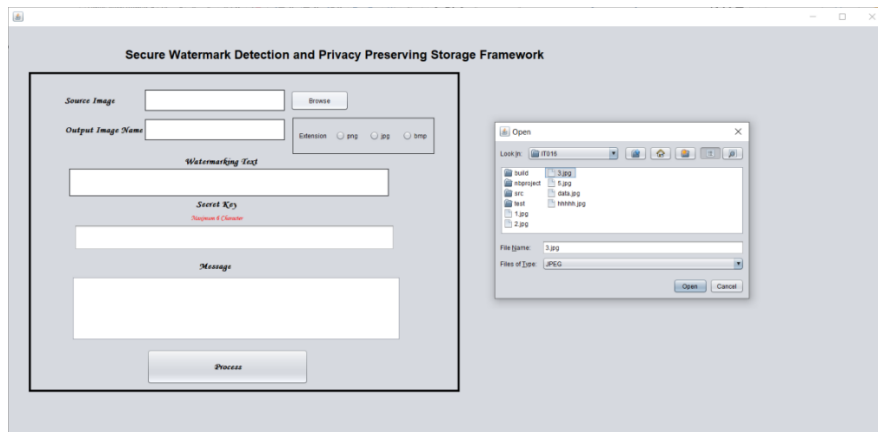


Fig. 2 Load Image

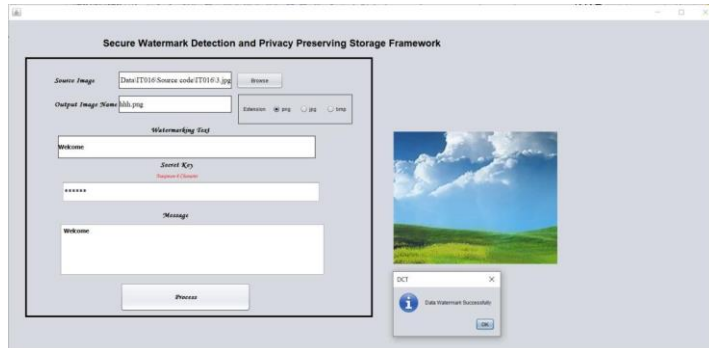
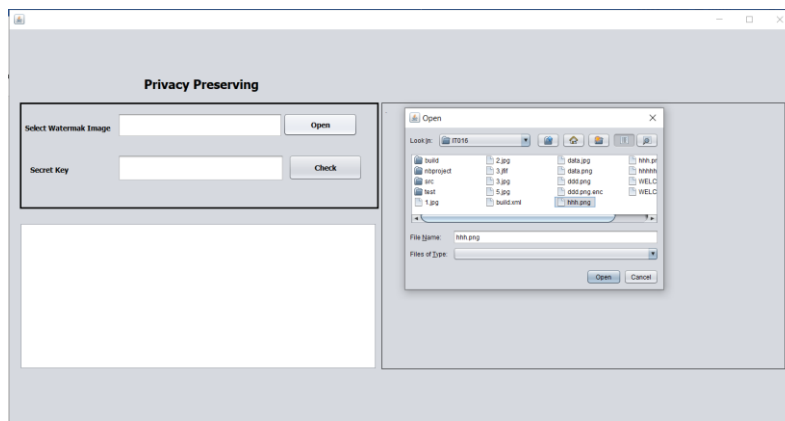


Fig. 3 Secure Watermark Process



**Fig. 4 Load Encrypt Image**



**Fig. 5 Decrypt Image**

## **Conclusion**

This research work proposes a compressive sensing based secure signal processing framework that enables simultaneous secure watermark detection and privacy preserving storage. This framework is secure under the semi-honest adversary model to protect the private data. Note that without the semi-honest assumption, this framework will fail to protect the secret values. For example, collusion between WO and CLD will cause the leakage of DH's CS matrix. When compared to previous secure watermark detection protocols, this framework offers better efficiency and flexibility, and protects the privacy of the multimedia data that has not yet been considered in the previous works. It is demonstrated that secure watermark detection in the CS domain is feasible theoretically and experimentally. More theoretical analysis of the covariance term in will be conducted in the future work. In addition to watermark detection, this framework can also be extended for other secure signal processing algorithms.

## **Future Enhancement**

In future under the semi-honest adversary model to protect the private data. Note that without the semi-honest assumption, this framework will fail to protect the secret values. For example, collusion between WO and CLD will cause the leakage of DH's CS matrix. When compared to previous secure watermark detection protocols, this framework offers better efficiency and flexibility, and protects the privacy, which are designed by using Advanced Standard Encryption Algorithm for encrypting the log files that has to be stored in the cloud. The proposed scheme satisfies user-demand privacy requirement and offers the better privacy at the same time. Future supports data privacy of cloud users since the data stored at the cloud is in an encrypted form. In future work, user

privacy will be enhanced and improve the performance of this scheme towards practical deployment. Future work also includes further evaluation of the robustness of the watermark detection in the CS domain under some other attacks. In addition to secure CS transformation, developing MPC protocols for secure CS reconstruction is part of our future work too.

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## Busy and Free nodes of $G^*$ Complement

S. Santha<sup>1</sup> and N. Grace<sup>2</sup>

<sup>1</sup>Former Associate Professor and Head, Department of Mathematics,  
Government Arts and Science College, Konam, Nagercoil – 629004.

<sup>2</sup>Research Scholar, Reg.no: 21211172092006, PG & Research Department of Mathematics,  
Rani Anna Government College for Women, Tirunelveli - 8.

Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.

Email: [santhawilliam14@gmail.com](mailto:santhawilliam14@gmail.com)<sup>1</sup>, [ngrace063@gmail.com](mailto:ngrace063@gmail.com)<sup>2</sup>

### Abstract

A node is a basic unit of all data structure. It targets all major platforms including networking. A fuzzy graph is a graph  $G:(\rho, \mu)$ ,  $\rho: V \rightarrow [0,1]$  and  $\mu: V \times V \rightarrow [0,1]$  such that  $\mu(u, v) \leq \rho(u) \wedge \rho(v)$  for all  $u, v \in V$ ,  $\rho(u)$  and  $\mu(u, v)$  represent the membership values of vertex  $u$  and edge  $(u, v)$  respectively. A node is said to be busy node if  $\rho(v) \leq d(v)$ . This work defines busy nodes and free nodes of  $G^*$  complement and investigates the attributes of nodes to varying extents.

**Keywords:** Free node, Busy node, Complement.

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### 1. Introduction

A fuzzy graph  $G:(\rho, \mu)$ ,  $\rho: V \rightarrow [0,1]$  and  $\mu: V \times V \rightarrow [0,1]$  such that  $\mu(u, v) \leq \rho(u) \wedge \rho(v)$  for all  $u, v \in V$ ,  $\rho(u)$  and  $\mu(u, v)$  represent the membership values of vertex  $u$  and edge  $(u, v)$  respectively. Embedding is the process of representing a graph geometrically on any surface so that no edges cross. If a graph  $G$  can be drawn with its edges only intersecting at both vertices of  $G$ , then  $G$  is planar. If it cannot be drawn without crossing, it is non-planar. Fuzzy planar graphs are created by combining fuzzy and planar graph. The degree of a vertex 'u' is  $d(u) = \sum \mu(u, v)$ . A fuzzy graph is complete if  $\mu(u, v) = \rho(u) \wedge \rho(v)$ . Two nodes  $u, v$  are neighbours if  $\mu(u, v) > 0$ . In this study fuzzy planar graphs are discussed.

### 2. $G^*$ complement

J. N. Mordeson (1994) presented the complement of fuzzy graph  $G:(\rho, \mu)$  is a fuzzy graph  $\bar{G}:(\bar{\rho}, \bar{\mu})$  where  $\bar{\rho} = \rho$  and  $\bar{\mu}(u, v) = 0$  if  $\mu(u, v) > 0$  and  $\bar{\mu}(u, v) = \rho(u) \wedge \rho(v) - \mu(u, v)$  otherwise. A. Vijaya Kumar and M.S. Sunitha later have altered the concept of complement of fuzzy graph. It holds many properties. However, Nagoorgani and V T Chandrasekaran sought to identify a new complement called  $\mu$  complement of a fuzzy graph which differed from the previous two complements. We present an additional complement for fuzzy planar graph, whereby the membership value of the edges and vertices is altered. When two nodes in

a crisp graph have identical degrees, we can say that their neighbour count is also equal. This isn't the case with this fuzzy graph.

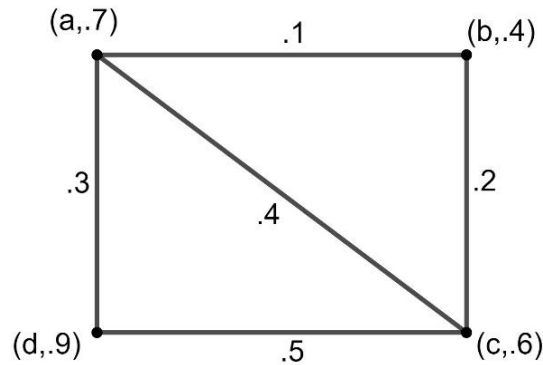


fig.2.1

The degree of nodes is  $d(a)=.8$ ,  $d(b)=.3$ ,  $d(c)=1.1$ ,  $d(d)=.8$ . Here, we observe that degree of 'a' and degree of 'd' are equal. But the node 'a' has three neighbours whereas the node 'd' has only two neighbours. Therefore, we are unable to compare a node's relationship with other nodes by simply focusing on its degree. Hence, a thorough study about degree of nodes is essential.

**Definition 2.1**

The  $\mu$ -complement of a fuzzy graph  $G:(\rho, \mu)$  is a fuzzy graph  $G^\mu:(\rho^\mu, \mu^\mu)$  where  $\rho^\mu = \rho$ .

$$\begin{aligned} \mu^\mu(u, v) &= \rho(u) \wedge \rho(v) - \mu(u, v) \text{ if } \mu(u, v) > 0 \\ &= 0 \text{ if } \mu(u, v) = 0 \end{aligned}$$

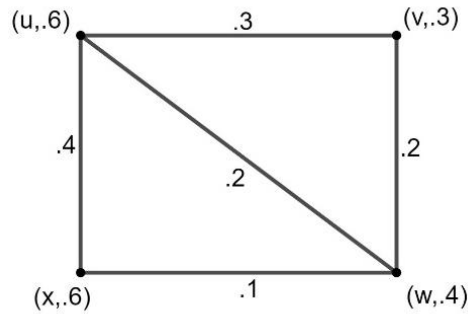
**Definition 2.2**

The  $G^*$  complement of a planar fuzzy graph  $G:(\rho, \mu)$  denoted as  $\bar{G}:(\bar{\rho}^*, \bar{\mu}^*)$  and is defined as

$$\begin{aligned} \bar{\rho}^* &= \rho(u) - [\mu(u, v) \wedge \mu(u, w) \text{ if } \mu(u, v) \neq \mu(u, w)] \\ \bar{\mu}^*(u, v) &= [\rho(u) \wedge \rho(v)] - \mu(u, v) \text{ if } \rho(u) \wedge \rho(v) \neq \mu(u, v) \end{aligned}$$

**Example 2.3**

$G^*$  complement of Fig.2.1



**Definition 2.4**

The busy value of a node  $u$  of  $\bar{G}^*$  of a fuzzy planar graph  $G:(\rho, \mu)$  is  $B(u) = \sum \rho(u) \wedge \rho(v)$  where  $u$  and  $v$  are neighbours.

**Example 2.5**

$$B(u) = \rho(u) \wedge \rho(v) + \rho(u) \wedge \rho(w) + \rho(u) \wedge \rho(x) \\ = .3 + .4 + .5 = 1.3$$

Similarly,  $B(v) = .6$ ,  $B(w) = 1.1$ ,  $B(x) = 1$

**Definition 2.6**

The busy value of a  $\bar{G}^*$  of a fuzzy planar graph is defined to be the sum of all busy values of all nodes. i.e.,  $B(G) = \sum B(u_i)$  where  $u_i$  are nodes of  $\bar{G}^*$ .

**Example 2.7**

For a  $\bar{G}^*$  of a fuzzy planar graph given in example 2.3,

$$B(u) = 1.3, B(v) = .6, B(w) = 1.1, B(x) = 1$$

Hence,  $B(G) = B(u) + B(v) + B(w) + B(x)$

$$= 4$$

**Proposition 2.8**

Let  $G:(\rho, \mu)$  be a fuzzy planar graph,  $\bar{G}^*:(\bar{\rho}^*, \bar{\mu}^*)$  is its  $G^*$  complement then  $d^*(u) = B(u) - d(u)$ .

**Proof**

$$d^*(u) = \sum \bar{\mu}^*(u, v) \\ = \sum [\rho(u) \wedge \rho(v)] - \mu(u, v) \\ = \sum \rho(u) \wedge \rho(v) - \sum \mu(u, v) \\ = B(u) - d(u)$$

**Remark 2.9**

In every complete  $\bar{G}^*$  of fuzzy planar graph for each node  $u$ ,  $d^*(u) = B^*(u)$ .

**3. Properties of nodes**

**Definition 3.1**

A node  $u$  of  $\bar{G}^* : (\bar{\rho}^*, \bar{\mu}^*)$  is said to be busy node if  $\bar{\rho}^*(u) \leq d^*(u)$ , otherwise it is a free node.

**Example 3.2**

In example 2.3, the nodes  $u$ ,  $v$  and  $w$  are busy nodes and  $x$  is a free node.

**Definition 3.3**

Given a fuzzy graph  $G : (\rho, \mu)$  with the underlying set  $S$ , the order and size of  $G^*$  is defined and denoted as  $O(\bar{G}^*) = \sum \bar{\rho}^*(u)$  and  $S(\bar{G}^*) = \sum \bar{\mu}^*(u, v)$ .

**Definition 3.4**

An edge  $e = (u, v)$  of  $\bar{G}^*$  is called an effective edge if  $\bar{\mu}^*(u, v) = \bar{\rho}^*(u) \wedge \bar{\rho}^*(v)$ .

**Example 3.5**

In example 2.3, the edge  $(u, v)$  is an effective edge.

**Definition 3.6**

A node  $v$  of  $\bar{G}^*$  of a fuzzy planar graph  $G$  is said to be a

- i) Partial free node if it is a free node in both  $G$  and  $\bar{G}^*$ .
- ii) Fully free node if it is a free node in  $G$  but it is a busy node in  $\bar{G}^*$ .
- iii) Partial busy node if it is a busy node in both  $G$  and  $\bar{G}^*$ .
- iv) Fully busy node if it is a busy node in  $G$  but it is a free node in  $\bar{G}^*$ .

**Example 3.7**

Let  $V = \{v_1, v_2, v_3, v_4\}$  and define  $\rho(v_1) = .7, \rho(v_2) = .4, \rho(v_3) = .6, \rho(v_4) = .9$  and  $\mu(v_1, v_2) = .1, \mu(v_2, v_3) = .6, \mu(v_3, v_4) = .5, \mu(v_1, v_4) = .3, \mu(v_1, v_3) = .4$ .

Then,  $v_1$  and  $v_3$  are partial busy node,  $v_2$  is a fully free node,  $v_4$  is a partial free node.

**Proposition 3.8**

$$S(G) + S(\bar{G}^*) = \frac{B(G)}{2}$$

**Proof**

From proposition 2.8,

We have,  $d^*(u) = B(u) - d(u)$

$$d^*(u) + d(u) = B(u)$$

$$\sum d^*(u) + \sum d(u) = \sum B(u)$$

$$2S(G) + 2S(\bar{G}^*) = B(G)$$

$$S(G) + S(\bar{G}^*) = \frac{B(G)}{2}$$

#### 4. Results

##### Proposition 4.1

If  $\bar{G}^*$  of a fuzzy planar graph has effective edges then it has at least one busy node.

##### Proof

Let  $G:(\rho, \mu)$  be a fuzzy planar graph.

$\bar{G}^*:(\bar{\rho}^*, \bar{\mu}^*)$  is its  $G^*$  complement which has some effective edges.

Let  $(u, v)$  be an effective edge of  $\bar{G}^*$ .

Without loss of generality let us assume that  $\bar{\rho}^*(u) \leq \bar{\rho}^*(v)$ .

Then clearly  $d^*(u) \geq \bar{\rho}^*(u)$ , which means  $u$  is a busy node.

##### Example 4.2

Let  $G:(\rho, \mu)$  be a fuzzy planar graph such that  $\rho(a) = .6, \rho(b) = .9, \rho(c) = .9, \rho(d) = .9, \mu(a, b) = .1, \mu(a, c) = .1, \mu(a, d) = .1, \mu(a, e) = .1$ . Then,  $\bar{G}^*:(\bar{\rho}^*, \bar{\mu}^*)$  is  $\bar{\rho}^*(a) = .5, \bar{\rho}^*(b) = .8, \bar{\rho}^*(c) = .8, \bar{\rho}^*(d) = .9, \bar{\mu}^*(a, b) = .5, \bar{\mu}^*(a, c) = .5, \bar{\mu}^*(a, d) = .5, \bar{\mu}^*(a, e) = .5$ . In this  $\bar{G}^*:(\bar{\rho}^*, \bar{\mu}^*)$  all edges are effective edges, but it has exactly one busy node.

##### Proposition 4.3

If  $\bar{G}^*:(\bar{\rho}^*, \bar{\mu}^*)$  is a complete fuzzy planar graph with  $n$  nodes, where  $n > 1$  then it has at least  $n - 1$  fully free nodes.

##### Proof

Let  $G:(\rho, \mu)$  be a fuzzy planar graph with  $n$  nodes and the nodes be  $V_1, V_2, V_3, \dots, V_n$  such that

$$\bar{\rho}(V_1) \geq \bar{\rho}(V_2) \geq \bar{\rho}(V_3) \geq \dots \geq \bar{\rho}(V_n)$$

$\bar{G}^*$  be the complement of  $G$ .

$$d^*(V_1) = \bar{\rho}^*(V_2) + \bar{\rho}^*(V_3) + \dots + \bar{\rho}^*(V_n) \quad \text{I}$$

$$d^*(V_2) = \bar{\rho}^*(V_3) + \bar{\rho}^*(V_4) + \dots + \bar{\rho}^*(V_n) \quad \text{II}$$

$$d^*(V_3) = 2\bar{\rho}^*(V_4) + \bar{\rho}^*(V_5) + \dots + \bar{\rho}^*(V_n) \quad \text{III}$$

$$d^*(V_3) = 3\bar{\rho}^*(V_3) + \bar{\rho}^*(V_4) + \dots + \bar{\rho}^*(V_n) \text{----- IV}$$

⋮

$$d^*(V_k) = (k-1)\bar{\rho}^*(V_k) + \bar{\rho}^*(V_{k+1}) + \dots + \bar{\rho}^*(V_n)$$

⋮

$$d^*(V_{n-1}) = (n-2)\bar{\rho}^*(V_{n-1}) + \bar{\rho}^*(V_n) \dots (n-1)$$

$$d^*(V_n) = (n-1)\bar{\rho}^*(V_n) \dots (n)$$

From the above n equations, it follows that  $d^*(V_i) > \bar{\rho}^*(V_i)$  for  $i = 2, 3, 4, \dots, n$ . Hence in a complete fuzzy graph there are at least n-1 fully free nodes.

**Remark 4.4**

From I, we infer that if  $\bar{\rho}^*(V_1) \leq \bar{\rho}^*(V_2) + \bar{\rho}^*(V_3) + \dots + \bar{\rho}^*(V_n)$  then all the nodes are busy nodes.

**Corollary 4.5**

In a complete  $\bar{G}^*$  fuzzy planar graph if there are at least two nodes with highest  $\rho$  value then all the nodes are busy nodes.

**Conclusion**

In this paper, definitions of complement of fuzzy graph were studied. By concentrating on its degree, we have compared a node's relation with other nodes. We develop this idea further and present various attributes of fuzzy planar graph and its  $\bar{G}^*$  complement.

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## Harmonic Index of Some Standard Directed Graphs

S. S. Sandhya<sup>1</sup>, P. S. Akshaya<sup>2</sup>

<sup>1</sup>Associate Professor, Department of Mathematics, Sree Ayyappa College for Women, Chunkankadai  
[Affiliated to Manonmaniam Sundaranar University]

<sup>2</sup>Research Scholar, Reg No.: 23213182092001, Sree Ayyappa College for Women, Chunkankadai  
[Affiliated to Manonmaniam Sundaranar University]

Email: [sssandhya2009@gmail.com](mailto:sssandhya2009@gmail.com), [akhshayapadmakumar12@gmail.com](mailto:akhshayapadmakumar12@gmail.com)

### Abstract

The Harmonic index of a graph  $G$  is defined as the sum of weights  $\frac{2}{d(u)+d(v)}$  of all edges  $v_i, v_j$  of  $G$ , where  $d(v_i)$  denotes the degree of the vertex  $v_i$  in  $G$ . In this paper, we investigate Harmonic Index of some standard directed graphs which satisfies Harmonic Mean labeling.

**Keywords:** Graph, Harmonic Mean graph, Path, Cycle, Triangular graph, Double Triangular graph, Quadrilateral graph, Double Quadrilateral graph, Sparkler graph, Mobius Ladder graph,  $T_n \odot k_1$ ,  $Q_n \odot k_1$ .

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### Introduction

All graphs in this paper are finite, simple and undirected graphs. Let  $G = (V, E)$  be a graph with  $p$  vertices and  $q$  edges. For a detailed survey of graph labeling, we refer to Gallian [1]. For all other standard terminology and notation, we follow Harary [2]. S. Somasundaram, R. Ponraj and S.S. Sandhya introduced Harmonic Mean labeling of graphs.

A directed graph, also called a digraph, is a graph in which the edges have a direction. This is usually indicated with an arrow on the edge. Harmonic index is one of the most important Topological indices in chemical and mathematical fields were introduced by Zhong [8]. It is a variant of the Randic index which is the most successful molecular descriptor in structure property and structure activity relationship studies. For a graph  $G$ , the Harmonic index of a graph  $H(G)$  is defined by as  $H(G) = \sum_{u,v \in E(G)} \frac{2}{d(u)+d(v)}$ , where  $d(u)$  is the degree of the vertex  $u$  in  $G$ .

So far, we have constructed only the undirected graphs. Now we try to find the same result in directed graphs. Here, Harmonic Index is the degree-based index, we consider the in-degree based and out-degree based indices in some graphs.

For directed graphs the indegree of a vertex is the number of edges leading into that vertex and its outdegree, the number of edges leading away from it. The outdegree  $d_u^+$  of a

vertex  $u$  of  $D$  is the number of vertices of  $D$  that are adjacent from  $u$ . The indegree  $d_u^-$  of  $u$  is the number of vertices of  $D$  adjacent to  $u$ .

We provide a brief summary of definitions which are necessary for the present investigation.

**Definition 1.1:** A Graph  $G = (V, E)$  with  $p$  vertices and  $q$  edges is said to be a Harmonic Mean graph if it is possible to label the vertices  $x \in V$  with distinct labels  $f(x)$  from  $1, 2, \dots, q + 1$  in such way that when each edge  $e = uv$  is labeled with  $f(e = uv) = \left\lfloor \frac{2f(u)f(v)}{f(u)+f(v)} \right\rfloor$  (or)  $\left\lceil \frac{2f(u)f(v)}{f(u)+f(v)} \right\rceil$ , then the resulting edge labels are all distinct. In this case,  $f$  is called Harmonic Mean labeling of  $G$ .

**Definition 1.2:** A walk in which  $u_0, u_1, u_2, \dots, u_n$  are distinct is called a **Path**. A Path on  $n$  vertices is denoted by  $P_n$ .

**Definition 1.3:** A cycle  $C_n$  is a closed walk in which no vertices repeated more than once.

**Definition 1.4:** A **Triangle snake**  $T_n$  is obtained from a Path  $u_1, u_2, u_3, u_4 \dots u_n$  by joining  $u_1$  and  $u_{i+1}$  to a new vertex  $v_i$  from  $1 \leq i \leq n - 1$ . That is every edge of the Path is replaced by a Triangle  $C_3$ .

**Definition 1.5:** A **Double Triangular Snake**  $D(T_n)$  consists of two triangular snakes that have a common path.

**Definition 1.6:** A **Quadrilateral Snake**  $Q_n$  is obtained from a path  $u_1, u_2, u_3, u_4 \dots u_n$  by joining  $u_1$  and  $u_{i+1}$  to a new vertices  $v_i, w_i$  respectively and joining  $v_i$  and  $w_i$ . That is every edge of the Path is replaced by a cycle  $C_4$ .

**Definition 1.7:** A **Double Quadrilateral Snake**  $D(Q_n)$  consists of two Quadrilateral snakes that have a common path.

**Definition 1.4:** The **Möbius ladder** on  $n$  vertices, denoted  $M_n$ , is constructed by connecting vertices  $u$  and  $v$  in the cycle  $C_n$  if  $d(u, v) = \text{diam}(C_n)$ .

**Definition 1.5:** The **Corona**  $G = G_1 \odot G_2$  of two graphs  $G_1$  and  $G_2$  is defined as a graph obtained by taking one copy of  $G_1$  (with  $p$  vertices) and  $p$  copies of  $G_2$  and then joining the  $i^{\text{th}}$  vertex of  $G_1$  to every vertex of  $i^{\text{th}}$  copy of  $G_2$ .

**Result 1.6:** Harmonic Index of Path graph is  $\frac{1}{3+2(n-3)}$



**Result 1.7:** Harmonic Index of Cycle graph is  $\frac{1}{2n}$

**Result 1.8:** Harmonic Index of Triangular Snake graph is  $\frac{1}{10n-4}$

**Result 1.9:** Harmonic Index of Double Triangular Snake graph is  $\frac{1}{22n-9}$

**Result 1.10:** Harmonic Index of Quadrilateral Snake graph is  $\frac{1}{12n-4}$

**Result 1.11:** Harmonic Index of Double Quadrilateral Snake graph is  $\frac{1}{26n-9}$

## 2. Main Results

**Theorem 2.1:** The Harmonic index of Path graph  $P_n$  is  $H(P_n) = 2n - 2$

**Proof:**

Let  $G = P_n$  be a Harmonic Mean labeled graph.

There are  $n$  vertices and  $n - 1$  edges.

And  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

Harmonic index of Path graph  $P_n$  is

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)} \\ &= \frac{2}{1+0} + \frac{2}{1+1} + \frac{2}{1+1} + \dots + \frac{2}{0+1} \\ &= 2 + \frac{2}{2} + \frac{2}{2} + \dots + 2 \\ &= 2n - 2 \end{aligned}$$

### Example 2.2

Harmonic index of directed Path graph  $P_6$  is given below



**Figure 1:**  $P_6$

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)} \\ &= \frac{2}{1+0} + \frac{2}{1+1} + \frac{2}{1+1} + \dots + \frac{2}{0+1} \\ &= 2 + 8 \times \frac{2}{2} + 2 \end{aligned}$$

$$= 10$$

**Theorem 2.3:** The Harmonic index of Cycle graph  $C_n$  is  $H(C_n) = n$

**Proof**

Let  $G = C_n$  be a Harmonic Mean labeled graph.

There are  $n$  vertices and  $n - 1$  edges.

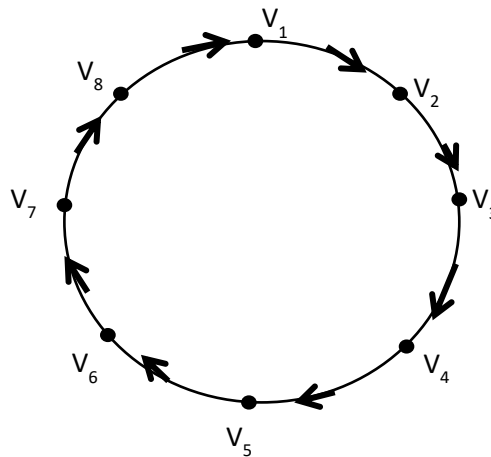
And  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

Harmonic index of Path graph  $C_n$  is

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)} \\ &= \frac{2}{1+1} + \frac{2}{1+1} + \dots + \frac{2}{1+1} \\ &= \frac{2}{2} + \frac{2}{2} + \dots + \frac{2}{2} \\ &= n \end{aligned}$$

**Example 2.4**

Harmonic index of directed Cycle graph  $C_6$  is given below



**Figure 2:**  $C_8$

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)} \\ &= \frac{2}{1+1} + \frac{2}{1+1} + \dots + \frac{2}{1+1} \\ &= 8 \end{aligned}$$

**Theorem 2.5:** The Harmonic index of Traingular Snake graph  $T_n$  is  $H(T_n) = \frac{3(n+1)}{2}$

**Proof**

Let  $G = T_n$  be a Harmonic Mean labeled graph.

$$\deg(v_1) = \deg(v_n) = 2$$

$$\deg(v_{2n}) = 2, \forall n = 1, 2, 3, \dots$$

$$\deg(v_{2n+1}) = 4, \forall n = 1, 2, 3, \dots$$

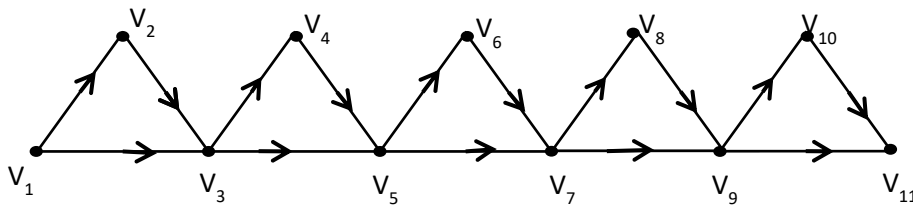
And  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

Harmonic index of Triangular Snake graph  $T_n$  is,

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\ &= \frac{2}{0+2} + \frac{2}{1+1} + \frac{2}{2+2} + \dots + \frac{2}{2+0} \\ &= (n+2) \times \frac{2}{2} + \frac{(n-1)}{2} \\ &= \frac{3n+3}{2} \\ &= \frac{3(n+1)}{2} \end{aligned}$$

**Example 2.6**

Harmonic index of directed Triangular Snake graph  $T_5$  is given below



**Figure 3:  $T_5$**

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\ &= \frac{2}{2+0} + \frac{2}{1+1} + \frac{2}{2+2} + \dots + \frac{2}{0+2} \\ &= 7 + 4 \times \frac{1}{2} \\ &= 9 \end{aligned}$$

**Theorem 2.7** The Harmonic index of Double Triangular Snake graph  $D(T_n)$  is

$$H(D(T_n)) = \frac{7n+3}{3}$$

**Proof**

Let  $G = D(T_n)$  be a Harmonic Mean labeled graph.

$$\deg(u_1) = \deg(u_n) = 2$$

$$\deg(w_1) = 2, \forall n = 1, 2, 3, \dots$$

$$\deg(v_1) = \deg(v_{n+1}) = 3$$

$$\deg(v_n) = 6, \forall n = 2, 3, \dots, n$$

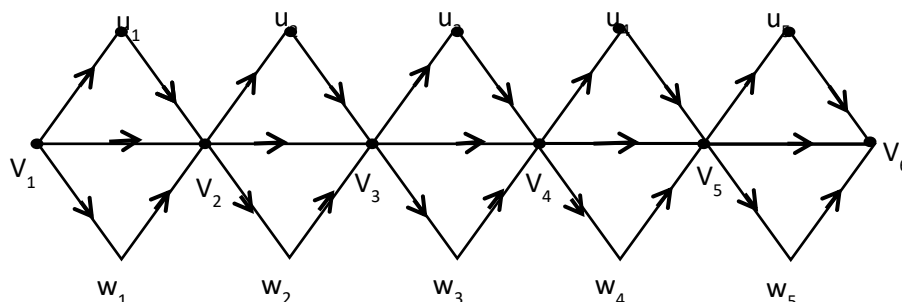
And  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

Harmonic index of Double Triangular Snake graph  $D(T_n)$  is,

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\ &= \frac{2}{3+0} + \frac{2}{1+1} + \frac{2}{1+1} + \frac{2}{3+3} + \dots + \frac{2}{3+0} \\ &= \left(2 \times \frac{2}{3}\right) + 2n + \frac{(n-1)}{3} \\ &= \frac{7n+3}{3} \end{aligned}$$

**Example 2.8**

Harmonic index of directed Double Triangular Snake graph  $T_5$  is given below



**Figure 4:  $D(T_5)$**

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\ &= \frac{2}{3+0} + \frac{2}{1+1} + \frac{2}{1+1} + \frac{2}{3+3} + \dots + \frac{2}{0+3} \\ &= \frac{38}{3} \end{aligned}$$

**Theorem 2.9** The Harmonic index of Quadrilateral Snake graph  $Q_n$  is  $H(Q_n) = \frac{5n+3}{2}$

**Proof**

Let  $G = Q_n$  be a Harmonic Mean labeled graph.

$$\deg(v_1) = \deg(v_{n-1}) = 2$$

$$\deg(u_n) = 2, \forall n = 1, 2, 3, \dots, n + 1$$

$$\deg(v_n) = 4, \forall n = 2, 3, \dots, n - 2$$

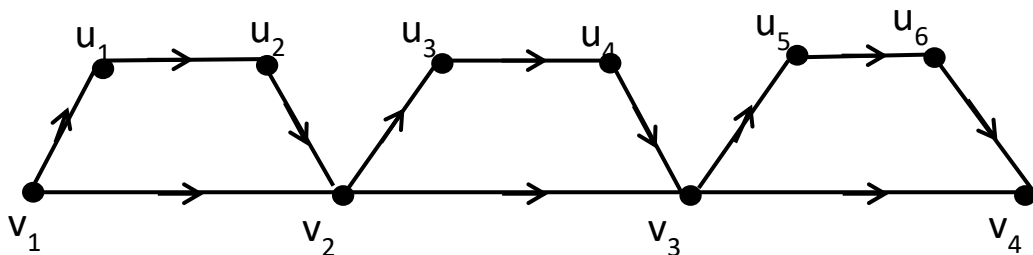
And  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

Harmonic index of Quadrilateral Snake graph  $Q_n$  is,

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\ &= \frac{2}{0+2} + \frac{2}{1+1} + \frac{2}{2+2} + \dots + \frac{2}{2+0} \\ &= (2n+2) + \frac{(n-1)}{2} \\ &= \frac{5n+3}{2} \end{aligned}$$

**Example 2.10**

Harmonic index of directed Quadrilateral Snake graph  $Q_3$  is given below



**Figure 5:  $Q_3$**

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\ &= \frac{2}{2+0} + \frac{2}{1+1} + \frac{2}{2+2} + \dots + \frac{2}{0+2} \\ &= 8 + 2 \times \frac{1}{2} \\ &= 9 \end{aligned}$$

**Theorem 2.11** The Harmonic index of Double Quadrilateral Snake graph  $Q_n$  is

$$H(D(Q_n)) = \frac{13n+3}{3}$$

**Proof**

Let  $G = D(Q_n)$  be a Harmonic Mean labeled graph.

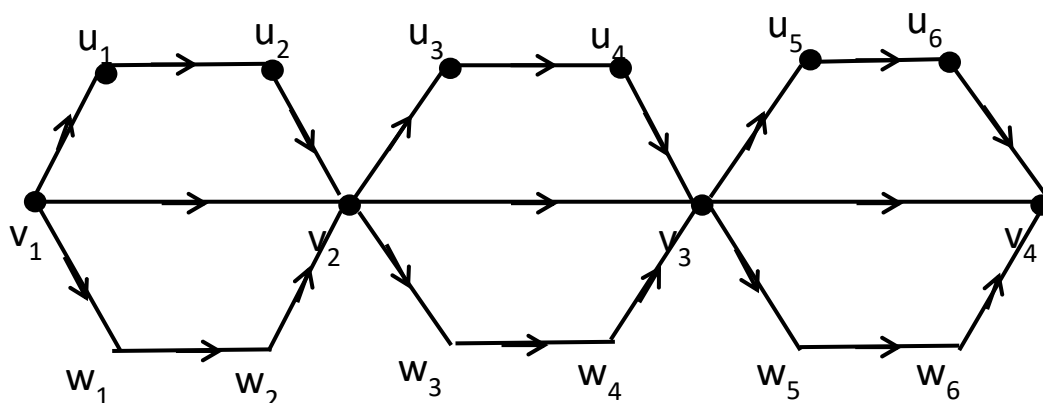
Here,  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

Harmonic index of Double Quadrilateral Snake graph  $D(Q_n)$  is,

$$\begin{aligned} H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)} \\ &= \frac{2}{0+3} + \frac{2}{1+1} + \frac{2}{1+1} + \frac{2}{3+3} + \dots + \frac{2}{3+0} \\ &= \frac{4}{3} + 4n + \frac{n-1}{3} \\ &= \frac{13n+3}{3} \end{aligned}$$

**Example 2.12**

Harmonic index of directed Double Quadrilateral Snake graph  $D(Q_3)$  is given below



**Figure 6:  $Q_3$**

Hence, the Harmonic index of directed Double Quadrilateral Snake graph  $D(Q_3)$  is 14.

**Theorem 2.13** The Harmonic index of Sparkler graph  $P_n \odot k_{1,4}$  is  $H(P_n \odot k_{1,4}) = \frac{125n+2}{15}$

**Proof**

Let  $G = Q_n$  be a Harmonic Mean labeled graph.

$$\deg(u_1) = \deg(u_n) = 5$$

$$\deg(u_n) = 6, \forall n = 2, 3, \dots, n-1$$

$$\deg(v_n) = 1, \forall n = 1, 2, 3, \dots, 4n$$

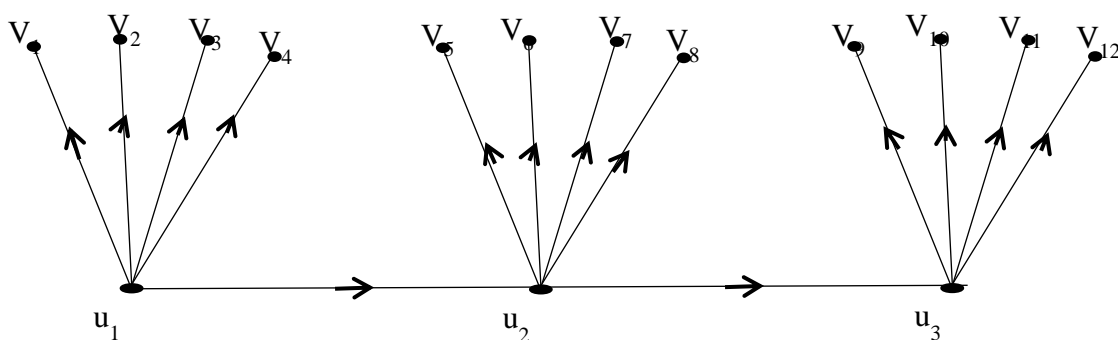
Here,  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

Harmonic index of Sparkler graph  $P_n \odot k_{1,4}$  is,

$$\begin{aligned}
 H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)} \\
 &= \frac{2}{5+0} + \frac{2}{1+5} + \frac{2}{1+5} + \dots + \frac{2}{5+0} \\
 &= \frac{4}{5} + \frac{n-2}{3} + 8n \\
 &= \frac{125n+2}{15}
 \end{aligned}$$

**Example 2.14**

Harmonic index of directed Sparkler graph  $P_3 \odot k_{1,4}$  is given below



**Figure 7:**  $P_3 \odot k_{1,4}$

$$\begin{aligned}
 H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)} \\
 &= \frac{2}{5+0} + \frac{2}{1+5} + \frac{2}{1+4} + 12 \times 2 \\
 &= \frac{4}{5} + \frac{1}{3} + 24 = \frac{377}{15}
 \end{aligned}$$

**Theorem 2.15** The Harmonic index of Sparkler graph  $T_n \odot k_1$  is  $H(T_n \odot k_1) = \frac{76n+44}{15}$

**Proof**

Let  $G = T_n \odot k_1$  be a Harmonic Mean labeled graph.

Here,  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

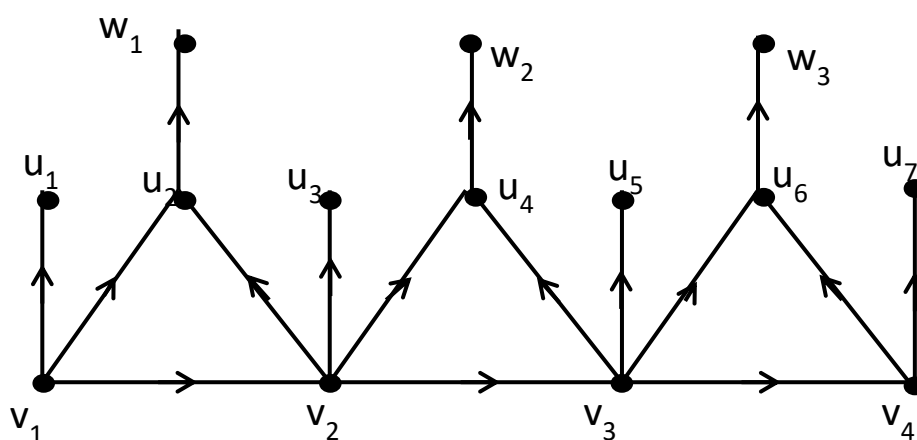
Harmonic index of  $T_n \odot k_1$  is,

$$H(G) = \sum_{u,v \in E(G)} \frac{2}{d^+(u)+d^-(u)}$$

$$\begin{aligned}
 &= \frac{2}{3+0} + \frac{2}{2+3} + \frac{2}{2+1} + \dots + \frac{2}{3+0} \\
 &= \frac{2n}{3} + \frac{4}{3} + \frac{2n}{5} - \frac{2}{5} + 4n + 2 \\
 &= \frac{76n + 44}{15}
 \end{aligned}$$

**Example 2.16**

Harmonic index of directed  $T_3 \odot k_1$  is given below



**Figure 8:**  $T_3 \odot k_1$

$$\begin{aligned}
 H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\
 &= \frac{2}{5+0} + \frac{2}{1+5} + \frac{2}{1+4} + 12 \times 2 \\
 &= \frac{10}{3} + \frac{4}{5} + 14 \\
 &= \frac{272}{15}
 \end{aligned}$$

**Theorem 2.17** For every even  $n > 4$ , the Harmonic index of Mobius Ladder  $M_n$  is

$$H(M_n) = \frac{2n}{3}$$

**Proof**

Let  $G = M_n$  be a Harmonic Mean labeled graph.

$$\deg(u_1) = \deg(u_n) = 3$$

Here,  $d^+(u)$  and  $d^-(u)$  is the in-degree and out-degree of  $u$

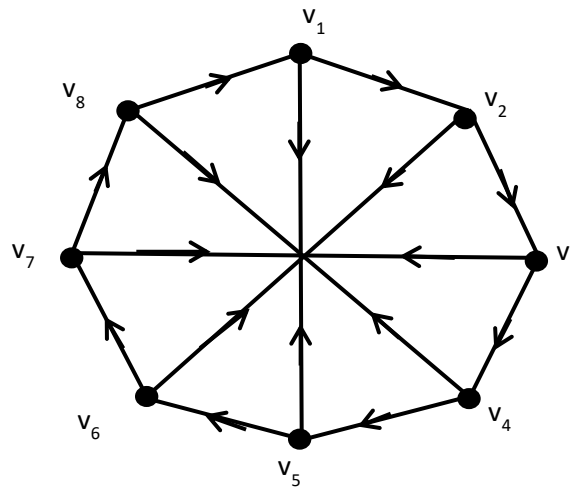
Harmonic index of Sparkler graph  $P_n \odot k_{1,4}$  is,



$$\begin{aligned}
 H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\
 &= \frac{2}{1+2} + \frac{2}{1+2} + \dots + \frac{2}{1+2} \\
 &= \frac{2n}{3}
 \end{aligned}$$

**Example 2.18**

Harmonic index of directed Mobius Ladder graph  $M_8$  is given below



**Figure 9:  $M_8$**

$$\begin{aligned}
 H(G) &= \sum_{u,v \in E(G)} \frac{2}{d^+(u) + d^-(u)} \\
 &= 8 \times \frac{2}{3} \\
 &= \frac{16}{3}
 \end{aligned}$$

**Conclusion**

We have studied Harmonic index for various directed graph structures derived using graph operators. In future a comparative study will be carried out with this for various directed and undirected graphs.

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## Contra Harmonic Coindex of Some Molecular Graphs

Anchu S Kumar<sup>1</sup>, Dr. S. S. Sandhya<sup>2</sup>

<sup>1</sup> Research Scholar, Reg. No.: 22113182092001, Sree Ayyappa College for Women, Chunkankadai,  
Affiliated to Manonmaniam Sundaranar University.

<sup>2</sup> Associate Professor and Head, Department of Mathematics, Sree Ayyappa College for Women,  
Chunkankadai, Affiliated to Manonmaniam Sundaranar University.  
Email: [anchuskumar09@gmail.com](mailto:anchuskumar09@gmail.com), [sssandhya2009@gmail.com](mailto:sssandhya2009@gmail.com).

### Abstract

Topological index is a mathematical coding of the molecular graphs that predicts the Physiochemical, Biological, Toxicological and Structural properties of chemical compounds that are directly associated with molecular graphs. In this paper, we find the Contra Harmonic coindex of some graphs which are also the chemical structures of certain molecular compounds.

**Keywords:** Graphs, Contra Harmonic coindex, Star, Bistar, Y-tree, Corona product, Comb, Biregular graph

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### 1. Introduction

A Topological graph coindex, also called a molecular descriptor, is a mathematical formula calculated based on the molecular graph of a chemical compound. A simple graph can be molded into a chemical structure by using some operations. So, many chemical graphs can be generated by using simple graphs based on operations such as  $C_{10}H_{22}$  is the corona product of  $P_5$  and  $K_1$ .

All graphs in this paper are finite, simple and undirected graphs. For a detailed survey of graph labeling we refer to Gallian[1]. For all other standard terminology and notations, we follow Harary[2]. S. S. Sandhya, S. Somasundaram and J. Rajeshni Golda introduced Contra Harmonic Mean labeling of graphs[3]. S. Ragavi and R. Sridevi introduced Contra Harmonic index of graphs[6]. Contra Harmonic index of some networks are discussed in [7]

We provide a brief summary of definitions which are necessary for the present investigation.

**Definition 1.1** A graph  $G(V, E)$  with  $p$  vertices and  $q$  edges is said to be Contra Harmonic Mean graph if it is possible to label the vertices  $x \in V$  with distinct labels  $f(x)$  from  $0, 1, 2, \dots, q$  in such a way that each edge  $e = uv$  is labeled with  $f(e = uv) = \left\lceil \frac{f(u)^2 + f(v)^2}{f(u) + f(v)} \right\rceil$  or  $\left\lfloor \frac{f(u)^2 + f(v)^2}{f(u) + f(v)} \right\rfloor$ . Then we get distinct edge labels. In this case  $f$  is called Contra Harmonic Mean labeling of  $G$  and  $G$  is called Contra Harmonic Mean graph.

**Definition 1.2** Contra Harmonic index of a graph  $G$  is defined as sum of the term  $\frac{d(u)^2+d(v)^2}{d(u)+d(v)}$  over all edges  $uv$  of graph  $G$ .

$$CH(G) = \sum_{uv \in E(G)} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)}$$

**Definition 1.3** Contra Harmonic coindex of a graph  $G$  is defined as sum of the term  $\frac{d(u)^2+d(v)^2}{d(u)+d(v)}$  over all non-adjacent pair of vertices  $u, v$  of graph  $G$ .

$$\overline{CH}(G) = \sum_{uv \notin E(G)} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)}$$

**Definition 1.4** The degree of a vertex in a graph  $G$  is the number of edges of  $G$  incident with  $v$  and is denoted by  $d(v)$

**Definition 1.5** A star graph is complete bigraph  $K_{1,n}$ . The vertex of  $K_{1,n}$  with degree  $n$  is called the central vertex

**Definition 1.6** A Bistar  $B_{m,n}$  is the graph obtained by joining the centre vertices of  $K_{1,m}$  and  $K_{1,n}$  by an edge.

**Definition 1.7** A Y-tree in  $n$  vertices can be defined as the graph obtained by adjoining a pendant edge to the  $(n-1)^{th}$  vertex of path  $P_n$

**Definition 1.8** The corona product  $G_1 \odot G_2$  is defined as the graph  $G$  obtained by taking one copy of  $G_1$  (which has  $P_1$  vertices) and  $P_1$  copies of  $G_2$  and then joining the  $i^{th}$  vertex of  $G_1$  to every vertices in  $i^{th}$  copy of  $G_2$ .

**Definition 1.9** The graph obtained by joining a single pendant edge to each vertex of a Path is called a Comb.

**Definition 1.10** A Biregular graph is a bipartite graph  $G = (U, V, E)$  for which every two vertices on the same side of the given bipartition have the same degree as each other. If the degree of the vertices in  $U$  is  $x$  and the degree of vertices in  $V$  is  $y$ , then the graph is said to be  $(x, y)$ -biregular.

## 2. Results

**Theorem 2.1** Contra Harmonic coindex of Star graph  $K_{1,n}$  is  $\frac{n(n-1)}{2}$

**Proof**

Let  $K_{1,n}$  be a star

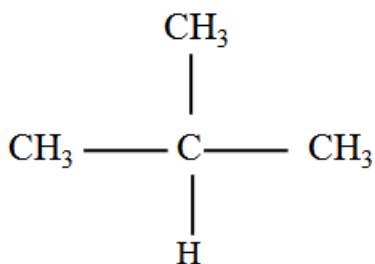
$K_{1,n}$  has  $\frac{n(n-1)}{2}$  pair of non-adjacent vertices and all non-adjacent vertices have degree 1

$$\begin{aligned} \overline{CH}(K_{1,n}) &= \sum_{uv \in E(G)} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)} \\ &= \frac{1^2 + 1^2}{1 + 1} + \dots + \frac{1^2 + 1^2}{1 + 1} \left( \frac{n(n-1)}{2} \text{ times} \right) \\ &= \frac{n(n-1)}{2} \end{aligned}$$

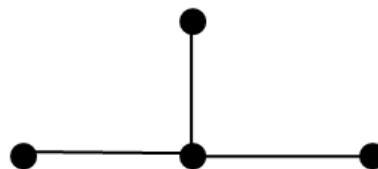
Therefore,  $\overline{CH}(K_{1,n}) = \frac{n(n-1)}{2}$

**Example 2.1**

The following example shows the Contra Harmonic coindex of isobutane using simple graph (hydrogen depleted graph)  $C_4H_{10}$ . Here,  $\overline{CH}(K_{1,3})$  is 3



a) Lewis structure of isobutane



b) Hydrogen depleted graph  $K_{1,3}$  of isobutane

**Figure 1**

**Theorem 2.2** Contra Harmonic coindex of bistar  $B_{m,n}$  is

$$\frac{m[n^2 + 2n + 2]}{n + 2} + \frac{n[m^2 + 2m + 2]}{m + 2} + \frac{(n + m)(n + m - 1)}{2}$$

**Proof**

Let  $B_{m,n}$  be a bistar

Then the number of non-adjacent pair of vertices  $u, v$  with degree  $(d_u, d_v)$  is given in the following table

$(d_u, d_v)$	Number of non-adjacent pair of vertices $u, v$
(1,1)	$\frac{(n + m)(n + m - 1)}{2}$
(1, $n + 1$ )	$m$
(1, $m + 1$ )	$n$

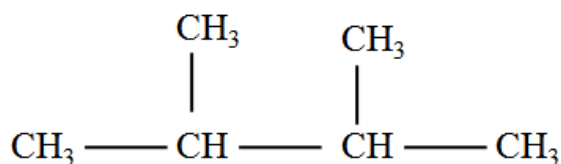
$$\begin{aligned} \overline{CH}(B_{m,n}) &= \sum_{uv \in E(G)} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)} \\ &= \frac{(n + m)(n + m - 1)}{2} \left[ \frac{1^2 + 1^2}{1 + 1} \right] + m \left[ \frac{(n + 1)^2 + 1}{n + 2} \right] + n \left[ \frac{(m + 1)^2 + 1}{m + 2} \right] \\ &= \frac{m[n^2 + 2n + 2]}{n + 2} + \frac{n[m^2 + 2m + 2]}{m + 2} + \frac{(n + m)(n + m - 1)}{2} \end{aligned}$$

Therefore,  $\overline{CH}(B_{m,n}) = \frac{m[n^2 + 2n + 2]}{n + 2} + \frac{n[m^2 + 2m + 2]}{m + 2} + \frac{(n + m)(n + m - 1)}{2}$

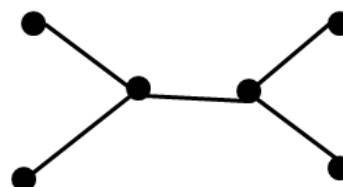
**Example 2.2**

The following example shows the Contra Harmonic coindex of 2,3-Dimethyl Butane  $C_6H_{14}$ .

Here,  $\overline{CH}(B_{2,2})$  is 16



a) Lewis structure of 2,3-Dimethyl Butane



b) Hydrogen depleted graph  $B_{2,2}$  of 2,3-Dimethyl Butane

**Theorem 2.3** Contra Harmonic coindex of  $Y_n$  is  $n^2 - \frac{17}{5}n - \frac{47}{16}$ ,  $n \geq 4$

**Proof**

Let  $Y_n$  be a Y-tree

Then the number of non-adjacent pair of vertices  $u, v$  with degree  $(d_u, d_v)$  is given in the following table

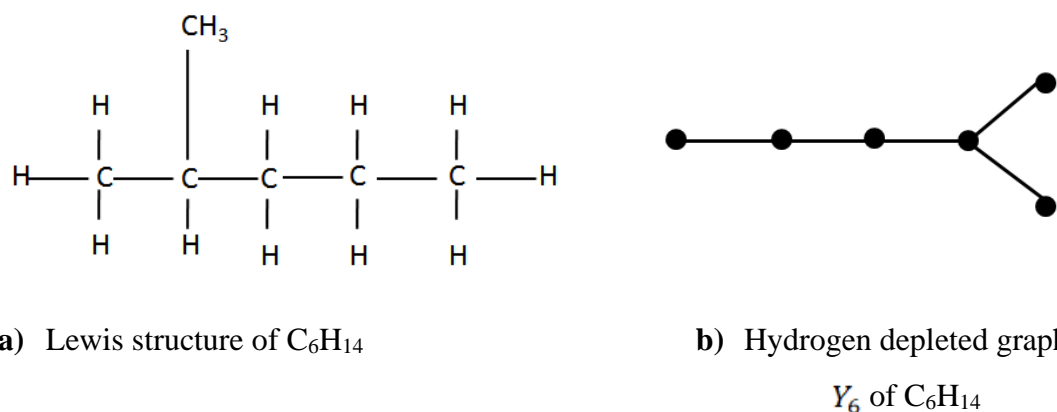
$(d_u, d_v)$	Number of non-adjacent pair of vertices $u, v$
(1,1)	3
(1,3)	1
(1,2)	$3n - 13$
(2,3)	$n - 5$
(2,2)	$\frac{(n-6)(n-5)}{2}$

$$\begin{aligned} \overline{CH}(Y_n) &= \sum_{uv \in E(G)} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)} \\ &= 3 \left( \frac{1^2 + 1^2}{1+1} \right) + 1 \left( \frac{1^2 + 3^2}{1+3} \right) + (3n - 13) \left( \frac{1^2 + 2^2}{1+2} \right) + (n - 5) \left( \frac{2^2 + 3^2}{2+3} \right) \\ &\quad + \frac{(n-6)(n-5)}{2} \left( \frac{2^2 + 2^2}{2+2} \right) \\ &= n^2 - \frac{17}{5}n - \frac{47}{16} \end{aligned}$$

Therefore,  $\overline{CH}(Y_n) = n^2 - \frac{17}{5}n - \frac{47}{16}$

**Example 2.3**

The following example shows the Contra Harmonic coindex of 2-methyl pentane  $C_6H_{14}$  using molecular graph  $Y_n$ . Here,  $\overline{CH}(Y_6) = \overline{CH}(C_6H_{14}) = 12.66$



**Figure 3**

**Theorem 2.4** Contra Harmonic coindex of Comb,  $P_n \odot K_1$  is

$$\frac{9}{2}n^2 - \frac{299}{30}n + \frac{91}{15}$$

**Proof**

Let  $G = P_n \odot K_1$  be the comb graph

Then the number of non-adjacent pair of vertices  $u, v$  with degree  $(d_u, d_v)$  is given in the following table

$(d_u, d_v)$	Number of non-adjacent pair of vertices $u, v$
(1,1)	$\frac{n(n-1)}{2}$
(1,2)	$2(n-1)$
(2,2)	1
(1,3)	$(n-2)(n-1)$
(2,3)	$2(n-3)$
(3,3)	$\frac{(n-4)(n-3)}{2}$

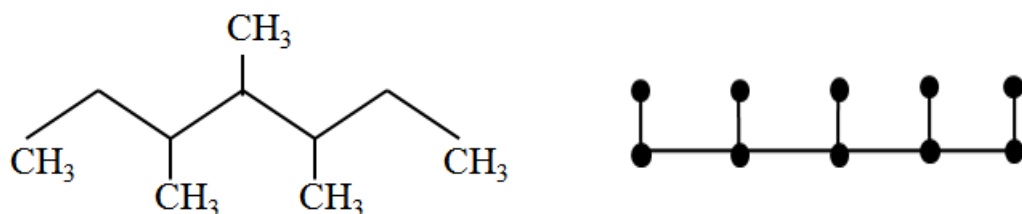


$$\begin{aligned} \overline{CH}(P_n \odot K_1) &= \sum_{uv \in E(G)} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)} \\ &= \frac{n(n-1)}{2} \left( \frac{1^2 + 1^2}{1+1} \right) + 2(n-1) \left( \frac{2^2 + 1^2}{2+1} \right) + 1 \left( \frac{2^2 + 2^2}{2+2} \right) + \\ &(n-2)(n-1) \left( \frac{3^2 + 1^2}{3+1} \right) + 2(n-3) \left( \frac{3^2 + 2^2}{3+2} \right) + \frac{(n-4)(n-3)}{2} \left( \frac{3^2 + 3^2}{3+3} \right) \\ &= \frac{9}{2}n^2 - \frac{299}{30}n + \frac{91}{15} \end{aligned}$$

Therefore,  $\overline{CH}(P_n \odot K_1) = \frac{9}{2}n^2 - \frac{299}{30}n + \frac{91}{15}$

**Example 2.4**

The following example shows the Contra Harmonic coindex of (3,4,5)- trimethylheptane,  $C_{10}H_{22}$  using molecular graph  $P_5 \odot K_1$ . Here,  $\overline{CH}(P_5 \odot K_1) = \overline{CH}(C_{10}H_{22})$  is 68.7333



a) Lewis structure of  $C_{10}H_{22}$

b) Hydrogen depleted graph  $P_5 \odot K_1$   
of  $C_{10}H_{22}$

**Figure 4**

**Theorem 2.5** Contra Harmonic coindex of  $(1, b)$  –biregular n-caterpillar is

$$\frac{n^2b^2 - 3n^2b - 6n + 2b + 7}{2} + \frac{[-2n^2 + 4n + nb(n-1) - 2][b^2 + 1]}{b+1}$$

**Proof**

Let  $BCT_n$  be a  $(1, b)$  –biregular n-caterpillar tree with  $n$  vertices of degree  $b$  and  $n(b - 2) + 2$  vertices of degree 1

Then the number of non-adjacent pair of vertices  $u, v$  with degree  $(d_u, d_v)$  is given in the following table

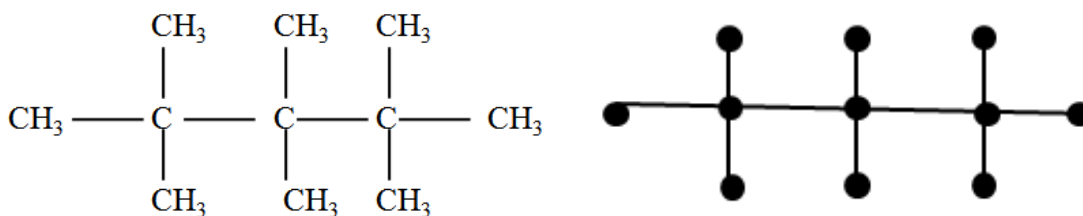
$(d_u, d_v)$	Number of non-adjacent pair of vertices $u, v$
(1,1)	$\frac{[n(b-2)]^2 + 3n(b-2) + 3}{2}$
(b,b)	$\frac{(n-2)(n-1)}{2}$
(1,b)	$-2n^2 + 4n + nb(n-1) - 2$

$$\begin{aligned} \overline{CH}(BCT_n) &= \sum_{uv \in E(G)} \frac{d(u)^2 + d(v)^2}{d(u) + d(v)} \\ &= \frac{[n(b-2)]^2 + 3n(b-2) + 3}{2} \left( \frac{1^2 + 1^2}{1+1} \right) + [-2n^2 + 4n + nb(n-1) - 2] \left( \frac{1^2 + b^2}{1+b} \right) + \frac{(n-2)(n-1)}{2} \left( \frac{b^2 + b^2}{b+b} \right) \\ &= \frac{n^2 b^2 - 3n^2 b - 6n + 2b + 7}{2} + \frac{[-2n^2 + 4n + nb(n-1) - 2][b^2 + 1]}{b+1} \end{aligned}$$

Therefore,  $\overline{CH}(BCT_n) = \frac{n^2 b^2 - 3n^2 b - 6n + 2b + 7}{2} + \frac{[-2n^2 + 4n + nb(n-1) - 2][b^2 + 1]}{b+1}$

**Example 2.5**

The following example shows the Contra Harmonic index of (2,2,3,3,4,4)-hexamethylpentane,  $C_{11}H_{24}$  represented by (1,4)-biregular caterpillar tree,  $BCT_3$ . Here,  $\overline{CH}(C_{11}H_{24})$  is  $-23.5$



a) Lewis structure of  $C_{11}H_{24}$

b) Hydrogen depleted graph (1,4)-biregular caterpillar tree of  $C_{11}H_{24}$

**Figure 4**

### **3. Conclusion**

In this paper, we present some applications of obtained results for particular chemical structures. Identifying the coindices of simple graph structures simplify the identification of complex chemical compounds.

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## Geometric Factorial Functions in Mixed Difference Operator

V. Rexma Sherine

Department of Mathematics, Sacred Heart College (Autonomous),

Tirupattur - 635 601, Tamil Nadu, India.

e-mail: [rexmaprabu123@gmail.com](mailto:rexmaprabu123@gmail.com)

**Abstract.** The goal of this paper is to develop a discrete version of fundamental theorem of fractional calculus for  $(q,h)$ -difference operator. Here, we have introduced a new concept called Factorial coefficient and Geometric factorial functions which help us to find the difference equations for fractional order theorems. This theory is then employed in the field of discrete fractional calculus to arrive various significant theorems on fractional order sums.

**Keywords and Phrases:** Anti-difference principle, Factorial coefficient function, Geometric factorial function, Fundamental theory of discrete fractional calculus.

**AMS Classification:** 39A05,39A12,39A60,39A70

### 1. INTRODUCTION

The theory of discrete fractional calculus has received a lot of attention in recent years and has found extensive use in many areas of physics, including quantum mechanics, thermodynamics, classical mechanics, etc( refer [5, 18, 20]). Discrete fractional calculus concerns the discrete analog of generalization of integration and differentiation to non-integer orders [8, 14, 15, 16, 17]. Systematic demonstration of the applications of discrete fractional calculus could be seen in the books [4, 7], and for more details one can also refer the articles [1, 2, 3, 6, 12, 13] and their references. The quantum fractional calculus was recently developed by the authors in [19, 22] using the  $q$ -difference operators.

2. MIXED OPERATOR AND ITS PROPERTIES

In this section, we present some basic definitions and its properties of  $(q, h)$  difference operator and its inverse operator. Here, we introduce the infinite set  $\mathcal{M}_h^q = \{k, kq + h, kq^2 + 2h, \dots\}$  satisfying the condition that for any  $k \in \mathcal{M}_h^q$  implies  $kq^{\pm 1} \pm h \in \mathcal{M}_h^q$  for any fixed number  $0 \neq k \in R$ .

**Definition 2.1.** Let  $u : \mathcal{M}_h^q \rightarrow R$  be a function. Then the  $(q, h)$  difference operator, denoted by  $\Delta_{(q,h)}$  is defined as

$$\Delta_{(q,h)} u(k) = u(kq + h) - u(k), \quad k \in \mathcal{M}_h^q. \quad (1)$$

**Definition 2.2.** Let  $h, q, k \in R$  and  $n \in \mathbb{N}$ . The  $(q, h)$  polynomial factorial function  $k_{q,h}^{(n)}$  is defined as

$$k_{q,h}^{(n)} = k \prod_{r=1}^{n-1} (k - (q^r + rh)). \quad (2)$$

**Lemma 2.3.** If  $u, v : \mathcal{M}_h^q \rightarrow R$ ,  $q \in R - \{0, 1\}$  and  $0 \neq h \in R$ . Then the product rule of  $(q, h)$  difference operator is obtained as

$$\Delta_{(q,h)}^{-1} \{u(k)v(k)\} = u(k) \Delta_{(q,h)}^{-1} v(k) - \Delta_{(q,h)}^{-1} \left\{ \Delta_{(q,h)}^{-1} v(kq + h) \Delta_{(q,h)} u(k) \right\}. \quad (3)$$

**Proof:** Applying the operator  $\Delta_{(q,h)}$  on the function  $u(k)v(k)$  and then adding and subtracting the term  $u(k)v(kq + h)$ , we obtain

$$\Delta_{(q,h)}^{-1} \{u(k)v(k)\} = v(kq + h) \Delta_{(q,h)} u(k) + u(k) \Delta_{(q,h)v(k)}$$

Thus the proof completes by taking  $\Delta_{(q,h)} w(k) = v(k)$  and  $\Delta_{(q,h)}^{-1} v(k) = w(k)$ .

**Corollary 2.4.** For  $k \in \mathbb{N}$ , the falling factorial for the first  $t$  natural number is given by

$$1^{(k)} + 2^{(k)} + 3^{(k)} + \dots + t^{(k)} = \frac{(t+1)^{(k+1)}}{(k+1)}. \quad (4)$$

**Property 2.5.** Some of the properties of  $(q, h)$  difference operator are given below:

- (i) If  $q = 1$ , then  $\Delta_{(1,h)}$  becomes  $h$ -difference operator.

- (ii) If  $h = 0$ , then (1) becomes  $q$ -difference operator.
- (iii) If  $q > 1$  and  $h > 0$ , then we say (1) as  $(q, h)$ -difference operator.
- (iv) The solution does not exist if we take  $q = 1$  and  $h = 0$  simultaneously.

### 3. ANTI-DIFFERENCE PRINCIPLE OF MIXED OPERATOR

Here, we developed several theorems for integer order ( $x$ -th order) using the  $(q, h)$  difference operator.

**Theorem 3.1.** Let  $u, v : \mathcal{M}_h^q \rightarrow R$ ,  $k \in R$ ,  $n \in N$ , and assuming the (iv) condition given in Property 2.5. Then the first order anti-difference principle of  $(q, h)$  operator is given by

$$\Delta_{(q,h)}^{-1} u(k) - \Delta_{(q,h)}^{-1} u\left(\left(k - h \sum_{j=0}^{n-1} q^j\right) / q^n\right) = \sum_{r=0}^{n-1} u\left(\left(k - h \sum_{s=0}^r q^s\right) / q^{r+1}\right). \quad (5)$$

**Proof:** Since  $\Delta_{(q,h)}^{-1} u(k) = v(k)$ , we have

$$u(k) = \Delta_{(q,h)} v(k). \quad (6)$$

From Definition 2.1, the equation (6) becomes

$$u(k) = v(kq + h) - v(k).$$

The above equation can be represented as

$$v(qk + h) = u(k) + v(k). \quad (7)$$

Replacing  $k$  by  $k/q$  in equation (7), we get  $v(q(k/q) + h) = u(k/q) + v(k/q)$  which implies

$$v(k + h) = u(k/q) + v(k/q). \quad (8)$$

Replacing  $k$  by  $k-h$  in (8), we get  $v(k-h+h) = u((k-h)/q) + v((k-h)/q)$  which implies

$$v(k) = u((k-h)/q) + v((k-h)/q). \quad (9)$$

Replacing  $k$  by  $(k-h)/q$  in equation (9), we arrive

$$v((k-h)/q) = u([(k-h)/q] - h)/q + v([(k-h)/q] - h)/q,$$

which gives  $v((k-h)/q) = u((k-h-qh)/q^2) + v((k-h-qh)/q^2)$ .

The aforementioned equation can be written as

$$v((k-h)/q) = u\left((k-h \sum_{r=0}^1 q^r)/q^2\right) + v\left((k-h \sum_{r=0}^1 q^r)/q^2\right). \quad (10)$$

Now, substituting the equation (10) in equation (9), we obtain

$$v(k) = u((k-h)/q) + u\left((k-h \sum_{r=0}^1 q^r)/q^2\right) + v\left((k-h \sum_{r=0}^1 q^r)/q^2\right). \quad (11)$$

Again, replacing  $k$  by  $(k-h-qh)/q^2$  in equation (9), we get

$$v\left(\frac{(k-h-qh)}{q^2}\right) = u\left(\frac{[(k-h-qh)/q^2]-h}{q}\right) + v\left(\frac{[(k-h-qh)/q^2]-h}{q}\right),$$

which is same as

$$v\left(\frac{(k-h \sum_{r=0}^1 q^r)}{q}\right) = u\left(\frac{(k-h \sum_{r=0}^2 q^r)}{q^3}\right) + v\left(\frac{(k-h \sum_{r=0}^2 q^r)}{q^3}\right). \quad (12)$$

Substituting the equation (12) in equation (11), we get

$$v(k) = u((k-h)/q) + u\left(\frac{(k-h \sum_{r=0}^1 q^r)}{q^2}\right) + u\left(\frac{(k-h \sum_{r=0}^2 q^r)}{q^3}\right) + v\left(\frac{(k-h \sum_{r=0}^2 q^r)}{q^3}\right). \quad (13)$$

Similarly, replacing  $k$  by  $(k-h \sum_{r=0}^2 q^r)/q^3$  in equation (9), we get

$$v\left(\frac{(k-h \sum_{r=0}^2 q^r)}{q^3}\right) = u\left(\frac{(k-h \sum_{r=0}^3 q^r)}{q^4}\right) + v\left(\frac{(k-h \sum_{r=0}^3 q^r)}{q^4}\right). \quad (14)$$

Substitute the equation (14) in the equation (13), we obtain

$$v(k) = u((k-h)/q) + u\left(\frac{(k-h \sum_{r=0}^1 q^r)}{q^2}\right) + u\left(\frac{(k-h \sum_{r=0}^2 q^r)}{q^3}\right) + u\left(\frac{(k-h \sum_{r=0}^3 q^r)}{q^4}\right) + v\left(\frac{(k-h \sum_{r=0}^3 q^r)}{q^4}\right). \quad (15)$$

Similarly, again replacing  $k$  by  $(k-h(q^3+q^2+q+1))/q^4$  in equation (9), and then substituting the equation (9) in equation (15), we arrive

$$v(k) = u((k-h)/q) + u\left(\frac{(k-h \sum_{r=0}^1 q^r)}{q^2}\right) + u\left(\frac{(k-h \sum_{r=0}^2 q^r)}{q^3}\right)$$

$$+u\left((k-h)\sum_{r=0}^3 q^r/q^4\right)+u\left((k-h)\sum_{r=0}^4 q^r/q^5\right)+v\left((k-h)\sum_{r=0}^4 q^r/q^5\right). \quad (16)$$

Proceeding the similar manner for  $n$  times, we obtain the general term as

$$\begin{aligned} v(k) &= u((k-h)/q)+u\left((k-h)\sum_{r=0}^1 q^r/q^2\right)+u\left((k-h)\sum_{r=0}^2 q^r/q^3\right)+u\left((k-h)\sum_{r=0}^3 q^r/q^4\right) \\ &+u\left((k-h)\sum_{r=0}^4 q^r/q^5\right)+\dots+u\left((k-h)\sum_{r=0}^{n-1} q^r/q^n\right)+v\left((k-h)\sum_{r=0}^{n-1} q^r/q^n\right). \end{aligned} \quad (17)$$

Since  $\Delta_{(q,h)}^{-1} u(k) = v(k)$ , then (17) becomes

$$\begin{aligned} \Delta_{(q,h)}^{-1} u(k) - \Delta_{(q,h)}^{-1} u\left((k-h)\sum_{r=0}^{n-1} q^r/q^n\right) &= u((k-h)/q)+u\left((k-h)\sum_{r=0}^1 q^r/q^2\right) \\ &+u\left((k-h)\sum_{r=0}^2 q^r/q^3\right)+u\left((k-h)\sum_{r=0}^3 q^r/q^4\right)+\dots+u\left((k-h)\sum_{r=0}^{n-1} q^r/q^n\right), \end{aligned}$$

which completes the proof.

#### 4. HIGHER ORDER MIXED FINITE DIFFERENCE EQUATIONS

Here, we developed several higher order theorems for integer order ( $x$ -th order) using the  $(q, h)$  difference operator.

**Theorem 4.1.** Let  $u, v : \mathcal{M}_h^q \rightarrow R$ ,  $x, n \in N$ ,  $k \in R$  and assuming the (iv) condition of Property 2.5. Then the higher order of  $(q, h)$  difference equation is given by

$$\begin{aligned} \Delta_{(q,h)}^{-x} u(k) - \sum_{d=0}^{x-1} (n^{(d)}/d!) \Delta_{(q,h)}^{-(x-d)} u\left((k-h)\sum_{j=0}^{n-1} q^j/q^n\right) \\ = \sum_{r=x-1}^{n-1} (r^{(x-1)}/(x-1)!) u\left((k-h)\sum_{s=0}^r q^s/q^{r+1}\right). \end{aligned} \quad (18)$$



**Proof:** Theorem 3.1 provides the proof for  $x = 1$ .

When we apply  $\bar{\Delta}_{(q,h)}^{-1}$  to both sides of the equation (5), we obtain

$$\bar{\Delta}_{(q,h)}^{-2} u(k) - \bar{\Delta}_{(q,h)}^{-2} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) = \bar{\Delta}_{(q,h)}^{-1} \left[ \sum_{r=0}^{n-1} u\left(\left(k-h \sum_{s=0}^r q^s\right)/q^{r+1}\right) \right]. \quad (19)$$

The right side of equation (19) becomes

$$\begin{aligned} \bar{\Delta}_{(q,h)}^{-1} \left[ \sum_{r=0}^{n-1} u\left(\left(k-h \sum_{s=0}^r q^s\right)/q^{r+1}\right) \right] &= \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{s=0}^0 q^s\right)/q\right) \\ &+ \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{s=0}^1 q^s\right)/q^2\right) + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{s=0}^2 q^s\right)/q^3\right) \\ &+ \dots + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{s=0}^{n-1} q^s\right)/q^n\right), \end{aligned}$$

which gives

$$\begin{aligned} \bar{\Delta}_{(q,h)}^{-1} \left[ \sum_{r=0}^{n-1} u\left(\left(k-h \sum_{s=0}^r q^s\right)/q^{r+1}\right) \right] &= \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h\right)/q\right) + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^1 q^r\right)/q^2\right) \\ &+ \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^2 q^r\right)/q^3\right) + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^3 q^r\right)/q^4\right) + \dots + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^{n-1} q^r\right)/q^n\right). \end{aligned} \quad (20)$$

Replacing  $k$  by  $(k-h)/q$ ,  $(k-h \sum_{r=0}^1 q^r)/q^2$ ,  $(k-h \sum_{r=0}^2 q^r)/q^2$ , ... in equation (17) and then substituting the equation (17) on right side of the equation (20), we obtain

$$\begin{aligned} \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h\right)/q\right) &= u\left(\left(k-h \sum_{r=0}^1 q^r\right)/q^2\right) + u\left(\left(k-h \sum_{r=0}^2 q^r\right)/q^3\right) \\ &+ u\left(\left(k-h \sum_{r=0}^3 q^r\right)/q^4\right) + \dots + u\left(\left(k-h \sum_{r=0}^{n-1} q^r\right)/q^n\right) + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^{n-1} q^r\right)/q^n\right). \\ &+ u\left(\left(k-h \sum_{r=0}^4 q^r\right)/q^5\right) + \dots + u\left(\left(k-h \sum_{r=0}^{n-1} q^r\right)/q^n\right) + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^{n-1} q^r\right)/q^n\right). \end{aligned}$$

$$\begin{aligned} \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^2 q^r\right)/q^3\right) &= u\left(\left(k-h \sum_{r=0}^3 q^r\right)/q^4\right) + u\left(\left(k-h \sum_{r=0}^4 q^r\right)/q^5\right) \\ &+ u\left(\left(k-h \sum_{r=0}^5 q^r\right)/q^6\right) + \dots + u\left(\left(k-h \sum_{r=0}^{n-1} q^r\right)/q^n\right) + \bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^{n-1} q^r\right)/q^n\right). \end{aligned}$$

Similarly, we can easily find the other terms such as  $\bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^3 q^r\right)/q^4\right)$ ,

$$\bar{\Delta}_{(q,h)}^{-1} u\left(\left(k-h \sum_{r=0}^4 q^r\right)/q^5\right), \dots \text{ and goes on. Substituting all the above terms}$$

in the right side of the equation (20), we get

$$\begin{aligned} \Delta_{(q,h)}^{-1} \left[ \sum_{r=0}^{n-1} u \left( (k-h \sum_{s=0}^r q^s) / q^{r+1} \right) \right] &= u \left( (k-h \sum_{r=0}^1 q^r) / q^2 \right) + 2u \left( (k-h \sum_{r=0}^2 q^r) / q^3 \right) \\ &+ 3u \left( (k-h \sum_{r=0}^3 q^r) / q^4 \right) + 4u \left( (k-h \sum_{r=0}^4 q^r) / q^5 \right) + \dots \\ &+ (n-1)u \left( (k-h \sum_{r=0}^{n-1} q^r) / q^n \right) + n \Delta_{(q,h)}^{-1} u \left( (k-h \sum_{r=0}^{n-1} q^r) / q^n \right). \end{aligned}$$

Now, inserting the above all equations in (19), we obtain

$$\begin{aligned} \Delta_{(q,h)}^{-2} u(k) - \Delta_{(q,h)}^{-2} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) - n \Delta_{(q,h)}^{-1} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) \\ = u \left( (k-h \sum_{j=0}^1 q^j) / q^2 \right) + 2u \left( (k-h \sum_{j=0}^2 q^j) / q^3 \right) \\ + \dots + (n-1)u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right), \end{aligned}$$

which is same as

$$\begin{aligned} \Delta_{(q,h)}^{-2} u(k) - \Delta_{(q,h)}^{-2} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) - n \Delta_{(q,h)}^{-1} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) \\ = \sum_{r=1}^{n-1} r u \left( (k-h \sum_{s=0}^r q^s) / q^{r+1} \right). \quad (21) \end{aligned}$$

Again, applying  $\Delta_{(q,h)}^{-1}$  on both sides of equation (21) and then inserting

the equation (17) in right side of equation (21), we arrive

$$\begin{aligned} \Delta_{(q,h)}^{-3} u(k) - \Delta_{(q,h)}^{-3} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) - n \Delta_{(q,h)}^{-2} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) \\ = \left( \sum_{p=1} u \left( (k-h \sum_{j=0}^2 q^j) / q^3 \right) \right) + \left( \sum_{p=1} p \right) u \left( (k-h \sum_{j=0}^3 q^j) / q^4 \right) \\ + \left( \sum_{p=1}^3 p \right) u \left( (k-h \sum_{j=0}^4 q^j) / q^5 \right) + \dots + \left( \sum_{p=1}^{n-2} p \right) u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) \\ + \left( \sum_{p=1}^{n-1} p \right) \Delta_{(q,h)}^{-1} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right). \end{aligned}$$

Putting  $k = 1$  in (4) and then substituting in the above equation, it yields

$$\begin{aligned} \Delta_{(q,h)}^{-3} u(k) - \Delta_{(q,h)}^{-3} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) - n \Delta_{(q,h)}^{-2} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) \\ - (n^{(2)}/2!) \Delta_{(q,h)}^{-1} u \left( (k-h \sum_{j=0}^{n-1} q^j) / q^n \right) = \sum_{r=2}^{n-1} (r^{(2)}/2!) u \left( (k-h \sum_{s=0}^r q^s) / q^{r+1} \right). \end{aligned}$$

Similarly, the fourth inverse will be

$$\begin{aligned} & \Delta_{(q,h)}^{-4} u(k) - \Delta_{(q,h)}^{-4} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) - n \Delta_{(q,h)}^{-3} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) \\ &= \sum_{p=2}^3 (p^{(2)}/2) u\left(\left(k-h \sum_{j=0}^3 q^j\right)/q^4\right) + \sum_{p=2}^3 (p^{(2)}/2) u\left(\left(k-h \sum_{j=0}^4 q^j\right)/q^5\right) \\ &+ \sum_{p=2}^4 (p^{(2)}/2) u\left(\left(k-h \sum_{j=0}^5 q^j\right)/q^6\right) + \dots + \sum_{p=2}^{n-2} (p^{(2)}/2) u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) \\ &+ \sum_{p=2}^{n-1} (p^{(2)}/2) \Delta_{(q,h)}^{-1} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) \end{aligned}$$

Proceeding like this upto  $m$  times, we get the general form as

$$\begin{aligned} & \Delta_{(q,h)}^{-x} u(k) - \Delta_{(q,h)}^{-x} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) - (n^{(1)}/1!) \Delta_{(q,h)}^{-(x-1)} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) \\ & - (n^{(2)}/2!) \Delta_{(q,h)}^{-(x-2)} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) - \dots - (n^{(x-1)}/(x-1)!) \Delta_{(q,h)}^{-1} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) \\ &= \sum_{r=x-1}^{n-1} (r^{(x-1)}/(x-1)!) u\left(\left(k-h \sum_{s=0}^r q^s\right)/q^{r+1}\right), \end{aligned}$$

which completes the proof.

**Corollary 4.2.** Let  $u, v : \mathcal{M}_h^q \rightarrow R$ ,  $h \neq 0 \in R$ ,  $q \in R - \{0, 1\}$ ,  $n, x \in N$  and  $k \in R$ . Then the  $m$ -th order of  $(q, h)$  difference equation is given by

$$\begin{aligned} & \Delta_{(q,h)}^{-x} u(k) - \sum_{d=n-x}^{n-1} n^{(r-n+x)}/(r-n+x)! \Delta_{(q,h)}^{-(n-r)} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) \\ &= \sum_{r=0}^{n-x} (x+r-1)^{(x-1)}/(x-1)! u\left(\left(k-h \sum_{s=0}^{x+r-1} q^s\right)/q^{x+r}\right). \end{aligned} \tag{22}$$

**Proof:** The proof completes by replacing  $\sum_{d=0}^{x-1} \frac{n^{(d)}}{d!} \Delta_{(q,h)}^{-(x-d)} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right)$  by

$$\begin{aligned} & \sum_{d=n-x}^{n-1} \frac{n^{(r-n+x)}}{(r-n+x)!} \Delta_{(q,h)}^{-(n-r)} u\left(\left(k-h \sum_{j=0}^{n-1} q^j\right)/q^n\right) \text{ and} \\ & \sum_{r=x-1}^{n-1} \frac{r^{(x-1)}}{(x-1)!} u\left(\left(k-h \sum_{s=0}^r q^s\right)/q^{r+1}\right) \text{ by } \sum_{r=x-1}^{n-1} \frac{r^{(x-1)}}{(x-1)!} u\left(\left(k-h \sum_{s=0}^r q^s\right)/q^{r+1}\right) \end{aligned}$$

in equation (18).

5. MIXED GEOMETRIC FACTORIAL FUNCTIONS AND ITS  
 DIFFERENCE EQUATIONS

In this section, we developed the higher order  $(q, h)$  difference operator and its inverse operator using the factorial coefficient functions.

**Corollary 5.1.** *Let  $u, v : \mathcal{M}_h^q \rightarrow R, s \in R, k \in N, q, h \in R - \{0, 1\}$  and if the series  $\sum_{r=k+1}^{\infty} u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right)$  is convergent, then*

$$\Delta_{(q,h)}^{-1} u(s) - \sum_{r=k+1}^{\infty} u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right) = \sum_{r=0}^k u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right). \quad (23)$$

**Proof:** Taking  $\lim_{n \rightarrow \infty}$  in equation (17) and assuming  $v(0) = 0 = u(0)$ , then

$$\begin{aligned} \Delta_{(q,h)}^{-1} u(k) &= u((k-h)/q) + u\left(\left(k-h \sum_{r=0}^1 q^r\right) / q^2\right) + u\left(\left(k-h \sum_{r=0}^2 q^r\right) / q^3\right) \\ &+ u\left(\left(k-h \sum_{r=0}^3 q^r\right) / q^4\right) + u\left(\left(k-h \sum_{r=0}^4 q^r\right) / q^5\right) + \dots \\ &+ u\left(\left(k-h \sum_{p=0}^r q^p\right) / q^{r+1}\right) + u\left(\left(k-h \sum_{p=0}^{r+1} q^p\right) / q^{r+2}\right) + \dots \end{aligned} \quad (24)$$

Replacing 'k' by 's' and 'r' by 'k' in (24), we obtain

$$\begin{aligned} \Delta_{(q,h)}^{-1} u(s) &= u((s-h)/q) + u\left(\left(s-h \sum_{r=0}^1 q^r\right) / q^2\right) + u\left(\left(s-h \sum_{r=0}^2 q^r\right) / q^3\right) \\ &+ \dots + u\left(\left(s-h \sum_{r=0}^k q^r\right) / q^{k+1}\right) + u\left(\left(s-h \sum_{r=0}^{k+1} q^r\right) / q^{k+2}\right) + \dots, \end{aligned}$$

which is same as

$$\Delta_{(q,h)}^{-1} u(s) = \sum_{r=0}^k u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right) + \sum_{r=k+1}^{\infty} u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right). \quad (25)$$

Now, the proof completes by shifting the infinite series term of (25) to the left side.

**Definition 5.2.** Let  $s, k \in R$ ,  $h \in R - \{0\}$ ,  $q \in R - \{0, 1\}$  and if  $\sum_{r=k+1}^{\infty} u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right)$  is convergent. Then the  $(q, h)$  geometric function is defined as

$$\sum_{r=k+1}^{\infty} u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right) = \frac{\left[u\left(\left(s - h \sum_{j=0}^{k+1} q^j\right) / q^{k+2}\right)\right]^2}{u\left(\left(s - h \sum_{j=0}^{k+1} q^j\right) / q^{k+2}\right) - u\left(\left(s - h \sum_{j=0}^{k+2} q^j\right) / q^{k+3}\right)} \quad (26)$$

The following Theorem 5.3 is the finite series formula for the  $(q, h)$  difference operator derived from infinite series.

**Theorem 5.3.** Consider the conditions given in Corollary 5.1. Then, the first order anti-difference principle of  $(q, h)$  difference operator is given by

$$\begin{aligned} \Delta_{(q,h)}^{-1} u(s) &= \frac{\left[u\left(\left(s - h \sum_{j=0}^{k+1} q^j\right) / q^{k+2}\right)\right]^2}{u\left(\left(s - h \sum_{j=0}^{k+1} q^j\right) / q^{k+2}\right) - u\left(\left(s - h \sum_{j=0}^{k+2} q^j\right) / q^{k+3}\right)} \\ &= \sum_{r=0}^k u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+1}\right). \end{aligned} \quad (27)$$

**Proof:** The proof completes by substituting the equation (26) in (23).

**Theorem 5.4.** Let  $u, v : \mathcal{M}_h^q \rightarrow R$ ,  $s \in R$ ,  $x, k \in N$  and assuming the (iv) condition given in Property 2.5. Then the higher order of  $(q, h)$  difference operator is given by  $\Delta_{(q,h)}^{-x} u(s) -$

$$\begin{aligned} & \frac{(x-1)! \left[ \left( (k+x)^{(x-1)} / (x-1)! \right) u\left(\left(s - h \sum_{j=0}^{k+1} q^j\right) / q^{k+x+1}\right) \right]^2}{(k+x)^{(x-1)} u\left(\left(s - h \sum_{j=0}^{k+1} q^j\right) / q^{k+x+1}\right) - (k+x+1)^{(x-1)} u\left(\left(s - h \sum_{j=0}^{k+2} q^j\right) / q^{k+x+2}\right)} \\ &= \sum_{r=0}^k \left( (r+x-1)^{(x-1)} / (x-1)! \right) u\left(\left(s - h \sum_{j=0}^r q^j\right) / q^{r+x}\right). \end{aligned} \quad (28)$$

**Proof:** Let

$$\begin{aligned} \Delta_{(q,h)}^{-x} u(k) &= \frac{(x-1)^{(x-1)}}{(x-1)!} u\left(\left(k-h \sum_{j=0}^{x-1} q^j\right) / q^x\right) + \frac{x^{(x-1)}}{(x-1)!} u\left(\left(k-h \sum_{j=0}^x q^j\right) / q^{x+1}\right) \\ &+ \dots + \frac{(x-(r-1))^{(x-1)}}{(x-1)!} u\left(\left(k-h \sum_{j=0}^{x-(r-1)} q^j\right) / q^{x+r}\right) \\ &+ \frac{(x-r)^{(x-1)}}{(x-1)!} u\left(\left(k-h \sum_{j=0}^{x-r} q^j\right) / q^{x+r+1}\right) + \dots \end{aligned}$$

Replacing 'k' by 's' and 'r' by 'k', the above equation becomes

$$\Delta_{(q,h)}^{-x} u(s) = \sum_{y=x-1}^{x+k-1} \frac{y^{(x-1)}}{(x-1)!} u\left(\left(s-h \sum_{j=0}^y q^j\right) / q^{y+1}\right) + \sum_{y=x+k}^{\infty} \frac{y^{(x-1)}}{(x-1)!} u\left(\left(k-h \sum_{j=0}^y q^j\right) / q^{y+1}\right).$$

Interchanging the terms  $\sum_{y=x-1}^{x+k-1} (y^{(x-1)} / (x-1)!) u\left(s-h \sum_{j=0}^y q^j\right)$  by

$$\sum_{r=0}^k ((x+r-1)^{(x-1)} / (x-1)!) u\left(s-h \sum_{j=0}^{x+r-1} q^j / q^{x+r}\right) \text{ and}$$

$$\sum_{y=x+k}^{\infty} (y^{(x-1)} / (x-1)!) u\left(\left(k-h \sum_{j=0}^y q^j\right) / q^{y+1}\right) \text{ by}$$

$\sum_{r=k+1}^{\infty} ((x+r-1)^{(x-1)} / (x-1)!) u\left(s-h \sum_{j=0}^{x+r-1} q^j / q^{x+r}\right)$ , and then using the equation (26) for x-th order, the above equation becomes

$$\sum_{y=k+1}^{\infty} (y^{(x-1)} / (x-1)!) u\left(\left(k-h \sum_{j=0}^y q^j\right) / q^{y+1}\right) =$$

$$\frac{(x-1)! \left[ \left( (k+x)^{(x-1)} / (x-1)! \right) u\left( \left( s-h \sum_{j=0}^{k+1} q^j \right) / q^{k+x+1} \right) \right]^2}{(k+x)^{(x-1)} u\left( \left( s-h \sum_{j=0}^{k+1} q^j \right) / q^{k+x+1} \right) - (k+x+1)^{(x-1)} u\left( \left( s-h \sum_{j=0}^{k+2} q^j \right) / q^{k+3} \right)},$$

which completes the proof.

## 6. MIXED GAMMA GEOMETRIC FACTORIAL FUNCTIONS AND ITS GENERALIZED DIFFERENCE EQUATIONS

In this section, we develop fractional order anti-difference principle from its integer order given in Definition 5.2, by which we derive fundamental theorems of quantum fractional calculus. For  $\nu > 0$ , we obtain

$$\begin{aligned} & \sum_{r=\infty}^{k+1} (\Gamma(r+\nu)/\Gamma(r+1))u\left((k-h\sum_{j=0}^r q^j)/q^r+\nu\right) \\ & \quad \mathcal{A}u\left((s-h\sum_{j=0}^{k+1} q^j)/q^k+\nu+1\right)^2 \\ & = \frac{\mathcal{A}u\left((s-h\sum_{j=0}^{k+1} q^j)/q^k+\nu+1\right)^2}{\mathcal{A}u\left((s-h\sum_{j=0}^{k+1} q^j)/q^k+\nu+1\right)-\mathcal{B}u\left((s-h\sum_{j=0}^{k+2} q^j)/q^k+\nu+2\right)}, \end{aligned} \tag{29}$$

where  $\mathcal{A} = (\Gamma(k+\nu+1)/\Gamma(\nu)\Gamma(k+2))$  and  $\mathcal{B} = (\Gamma(k+\nu+2)/\Gamma(\nu)\Gamma(k+3))$ .

**Theorem 6.1.** Let  $u, v : \mathcal{M}_h^q \rightarrow R, h \neq 0 \in R, q \in R - \{0, 1\}, k, \nu \in R$  and  $n \in N$ . Then the  $\nu$ -th order of  $(q, h)$  difference equation is given by

$$\begin{aligned} & \Delta_{(q,h)}^{-\nu} u(k) - \sum_{d=n-\nu}^{n-1} (\Gamma(n+1)/\Gamma(2n-d-\nu+1)\Gamma(d-n+\nu-1)) \Delta_{(q,h)}^{-(n-d)} u\left((k-h\sum_{j=0}^{n-1} q^j)/q^n\right) \\ & = (1/\Gamma(\nu)) \sum_{r=0}^{n-\nu} (\Gamma(\nu+r)/\Gamma(r+1))u\left((k-h\sum_{s=0}^{\nu+r-1} q^s)/q^{\nu+r}\right). \end{aligned} \tag{30}$$

**Proof:** When generalizing the integer order to real order ( $m > 0 \in R = \nu$ ) in equation (22), we obtain

$$\begin{aligned} & \Delta_{(q,h)}^{-\nu} u(k) - \sum_{d=n-\nu}^{n-1} \frac{n^{(r-n+\nu)}}{(r-n+\nu)!} \Delta_{(q,h)}^{-(n-r)} u\left((k-h\sum_{j=0}^{n-1} q^j)/q^n\right) \\ & = \sum_{r=0}^{n-\nu} \frac{(\nu+r-1)^{(\nu-1)}}{(\nu-1)!} u\left((k-h\sum_{s=0}^{\nu+r-1} q^s)/q^{\nu+r}\right). \end{aligned}$$

Here,  $n^{(r-n+\nu)} = (\Gamma(n+1)/\Gamma(2n-d-\nu+1))$  and  $(\nu+r-1)^{(\nu-1)} = (\Gamma(\nu+r)/\Gamma(r+1))$  in equation (22).

**Theorem 6.2.** Let  $u, v : \mathcal{M}_h^q \rightarrow R, h \in R - \{0\}, q \in R - \{0, 1\}, k \in N$  and  $s, \nu \in R$ . Then the  $\nu$ -th order (fractional or real order) of  $(q, h)$  difference equation is given by

$$\Delta_{(q,h)}^{-\nu} u(s) - \frac{\Gamma(\nu)[(\Gamma(k+\nu+1)/\Gamma(\nu)\Gamma(k+2))u\left((s-h\sum_{j=0}^{k+1} q^j)/q^{k+\nu+1}\right)]^2}{\frac{\Gamma(k+\nu+1)}{\Gamma(k+2)}u\left((s-h\sum_{j=0}^{k+1} q^j)/q^{k+\nu+1}\right) - \frac{\Gamma(k+\nu+2)}{\Gamma(k+3)}u\left((s-h\sum_{j=0}^{k+2} q^j)/q^{k+\nu+2}\right)}$$

$$= (1/\Gamma(\nu)) \sum_{r=0}^k (\Gamma(r + \nu)/\Gamma(r + 1)) u\left(\left(k - h \sum_{j=0}^r q^j\right) / q^r + \nu\right). \quad (31)$$

**Proof:** By generalizing the integer order ( $m$ -th order) of equations (26) and (28) to any real order ( $\nu$ -th order), the proof is complete. Here,  $(k + \nu)^{(\nu-1)} = (\Gamma(k + \nu + 1)/\Gamma(k + 2))$  and  $(k + \nu + 1)^{(\nu-1)} = (\Gamma(k + \nu + 2)/\Gamma(k + 3))$ .

## 7. CONCLUSION

In this paper, we have introduced Factorial coefficient and Geometric factorial functions, and then developed several fundamental theorems in discrete fractional calculus using the anti-difference principle of  $(q, h)$ -delta operator with shift value.

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## சாதனை புரிய வாசி புத்தகம்

வி. ஜெய கலா

*நூலகர் திருச்சிலுவை கல்லூரி(தன்னாட்சி), நாகர்கோவில் - 629004.*

### முன்னுரை

- ❖ குவிந்திருக்கும் களிமண் தானாக குடமாக மாறாது  
குயவன் அங்கு வரவேண்டும்
- ❖ மல்லிகை மலர்கள் தானாக மலர் மாலையாகாது  
சரம் தொடுப்பவன் அங்கு வர வேண்டும்
- ❖ வீணையானது தானாக தான் விரும்பிய இசையை மீட்டாது  
இசை வித்துவான் அங்கு வர வேண்டும்
- ❖ மனிதன் தன் அறிவை தானாக வளர்த்துக் கொள்ள இயலாது  
புத்தகம் அங்கு வர வேண்டும்.

கல்வியென்னும் சக்தி தான் மனித அறிவை மாண்புடனே கடல் என விரியச் செய்து வெளிப்படுத்தி மனித குலத்தினை வாழச் செய்கிறது. நாம் பல ஆண்டு அனுபவத்தில் பெறுகின்ற அறிவை நல்ல சில புத்தகங்களை படிப்பதால் பெற்றிட முடியும். ஆம் நல்ல பல புத்தகங்களை படிப்பதால் சாதனைகள் பல புரிய முடியும். சாதித்தவர்கள் அனைவருமே புத்தகம் வாசிப்பவர்களாக தான் இருந்திருக்கிறார்கள். அதனால் ஒரு அறிஞர் கூறினார் சாதனையாளர்கள் பிறப்பதில்லை. உருவாக்கப்படுகிறார்கள்.

### புத்தகம் ஓர் காலக் கண்ணாடி

“ஆதி மனிதனின் வாழ்க்கையை காட்டி இறந்த காலத்தையும்  
நடைமுறை வாழ்வினைப் பகிர்ந்து நிகழ் காலத்தையும்  
சீரிய திட்டமிடலில் உற்ற துணையாய் எதிர்காலத்தையும்  
நமக்கு காட்டுவதில் காலக் கண்ணாடியாய் திகழ்வது புத்தகமே”

ஆம், புத்தகமானது ஓர் காலக்கண்ணாடியாக மூன்று காலங்களையும் நன்கு அறிய உதவுகிறது.

### வாசித்து சாதித்தவர்கள்

வாழ்வின் மிக உன்னத நிலையை அடைய வேண்டுமென்றால் பிரகாசிக்கும் அறிவும், தன்னம்பிக்கையும் நிறைந்தவனாக மாற வேண்டுமென்றால், புத்தகத்தை தேடு என்றார் புகழ்பெற்ற அறிஞர் ஒருவர்.

“கை நிறைய புத்தகத்தோடு என்னை யாரும்ற்ற தீவில் விட்டுவிடுங்கள். சில நிமிடத்தில் அந்தத் தீவு எனக்கு சொந்தமாகி விடும். அங்கேயே மகிழ்வோடும் நிறைவோடும் செத்துப்போவேன்” என்றார் மாஜினி.

### **வாசிப்பால் சாதித்த அறிஞர் அண்ணா**

அண்ணாமலை பல்கலைக்கழகத்தில் முன்னதாக தலைப்பைக் கொடுக்காமல் கூட்டம் தொடங்கிய பின் அண்ணா ஆற்றங்கரையினிலே என்ற தலைப்பில் மூன்று மணி நேரம் பேசுவார் என்று அறிவித்தனர். அண்ணா பேசினார், அறிஞர் பட்டத்தை பெற்றார். இதற்கு காரணம் தன் இளமைப் பருவத்தில் கன்னிமாறா நூலகத்தில் கட்டுச் சோற்றுடன் வாசித்ததால் தான் மூன்று மணி நேரம் அண்ணாவால் தொடர்ந்து தலைப்பு முன்னறிவிக்காமல் உடனே பேசமுடிந்தது.

அறிஞர் எந்த அளவிற்கு புத்தகப் பிரியர் என்றால் ஒரு முறை தனது தொண்டை புற்று நோய்க்காக அமெரிக்காவுக்குச் சென்றிருந்தார். அறுவை சிகிச்சை செய்யும் மருத்துவர் மில்லர் அண்ணாவை பரிசோதித்துவிட்டு மிஸ்டர் அண்ணா, நாளை அறுவைச் சிகிச்சையை வைத்துக் கொள்ளலாமா? என்று கேட்டார். அப்போது அண்ணா இரண்டு நாட்கள் தாண்டி வைத்தால் நன்றாக இருக்கும்” என்றார். உடனே மருத்துவர் ‘தமிழ் நாட்டின் முதல்வராக இருக்கின்ற ஏராளமாக வேலைகள் இருக்கிறதோ’ என்றார். அதற்கு அறிஞர் அண்ணா வேலை எல்லாம் இல்லை. இங்கு வந்த போது ஓர் அருமையான நூலான மாஸ்டர் கிறிஸ்டியன் நூல் ஒன்று எனக்குக் கிடைத்தது. அதை படித்துக் கொண்டிருக்கிறேன். இன்னும் இரண்டு நாட்கள் கிடைத்ததால் அதை படித்து முடித்துவிட்டு நிம்மதியாக அறுவை சிகிச்சைக்கு தயாராவேன் என்றார். அண்ணாவின் புத்தகம் படிக்கும் ஆவலைக் கண்ட மருத்துவர் மில்லர், அவர் விருப்பப்படி இரண்டு நாட்களுக்கு பிறகு அறுவைச் சிகிச்சையைச் செய்தார்.

### **தாமஸ் ஆல்வா எடிசன் வாழ்வில் புத்தகம்**

மனிதன் கடமைப்பட்டிருப்பது மூளைக்கு அல்ல. முயற்சிக்கே. கடவுள் வரங்களை விற்பனை செய்கிறார். முயற்சியே அதன் விலை. என்று கூறியவர் தாமஸ் ஆல்வா எடிசன்.

இப்படி கூறிய தாமஸ் ஆல்வா எடிசனின் இளமைக்காலம் எந்த நிலையில் இருந்தது என்றால் பிறக்கும் போதே கோணலான தலையுடன் பிறந்திருக்கிறார். இவன் அப்பாவிடமிருந்து இவன் நன்றாக படிப்பானா என்ற சந்தேகம். பள்ளிக்குச் சென்றால் ஆசிரியர் இவனுடைய தலை அமைப்பு மோசமாக இருக்கிறது இவன் படித்தாலும் இவன் மூளையில் ஏறாது என எழுதி தாமஸ் ஆல்வா எடிசனிடமே கொடுத்தனுப்பி இருந்தார். அதனைப் பார்த்த எடிசனின் தாயே தன்னுடைய மகனுக்கு ஆசிரியராக மாறிக் கற்றுக் கொடுக்க ஆரம்பித்து விட்டார். என் மகனை எப்படியும் பெரியவனாக்குவேன் என்று ஆசிரியருக்கு சவால் விட்டதுடன் அவனுக்கு சிரமப்பட்டு பாடங்களை கற்றுக் கொடுத்தார். அன்னையின் விடா முயற்சியாலும் தன்னுடைய உழைப்பாலும் எடிசன் மாமேதையானார்.

தாமஸ் ஆல்வா எடிசனுடைய தாய் எடிசன் ஒரு புத்தகம் வாசித்தால் உடனே ஒரு புத்தகம் பரிசாக கொடுத்துவிடுவாராம். 1093 கண்டுபிடிப்புகளை எடிசன் உலகிற்கு தருவதற்கு காரணம் அவருடைய புத்தக வாசிப்பு தான்.

### வாசிப்பால் படிப்போடு பண்பும் வளரும்

ஆபிரகாம் லிங்கன் புத்தகம் வாசிக்கும் ஆர்வம் கொண்டவர், பெரும்பாலான நேரங்களில் அவர் புத்தகமும் கையுமாகவே இருப்பார். ஒருமுறை அவரது நண்பர் ஒருவர் புத்தகம் படிப்பதால் பணம் கொட்டப் போவதில்லை. பின்பு எதற்காக எப்போதும் படித்துக் கொண்டே இருக்கிறீர்கள்? என்று கேட்டார். அதற்கு லிங்கன் நான் பணம் சேர்ப்பதற்காக படிக்கவில்லை. பணம் வரும் போது எப்படி பண்புடன் வாழ வேண்டும் என்பதை தெரிந்து கொள்வதற்காகவே படித்துக் கொண்டிருக்கிறேன் என்றார்

### வாசிப்பால் சாதித்தவர்கள்

- ❖ மோகன்தாஸ் காந்தியாக இருந்தவரை மகாத்மா காந்தியடிகளாக மாற்றியது. - ஜான்ரஸ்கின் எழுதிய “கடையனுக்கும் கடைத்தேற்றம்” என்ற புத்தகம்
- ❖ வெங்கடராமனாக இருந்தவரை மகான் ஸ்ரீரமணமகரிஷியாக மாற்றியது. சேக்கிழாரின் “பெரிய புராணம்” என்ற புத்தகம்.
- ❖ 33 ஆண்டுகள் லண்டன் நூலகத்தில் கிடந்து கார்ல்மார்க்ஸ் எழுதிய மூலதனம் என்ற புத்தகம் உலக சமுதாயத்தை உழைக்கும் வர்க்கத்தை உயர்த்தி பிடித்தது.
- ❖ டால்ஸ்டாயின் “போரும் அமைதியும்” “அன்னகரீனா” உலக இலக்கியத்தில் உயர்ந்த இடத்தைப் பெற்றவை. இப்படி மன மாற்றத்திற்கும் சமூக மாற்றத்திற்கும் புத்தகங்களே சாட்சியங்களாக இன்றும் திகழ்ந்து கொண்டிருக்கின்றன.

### புத்தகமும் சாதனையாளர்களும்

மிகப்பெரிய சாதனையாளர்கள் எல்லாம் மிகச் சிறந்த புத்தக காதலர்கள் தான்.

- ✓ எனது இக்கட்டான சூழ்நிலைகளில் முடிவெடுப்பதற்கு உதவியவை புத்தகங்கள் என்றார் நேரு. இரவு இரண்டு மணியானாலும் ஒரு புத்தகத்தின் பத்து பக்கங்களையேனும் படித்த பின்னரே உறங்க செல்வார் நேரு பெருமான்.
- ✓ மோகன் தாஸ் என்கிற சாதாரண மனிதனை உண்மைப் பேச வைத்து மகாத்மாவாக்கியது அரிச்சந்திரா என்ற நாடக நூல் தான்.
- ✓ படிக்காத மேதை காமராசர் பள்ளியில் தான் குறைவாக படித்தாரேயொழிய ஏராளமான புத்தகங்களை கற்றவர் என்பதும் ஆங்கில நூல்களைக் கூட அவர் படித்து அறிவாற்றலோடு திகழ்ந்தார் என்பதும் வரலாற்று உண்மை.
- ✓ முன்னாள் முதல்வர் கலைஞர் கருணாநிதி அவர்கள் தினமும் ஒரு புத்தகத்தையேனும் படிக்கிற பழக்கத்தை கொண்டிருக்கிறார். அதனால் தான் பத்தாம் வகுப்பே படித்த அவரால் ஐந்து முறை தமிழகத்தை ஆட்சி செய்ய முடிந்தது.
- ✓ மாவீரனின் நெப்போலியன் தனது வெற்றிக்குக் காரணம் “ஹோமரின் காவியம்” என்கிறான். எத்தனையோ நாடுகளில் நடந்த புரட்சிகளுக்கு காரணம் புத்தகங்கள் தான்.
- ✓ கார்ல்மார்க்சின் “மூலதனம்” புத்தகம் ஒரே இரவில் பொருளாதார புரட்சியை உருவாக்கி உலகத்தையே உருட்டி போட்ட அதிசயத்தை யாரால் மறக்க முடியும்.

### நெல்சன் மண்டேலா வாழ்வில் புத்தகம்

இருபத்தேழு ஆண்டுகள் சிறையிலிருந்து மீண்ட கறுப்பின மக்களின் இரட்சகன் மண்டேலாவிடம் நிருபர்கள் கேட்டார்கள். “இருபத்தேழு ஆண்டுகளை ஒற்றையறையில் எப்படி கழித்தீர்கள்?” மண்டேலா பதில் சொன்னார். தனியாகவா இருந்தேன்! என்னுடைய புத்தக நண்பர்களுடன் அல்லவா இருந்தேன்!. மகாத்மாவின் சத்திய சோதனை படித்தல்லவா வரம் பெற்றும் உரம் பெற்றும் வந்திருக்கிறேன் என்றார்.

### ஜப்பானின் மொழியியல் மாணவியின் புத்தகம் பற்றிய கருத்து

கன்னியாகுமரியில் வள்ளுவருக்கு 133 அடியில் கலைஞர் சிலை திறந்த போது ஜப்பானிலிருந்து ஒரு மொழியியல் மாணவி வந்திருந்தார். அவர் பேசும் போது ‘ஜப்பான் நாட்டின் ஒரு கிராமத்தில் பிறந்த எனக்கு இந்தியாவின் தென் முனையில், பேரறிஞர்கள் இருக்கும் அவையில் உரையாற்றும் பாக்கியத்தை அளித்தது யார் தெரியுமா? உலக பொதுமறை தந்த திருவள்ளுவர் தான். அவர் எழுதிய திருக்குறளை நான் படிக்காமலிருந்தால் அப்பெருஞ்சிறப்பு எனக்கு கிடைத்திருக்காது’ என்றாள்.

### அப்துல்கலாம் வாழ்வில் புத்தகம்

இளைஞர்களே கனவு காணுங்கள் எனக்கூறி இளைஞர்களை மலர்ச்சி அடைய செய்தவர் நமது முன்னாள் ஜனாதிபதி அப்துல் காலம். அவர் தன்னுடைய வாழ்வில் ஷேக்ஸ்பியர் எழுதிய வரிகளை தாரக மந்திரமாகக் கொண்டார். அந்த வார்த்தைகள் இவைகள் தான்

பிறரை விட அதிகமாக தெரிந்து கொள்

பிறரை விட அதிகமாக உழை

பிறரை விட அதிகமாக எதிர்பார்

இந்த வார்த்தைகளை தாரக மந்திரமாகக் கொண்டு தான் தனது குடும்ப சூழ்நிலை கடினமாக இருந்த போதிலும் பிறரை விட அதிகமாக தெரிந்துக் கொண்டு. அதிகமாக உழைத்து, அதிகமாக எதிர்பார்த்து வெற்றிக்கனியாம் இந்திய நாட்டின் முதல் குடிமகன் என்ற பெரும் பகுதியை தட்டிச் சென்றார்.

### வாசித்து சிகரம் தொட்ட சாதனையாளர்கள்

- ரா. சு. நல்ல பெருமாள் விடுதலைப் போரை பின்னணியாகக் கொண்டு எழுதிய ‘கல்லுக்குள் ஈரம்’ என்ற நாவலை பல முறை வாசித்த பிறகு தான் சிறந்த போராளியாகி கேப்டன் பிரபாகரன் ஆனான்.
- வெள்ளையரின் அடக்கு முறையால் தூக்கி கொல்லப்பட்ட பக்தசிங் தனது கடைசி விருப்பமாக “போரும் விடுதலையும்” என்ற நூலை படித்து முடித்தப் பிறகுதான் தனது தூக்கு கயிறறை முத்தமிட்டான்.
- நமது சட்ட மாமேதை டாக்டர் அம்பேத்கர் லண்டன் நூலகத்திலுள்ள நூல்களை காரல்மார்க்சுக்கு அடுத்தபடியாக அகிகம் நூல்களை படித்தவராகும். வாசிப்பை தனது

முச்சாக கொண்ட அண்ணல் அம்பேத்கர் இந்திய அரசியல் சாசனத்தை வடிவமைத்த குழுவின் தலைவராக திகழ்ந்தவராம்.

- இங்கிலாந்து நாட்டின் மிகப்பெரிய நூலகம் லண்டன் மாநகரம் நூலகமாகும். இதில் நீண்ட நேரம் அதிகமான புத்தகங்களை படித்தவர் காரல்மார்க்ஸ் ஆகும். 23 ஆண்டுகளில் 43.000 நூல்களை படித்த பெருமைக்கு உரியவர். வாசிப்பின் வல்லமையால் உலகையாளும் வல்லமையுடைய “டாஸ்காப்பிடல்” என்ற மூலதனம் நூலைப் படைத்தார். லண்டன் நூலகத்தில் இன்றும் காரல்மார்க்ஸ், அம்பேத்கர் ஆகியோரது படம் வைக்கப்பட்டுள்ளது சிறப்பாகும்.

### முடிவுரை

தினசரி ஒரு மணி நேரம் படித்தால் ஒரு வாரத்தில் ஒரு புத்தகத்தை படித்து முடித்து விடலாம். ஒரு வருடத்தில் ஐம்பத்திரண்டு புத்தகங்களை முடித்துவிடலாம். அதிலிருந்து பெறுகின்ற அறிவு எந்த துறையில் நீங்கள் பணியாற்றினாலும் உங்களை உயர்வடைய செய்வது உறுதி. நல்ல உணவு உடலை பேணிப்பது போல நல்ல புத்தகங்களைப் படிப்பது மனதை பேணிக்கிறது. என்று கூறுகிறார். வெற்றி பெற சிந்தியுங்கள் என்ற புத்தகத்தை எழுதிய வால்டர் டோயல் ஸ்டேபிள்.

**நாமும் வாழ்க்கைக்கு மாற்றம் தரும் நல்ல**

**புத்தகங்களை படிப்போம்! பாதுகாப்போம்!**

**சாதனைகள் புரிவோம்**

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**Voices of Valour: The Unseen Battles of Women in Kristin Hannah's  
*The Nightingale***

**C. Nesavathy<sup>1</sup> and Dr. Karthika Premkumar<sup>2\*</sup>**

<sup>1</sup>Research Scholar, Reg No. 18223154012005, Department of English, S.T. Hindu College, Nagercoil - 629002.

Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli - 627012

<sup>2</sup>Assistant Professor, Department of English, S.T. Hindu College, Nagercoil - 629002.

Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli - 627012

Email: [nesavathyroydhas@gmail.com](mailto:nesavathyroydhas@gmail.com) , [karthikapremkumar@ymail.com](mailto:karthikapremkumar@ymail.com)

**Abstract**

New Historical approach is a critical concept, when applied to the study of historical fiction, it unfolds significant outlooks of understanding. Moreover, frightening events of history that leads to loss of lives and shattering of world come forcefully on the readers. Readers all over the world become aware of the evils of such catastrophes and they may contribute towards preventing such disasters in the future. Kristin Hannah has presented the lives and experiences of women caught in the web of history. This paper highlights how World War II turns out to be a shadow war for women. It traces the sufferings, hardships and mental warfare undergone by women during war. It focuses on the physical, sexual, emotional, spiritual and social sufferings of women during war.

**Keywords:** Marginalization, Psychological trauma, Concentration camps, War-time violence, Women's suffering

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Women were always marginalized, they were not given first position in important circumstances, yet they were the first to undergo agony in all horrible situations in our society. War constantly brought double burden on women. Women have to face several challenges to safeguard themselves and their family during war. They suffer psychologically, physically and socially. They have to face unkind punishment worse than imprisonment and execution. In *The Nightingale*, When the Nazis saw the role women were playing in the war; they had imprisoned more than two hundred French women in Romainville. Women were physically tortured at the concentration camps. Their homeland became a hostile land. German soldiers sacked the home of French people and ill-treated the women mercilessly.

Women confronted numerous physical agonies during World War II. In *The Nightingale*, at the beginning, Isabelle is unaware of the dangers of being a spy by working against the Nazis, “And if you get caught, Anouk said, it will be as a woman. You understand? They have special...unpleasantries for us. Isabelle swallowed hard. She had thought-briefly –of

imprisonment and execution. This was something she had never even considered” (Hannah 171). Everyday Isabelle has to protect herself from the gazing eyes of the German Soldiers. She struggles hard in the cold weather to deliver the papers against Nazis.

In *The Nightingale*, it is the cold that freezes the life of young Isabelle. Isabelle helped nearly 117 airmen to cross the mountains near Saint-Jean-de-Luz to reach Spain. The jagged peaks of the mountain rose impossibly high into the clouds and were usually snow-covered or ringed in fog. She crossed these hazardous mountains for twenty seven times. She experienced the most horrible suffering during this dangerous journey; they starved, exhausted and were frozen to death, “The first pangs of hunger twister her empty stomach. Isabelle’s legs were on fire, aching painfully, and even with her espadrilles, blisters formed” (Hannah 209). “Her mind was muddling again, her thoughts blurring. She felt tears sting her eyes and freeze instantly, binding her lashes together”(212).

During the times of War, women are treated in a terrible way by the dominant power. Various incidents stand as a proof for the atrocious behavior of the men. Men show their fear, anger and hatred in the form of violence towards the helpless women. They were treated as nothing but a sex object. Women were raped in large numbers during all the major wars of the world. When Germany invaded France, French women felt insecure even to walk down the streets. In *The Nightingale*, Vianne is threatened and raped by the German officer, Von Richter. He violated her body and her soul, “He grabbed her by the hair and yanked hard, pulling her into the bedroom... Vianne hurt all over. She knew that there would be hand prints on her upper arms and an ugly bruise on her left breast” (Hannah 369). Vianne is forced to undergo this torture in order to protect her daughter Sophie and to prevent Daniel from getting deported. When the Germans started losing the war, “Von Richter seemed hell-bent on making Vianne pay for it” (Hannah 385). Even Wars of the modern world exposes the harsh truth of women being used by men to express their temper.

The torture of Isabelle and her subsequent removal to a concentration camp is yet another example for the brutal action of the Nazis. When Isabelle was helping the airmen to cross the Pyrenees Mountain, she gets arrested by several SS agents. She is beaten and investigated violently. Her wrists and ankles were tied to a wooden chair. She is hit with an iron ruler across her cheek. Rittmeister Schmidt, Kommandant of the Gestapo backhanded Isabelle with the



ruler, and the chair toppled sideways and crashed to the floor. Her head cracked on the stone, at the same time he kicked her in the stomach with the toe of his boot. The physical pain and brutal treatment of Isabelle is explained as:

Everything hurt. Her head, her face, her body. Her nostril hairs were frozen. She shivered hard, uncontrollably. She could feel her breath now, pluming in front of her face, turning to frost on her lips. Her eyelashes were frozen. She was naked, tied to a chair inside a...

Frozen. Dark. Humming. Small...

A refrigerator.

She started to cry and her tears froze, turning to icicles on her cheeks. Blunt, dirty fingers forced her mouth open; brandy splashed into her open mouth, gagging her. The man behind her kicked her in her spine, hard, and she stilled. (Hannah 362)

Isabelle along with the other women was put into a train, the heat and stench in the carriage was unbearable. Women were being herded like cattle into the train. They were all exhausted, hungry and thirsty. When they reached the camp, they were forced to form ragged lines and march across uneven ground through an open gate that was surrounded by barbed wire. Inside the gates,

Isabelle saw hundreds- thousands- of women who looked like ghosts moving through a surreal landscape of gray, their bodies emaciated, their eyes sunken and dead looking in gray faces, their hair shorn. They wore baggy, dirty striped dresses; some were barefooted. Only women and children. A corpse of a woman lay in the mud in front of them. Hundreds of women had been killed or gassed or beaten in the last month. (Hannah 381)

The concentration camp is the place where the extreme cruel activity of the German soldiers is implemented. Jewish people were gassed to death at the concentration camps. Isabelle grew sick and tired; she had been beaten so badly. During the nine months at the camp, she encountered disease, forced labour and physical torture. The sufferings she endured at the concentration camps leads to her death.

Terror and trauma emerge from psychological experiences as much as from external ones. Women's mental strength is put to test during horrific circumstances; they experience emotional chaos and suffer from depression. Madness often comes as a result of experiencing violence. In *The Nightingale*, when the German army conquered Carriveau, Isabelle could not

tolerate the destruction done by the German Soldiers. She looked like a lunatic who is trying to do something crazy or stupid.

Residing away from the family is one hard punishment during war. Women keep on waiting for their husbands who were in the war front. When people were dislocated from their loved ones, they feel lonely and dejected. When soldiers were separated from their family and put to fight in another country, they long for love, this often leads them to live in a miserable state. There are certain German soldiers who were forced to leave their family and fight in France. This is evident when Captain Beck expresses his pathetic condition of staying away from his wife and children. Parents were detached from their children to put into concentration camps. Women were afraid of losing their children, “a woman holding a baby tried to run. A gendarme shot her in the back. She pitched to the ground, dead; the baby rolled to the boots of the gendarme holding a smoking gun” (Hannah 267). Being a Jew, Vianne’s best friend Rachel was deported by the Nazis. Rachel whose hand is still smeared with her daughter’s blood is forced to give her only son under the care of Vianne.

Death is an important factor which damages a person’s mind internally. The loss of the loved ones will affect a person mentally. There is no time to grieve for the dead during war. There is no time to say a prayer or whisper a goodbye. Mothers witness their innocent children dying in front of them. To prevent Rachel from getting deported to the Camp, Vianne asked her to leave Carriveau. When Rachel and her children tried to cross the checkpoint, “The guard turned his machine gun on the crowd and opened fire. Sarah dropped to her knees in the grass. The girl’s chest was riddled with bullet holes. Blood bubbled up, spilled over, oozing. Rachel knelt beside Sarah and saw the terrible devastation of Sarah’s chest” (Hannah 258). The grief ripped her apart and left her broken forever. To live after a terrible loss is one of the hardest tasks of the victims. Missing someone is equally a great sorrow as death. Vianne used to tie scrap of fabric on the branch of the apple trees as a sign of anguish. She has tied fabrics for her husband Antoine, her friend Rachel, Daniel and Sarah. When Vianne’s father leaves her to save Isabelle “She grabbed for him. A piece of his cuff ripped away in her grasp. A strip of fabric like the others tied to her tree branches. Remembrances for lost and missing loved ones” (Hannah 368). The tree in the garden depicts the sadness of Vianne.

Women also suffered emotionally. Their peaceful mind is ruined by the wild realities of war. In *The Nightingale*, the nightmare of Vianne reveals her fear and guilt. Nightmares bring out the dreadful things experienced by humans. Vianne's nightmare plagued her for six days, in her nightmare, "she was in a chair, being interrogated. *The boy, Daniel. He's a Jew. Give him to me*, Von Richter said, shoving his gun in her face...and he turned into Beck, who was holding the photograph of his wife and shaking his head, but the side of his face was missing" (Hannah 314). They make her consistently feel exhausted and worried.

Letters connect the distance between loved ones. It is a reminder from the person who is far away. At times, it also brings sufferings as it brings happiness. During war, letters insist the reality of not being together with the family and friends. Letters contain all the untold sorrows, violence and longing for love. In *The Nightingale*, Antoine's letter indirectly states the sorrows within him. The sufferings of Antoine influence the mental health of Vianne. The crumbled letter resembles the beaten heart of Vianne and Antoine. At the beginning of the novel, the narrator receives a letter from Paris. "Something about the Croix de Guerre. So it's about World War Two? It is to a passeurs' reunion in Paris" (Hannah 146). This invitation for the War heroes makes the old narrator to remember the destitutions she has faced during Germany's invasion in France.

In *The Nightingale*, People suffered due to lack of heat, food and money. During the invasion, the refugees had no place to stay and nothing to eat. People became dull and exhausted by heat, dust and thirst. Life was disrupted when husbands and fathers were forced to enlist while the Germans took over their towns and villages, billeting themselves in people's homes, gorging on food, and forcing the starved locals to wait in endless lines for rations. There is chaos as the people waited to get whatever rations they can. The supplies become exceedingly scarce with the Germans taking the best of everything for themselves. "All over town are signs warning us not to eat rats and these signs are necessary. People are raising guinea pigs for food" (Hannah 156). Vianne sold all her family jewelry to buy food. Vianne is forced to take in a German captain to provide food for her young child. Children became thin due to poor nutrition. At the house of Vianne, they start to burn all the tool boxes and old furniture to keep away the cold.

War greatly influences the innocence of children. In *The Nightingale*, children witness their father and elder brothers leaving home to fight in the war. Children's exposure to violence ignites hatred and wrath in their minds. Gilles, the butcher's son says, "I got a knife. I'll kill any dirty Boches who show up in Carriveau" (Hannah 48). Children in war time are forced to grow up quickly. When Vianne tries to explain that Sarah has died, Sophie immediately understands the reason behind it and replies, "She's Jewish" (264). "Vianne hated what she saw in her daughter's eyes right now. There was nothing young in her gaze; no innocence, no hope. Not even grief. Just anger" (264). Sarah and Sophie had been ordinary children who laughed and played and defied their mothers for fun. After the invasion they, "moved forward cautiously, as if bombs could be buried beneath their feet" (233).

In *The Nightingale*, the Germans imposed harsh rules on the Jews. They were immediately arrested for not following the orders. Jews were mistreated, fired from their jobs, cut off from food supplies and forced to wear the yellow cloth cut in the shape of star that will mark them for the death camps. All the foreign-born Jews were deported to the camps in Germany. Thousands of French Jews were held at internment camps.

While men endure great hardships during war, it affects everyone. The children, the helpless, the soldiers and the old people were subject to the brutality of war. History often fails to expose the numerous sufferings confronted by women. Women faced terrible challenges and struggles during war time. Both their physical and mental health is ruined. They were affected directly and indirectly by the elements of war. Hannah brilliantly uncovers the pathetic journey of women in war.

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**Maternal Instinct vs. Ethical Dilemmas:  
The Complexities of Parenting in Jodi Picoult's *My Sister's Keeper***

**B. Angelin Majila<sup>1</sup> and M.F. Anne Feril<sup>2\*</sup>**

<sup>1</sup>*Reg. No: 23123044012012, Research Scholar, Department of English,  
Holy Cross College (Autonomous), Nagercoil - 629004.*

*Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli – 627012.*

*Email: [angelveronica3675@gmail.com](mailto:angelveronica3675@gmail.com)*

<sup>2</sup>*Assistant Professor, Department of English, Holy Cross College (Autonomous), Nagercoil - 629004.*

*Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli – 627012.*

*Email: [ferilanne@gmail.com](mailto:ferilanne@gmail.com)*

**Abstract**

This paper provides the power struggles and parental sacrifice exemplified in Jodi Picoult's novel *My Sister's Keeper*. It also attempts to expose the familial bond that the individuals in the novel possess each other wholeheartedly. Jodi Picoult is skillful in delivering the concept and themes on familial love, motherhood and maternal resistance. In between the intricate concepts, she delves into the intrinsic ideas such as love, race relations, LGBT rights, family and sexual identity. The plot delves into the complex relationships among the Fitzgerald family members, focusing on the tension, love and conflicts that shape their interactions. The protagonist Anna Fitzgerald's mother Sara's relentless pursuit of medical interventions for Kate, including conceiving Anna as a genetically compatible donor, illustrates the complexity of maternal love and the lengths a mother might go to protect her child. The paper discusses the notion of a singular approach to motherly love by presenting other characters like Anna and Campbell, who question traditional views and offer alternative perspectives. It also explores how each character's perspectives and motivations influence the family dynamic, particularly revolving around Anna's role as genetically engineered child conceived to save her sister's life.

**Keywords:** Maternal Resistance, Gender, Family Dynamics, Motherhood, Bonding, Dilemma, Healing.

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Literature refers to the creative and imaginative writing which is designed to engage readers emotionally and intellectually through the major literary genres such as novels, drama and poetry and other sub genres like fable, parable and short stories. It is a reflection of social, political, economic and cultural realities. It is a part and parcel of man's self-realization and a symbol of man's success and failure. It explains human nature, caliber and their destination.

American literature refers to the body of written or literary works shaped in the history of the United States and its former colonies. Tracing back America's history, America was once under the rule of Britain as part of the latter's colonies therefore its literary institution is

associated to the expansive tradition of English literature. However, American literature is now considered a separate course and institution because of its characteristics and the production of its literature.

Jodi Lynn Picoult is a recent popular name in the American young adult fiction. Her novels deal with the psychological issues in a teenager's life. Her novel *My Sister's Keeper* contains the self-identity and relationship bond of a coming age narrative. The novel centers on the experience of two teenage characters, Anna and Kate.

*My Sister's Keeper* is the eleventh novel of Jodi Picoult, published in 2004. It tells the story of thirteen-year-old Anna Fitzgerald, who sues her parents for medical emancipation when she discovers that she was supposed to donate a kidney to her elder sister Kate, who is gradually dying from acute Leukemia. Anna was conceived with the purpose that she could immediately provide opportunities to aid in Kate's fight against it, first by her umbilical cord blood and later with transplants. Anna functions as a savior sister. They make progress at times in Kate's treatment, but then it is always followed by relapses. Anna seeks the successful lawyer Campbell Alexander trying to hire him to earn medical emancipation from her parents who want Anna to donate her kidney to her sister.

Maternal Instinct refers to the innate drive a mother has to nurture, care for, and protect her children. This natural inclination often manifests in behaviors aimed at ensuring the safety, health and well-being of her offspring. It is an evolutionary trait that enhances the survival chances of her children by providing them with consistent care and protection. This instinct can lead mothers to make significant sacrifices and take extraordinary measures to support their children's needs (Collins).

Sara Fitzgerald, the mother, is depicted as a character driven by her maternal instinct to save her dying daughter, Kate, at all costs. This instinct leads her to make morally and ethically challenging decisions, such as conceiving Anna for the sole purpose of being a genetic match for Kate and subjecting Anna to numerous medical procedures from a young age. Sara's single-minded focus on saving Kate blinds her to the ethical implications of her actions and the autonomy and well-being of her other children, especially Anna. She regrets, "... I am much better at being a mother than I ever would have been as a lawyer. I sometimes wonder if it is

just me, or if there are other women who figure out where they are supposed to be by going nowhere (Picoult 26).

Sara's struggle reflects the ethical dilemma of whether it is justifiable to compromise one child's bodily autonomy to save another. Her actions are driven by a deep, unconditional love for Kate, but they raise questions about the morality of using one child as a means to an end. This tension illustrates the complexity of maternal love, showing how it can lead to ethically ambiguous decisions when a parent's desire to protect and save their child conflicts with broader ethical principles.

Anna's decision to seek medical emancipation from her parents is a pivotal moment that highlights her struggle for autonomy and control over her own body. Despite her love for Kate, Anna grapples with the burden of being conceived for the purpose of saving her sister. Her lawsuit against her parents to gain control over her own medical decisions underscores the ethical dilemma of bodily autonomy versus familial duty. Anna's actions reflect her internal conflict and the maturation of her understanding of her own identity and rights. Anna once asks, "If you have a sister and she dies, do you stop saying you have one? Or are you always a sister, even when the other half of the equation is gone?" (Picoult 136).

Brian Fitzgerald, the father, also faces ethical dilemmas, though his role is often more passive compared to Sara's. He is portrayed as more empathetic to Anna's situation and her desire for autonomy. Brian's internal conflict illustrates the challenges parents face when their instincts to protect their children are at odds with ethical considerations and the children's own wishes.

Jesse, the eldest sibling, deals with feelings of neglect and abandonment as the family's focus remains on Kate's illness. His struggles with delinquency and self-destructive behavior highlight the broader impact of the ethical dilemmas faced by the family. Once he replies to Julia Romano, "Am I my sister's keeper?" (Picoult 185) when she enquires about Anna. His actions reflect the psychological toll on siblings who are not the primary focus of parental attention due to the health needs of another child.

Kate, the ill daughter, also faces ethical dilemmas, particularly concerning her feelings about Anna's role in her life. Kate's quiet acceptance and her eventual revelation that she does not want Anna to continue suffering for her sake adds depth to the ethical conflict. Her

perspective introduces the idea of agency and consent in medical decisions, even for those who are seriously ill.

Attachment theory, developed by John Bowlby and expanded by Mary Ainsworth, emphasizes the importance of early emotional bonds between children and their caregivers. This theory proposes that the emotional and social development of an infant is profoundly shaped by their relationship with their primary caregivers.

Bowlby's theory is rooted in the belief that infants are biologically wired to form attachments, a mechanism that serves as a survival strategy. These early attachments, formed during the initial years of life, are not just transient bonds but play a pivotal role in shaping the child's future emotional health and relationships.

This theory provides a framework to analyze Sara Fitzgerald's behavior and her emotional bond with her children in Jodi Picoult's *My Sister's Keeper*.

Sara's attachment to her sick daughter, Kate, is characterized by an intense, almost anxious, attachment style. Her overwhelming focus on Kate's survival reflects her deep emotional bond and fear of losing her. This bond drives Sara to prioritize Kate's needs above all else, sometimes to the detriment of her other children. The anxious attachment style can lead to overprotection and a singular focus on the child's immediate needs, which is evident in Sara's relentless pursuit of medical treatments for Kate. Sara soliloquies, "You can stay up all night and still not count all the ways to lose the people you love" (Picoult 226).

Sara's attachment to Kate impacts her relationship with Anna, who was conceived as a savior sibling. Sara's strong attachment to Kate and her role as Kate's primary caregiver led to a more utilitarian relationship with Anna. While Sara undoubtedly loves Anna, her behavior often reflects a more dismissive attachment style towards Anna, seeing her more as a means to an end rather than as an individual with her own needs and rights. This dynamic creates a sense of neglect and emotional distance in Anna, contributing to Anna's struggle for autonomy and identity. Brian Fitzgerald, the father, exhibits a more secure attachment style. He shows empathy towards Anna's feelings and needs, recognizing her desire for independence and her right to make decisions about her own body. Brian's secure attachment allows him to balance his emotional bonds with both daughters, supporting Anna's quest for autonomy while still



caring deeply for Kate. His behavior contrasts with Sara's, highlighting the differences in how attachment styles can influence parenting decisions and family dynamics.

Jesse, the eldest sibling, feels neglected due to the overwhelming focus on Kate's illness. The lack of secure attachment with his parents leads to feelings of abandonment and behavioral issues. Jesse's delinquency and self-destructive actions can be seen as a cry for attention and an attempt to cope with the emotional void created by the family's focus on Kate. His insecure attachment style manifests in his troubled behavior, underscoring the broader impact of Sara's attachment to Kate on the entire family. He mourns,

My parents would shower her with all kinds of cool shit whenever she had to have something done to her; and since Anna was usually involved, she got some amazing presents, too, and then a week later my parents would feel bad about the inequality and would buy me some toy to make sure I didn't feel left out. (Picoult 240)

Kate, despite being the center of her mother's attention, experiences a complex emotional bond with Sara. While she is the recipient of Sara's intense care, Kate also feels the burden of Anna's sacrifices and the family's distress. Her eventual acceptance of her condition and her desire not to see Anna suffer reflects an understanding of the ethical and emotional complexities within the family. Kate's own attachment to her family members is shaped by her illness and the dynamics it creates, leading to a mix of gratitude and guilt.

Attachment theory provides a valuable lens to understand Sara Fitzgerald's behavior and her emotional bonds with her children in *My Sister's Keeper*. Sara's anxious attachment to Kate drives her actions and decisions, creating a complex family dynamic that impacts each member differently. Through this lens, we can see how varying attachment styles influence the characters' relationships, decisions, and emotional well-being.

*My Sister's Keeper* addresses parenting complexities through moral dilemmas, ethical choices and familial conflicts, highlighting the importance of communication, empathy and understanding diverse perspectives in family dynamics.

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**Surviving the Past: Trauma and Resilience in Kate Quinn's  
*The Huntress***

**Mary Babina J<sup>1</sup> and Selva Mary Gokila S George<sup>2</sup>**

<sup>1</sup>Research Scholar (Reg. No 22213044012014), Department of English and Centre for Research,  
Holy Cross College (Autonomous), Nagercoil – 629004.

Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli – 627012.

<sup>2</sup> Holy Cross College (Autonomous), Nagercoil – 629004.

**Abstract**

This study examines the intricate interplay of trauma and resilience during World War II, using Resilience Theory as a framework. This perspective focuses on individuals' capacity to adapt and thrive despite adversity, offering a lens to understand the journeys of the protagonists: Nina Markova, Ian Graham, and Jordan McBride, each dealing with profound wartime traumas. Central to their stories is Lorelei Vogt, known as the Huntress, a notorious Nazi war criminal whose actions have deeply affected their lives. Their pursuit of justice against Lorelei epitomizes their struggles with memory, guilt, and vengeance. Resilience Theory illustrates how the characters confront and overcome their traumas. Nina's survival and determination, Ian's relentless quest for retribution, and Jordan's search for hidden truths showcase diverse responses to extreme adversity. Lorelei Vogt serves as the focal point of their traumas and quests for justice, adding depth to their psychological resilience. Despite immense challenges, the characters rebuild their identities and find new purposes, demonstrating the transformative power of resilience. This analysis of Quinn's novel deepens our understanding of resilience as a multifaceted concept, highlighting that it involves not just recovering from adversity but also experiencing personal growth and transformation, illustrating the interplay between trauma, justice, and the enduring strength of the human spirit.

**Keywords:** Trauma, Justice, Adversity, Resilience, Strength.

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Kate Quinn is an American writer known for her historical fiction, focusing on women who defy expectations and change pivotal moments in history. Her novels include *The Alice Network* (2017), *The Rose Code* (2021), *The Diamond Eye* (2022), and *The Lion and the Rose* (2014). She excels at weaving together multiple timelines and perspectives, providing a panoramic view of historical events and their impact on individuals.

*The Huntress*, published in 2019, explores themes of war, trauma, and resilience. It follows Nina Markova, a Russian bomber pilot; Ian Graham, a British war correspondent; and Jordan McBride, a young woman in post-war America, as they hunt a Nazi war criminal. Each

character confronts their haunting pasts and demonstrates remarkable strength, highlighting the enduring human spirit's capacity to heal and seek justice amidst profound psychological scars.

This paper analyzes *The Huntress* through the lens of resilience theory, a psychological framework that examines how individuals adapt and recover in the face of adversity and trauma. According to Dr. Garmezy, resilience is not about being brave in adversity but about recovering and maintaining adequate behavior despite emotional distress. He also said that a person is resilient even if they initially retreat when faced with tragedy, provided they eventually return and do what is necessary (*The Happiness Coach*).

Nina grew up in the wilds of Siberia in a dysfunctional family headed by an alcoholic father. After her father tries to drown her in Lake Baikal, she seeks out "the opposite of drowning" (Kate Quinn 40). She desperately wants to be a pilot because ascending, rather than descending, makes her feel at home. This anguish drives her to directly approach Mikhailovna Raskova, a hero of the Soviet Union and famous aviatrix, instead of going through official channels. Nina boldly expresses her resilience to the woman who parachuted out when her team couldn't find the final runway due to poor visibility, eventually becoming separated from her pilot and copilot and spending ten days alone in the wilderness of the taiga.

I grew up in that taiga. Nina took another step. You survived ten days there. I survived nineteen Years. Cold, ice, a landscape that wants you dead none of it scares me. Flying at night doesn't scare me either, or bombs exploding, or fascists trying to shoot me down. Nothing scares me. I'm tougher than any university girl with a perfect record and a thousand hours of flying time. (Kate Quinn 117)

Thus, Nina's grit leads her to join Marina Raskova's famed all-female aviation regiment, and during the war against Nazi Germany, she becomes part of the 588th Aviation Group, famously known as the Night Witches. The razor Nina Markova carries serves as a powerful symbol of her trauma and resilience. It is not just a practical tool for self-defense but also a significant object that encapsulates her experiences and emotional journey.

It is the depiction of violence Nina has encountered and been forced to engage in. Throughout her life, from her upbringing in Siberia to her time as a Night Witch and beyond, Nina has been surrounded by brutality and death. The razor symbolizes the ever-present threat of violence and the harsh realities she has faced. At the same time, it represents her remarkable

ability to survive, her fierce independence, and her empowerment in the face of adversity. It symbolizes her ability to take care of herself and not depend on others for protection. This trait was essential for her survival in Siberia and continues to be crucial in her later life as she faces various threats. “Yelena had a pistol in her cockpit like most pilots, but Nina never went into the sky without her razor” (Kate Quinn 212), it reflects her preference for relying on her own skills and resources rather than depending solely on standard-issue military equipment also the trust she has on herself rather than humans. It is clearly understandable when Sebastian said her, there are good people in the world and you have to trust them but Nina on the other hand, “Held up her razor. “I only trust this”” (Kate Quinn 482). The survival instinct makes her distant from her loved ones, because she doesn’t want to fail another sestra, another teammate or another comrade. At the end she understands that her journey is not just about seeking revenge but also about confronting her past traumas and finding a path to healing. And she bravely faced her fear to protect her team.

Ian Graham’s transition from a war correspondent to hunting war criminals is driven by multiple factors rooted in his traumatic experiences, sense of justice, and personal loss. As a war correspondent, Ian witnessed the brutal realities of World War II, including the Holocaust and the immense suffering of its victims. These experiences left him deeply traumatized and profoundly affected by the inhumanity he observed. Documenting these atrocities without being able to intervene or prevent them contributed to Ian’s sense of helplessness. This feeling was compounded by the guilt of surviving and only bearing witness rather than taking direct action. Ian’s attempts to confront and rationalize his fear show resilience.

There is no parachute, no fall. No bloody nightmare either, because you have no right to it. You were just a journalist. A goddamn writer, not a soldier. They carried guns, you carried pens. They fought, you didn’t. They bled and died, you wrote and lived. You haven’t earned the nightmares (Kate Quinn 164)

This shows his struggle to reconcile his feelings of inadequacy with the reality of his contributions and the impact of his experiences. The death of Ian’s younger brother, Sebastian, during a mission related to their pursuit of justice for war crimes, profoundly impacted Ian. This pain could easily drive Ian toward a path of vengeance, seeking to punish those responsible out of personal anger and grief. However, Ian consciously chooses to rise above this urge

because he believes that “principle should be stronger than the need for vengeance” (Kate Quinn 172). His commitment to principles over personal vengeance is a key coping mechanism. This ethical framework provides him with a stable foundation, helping him navigate his trauma without being consumed by anger or retribution. This emotional regulation is crucial for his long-term resilience and mental health. Thus, his ability to transform trauma into purposeful action, maintain ethical conduct, and achieve positive outcomes demonstrates the core components of resilience.

Jordan is a dutiful daughter whose responsibilities and devotion to her family conflict with her passion for photography. The shocking and devastating revelation that her father was murdered by her stepmother, Anneliese Weber, leaves Jordan grappling with intense grief, confusion, and betrayal. Instead of succumbing to despair, Jordan channels her emotions into the pursuit of justice. She joins forces with Ian Graham and Nina Markova to uncover the truth about her stepmother and bring her to justice.

This mission provides Jordan with a sense of purpose and direction, helping her cope with her grief. Jordan takes an active role in the investigation, using her skills and intelligence to help uncover the truth about the Huntress. This proactive approach gives her a sense of agency and control, which is essential for resilience. Although Anneliese tries to justify her actions by saying, “Cowardice doesn’t exist, you know. Nor does bravery. Only nature. If you’re the hunter, you stalk and if you’re the prey, you run, and I am quite realistic enough to know that I have been the prey ever since the war ended and the Victors decided I was a monster” (Kate Quinn 470), Jordan’s willingness to confront danger and uncertainty in her pursuit of justice highlights her courage and tenacity. Her experience illustrates how she indirectly faces the traumas of World War II through her interactions with Ian Graham, Nina Markova, and the discovery of the Huntress’s true identity. Thus, her journey of resilience not only helps her cope with her trauma but also positions her for a hopeful and empowered future.

In essence, this paper reflects that resilience goes beyond mere survival; it encompasses growth, transformation, and the pursuit of justice and truth. Resilience theory provides a valuable framework for understanding and analyzing the characters. By focusing on how individuals respond to and recover from adversity, it sheds light on the processes that enable people to withstand and grow from their traumatic experiences.

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**Displaced Souls: The Dynamics of Deterritorialization in *The Wasted Vigil*  
by Nadeem Aslam**

**Monica Prems<sup>1</sup> and Selva Mary Gokila S. George<sup>2</sup>**

<sup>1</sup>Research Scholar (Reg.no:21213044012009), Department of English and Centre for Research,  
Holy Cross College (Autonomous), Nagercoil – 629004.

Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli - 627012

<sup>2</sup>Research Supervisor and Assistant Professor, Department of English and Centre for Research,  
Holy Cross College (Autonomous), Nagercoil – 629004.

**Abstract**

Nadeem Aslam is one of the prominent writers of twenty first century, whose works delve into the complexities of socio-political life of immigrants in Afghanistan. This article aims to present a clear picture of deterritorialization through the displaced lives of the characters in Nadeem Aslam's novel *The Wasted Vigil*. The narrative unfolds in Afghanistan, providing a distressing backdrop for examining the displacement of all the characters. Set against the backdrop of war and destruction, the novel delves deeply into the lives of its characters, each grappling with the loss of their homes, identities and questioning their sense of belonging. In *The Wasted Vigil*, Nadeem Aslam explores the intricate and painful process of deterritorialization experienced by the characters who navigate through the war-torn landscapes of Afghanistan. Analyzing the journey of the novel's main characters, this paper investigates how Aslam portrays the fragmentation of identities and the quest for belonging in a fractured world. This paper highlights the theme of displacement and deterritorialization to reveal the complicated impacts of conflict on identity, culture and personal relationships. Through a detailed examination of the characters and their interactions with the Afghan landscape, this article seeks to illuminate the complex dynamics of deterritorialization in *The Wasted Vigil*.

**Keywords:** Deterritorialization, displacement, conflict, trauma, identity, culture, Afghanistan

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**Introduction**

Nadeem Aslam's *The Wasted Vigil* is set in post -9/11 Afghanistan. It is a profound narrative that probes into the themes of identity, loss, and belonging of each character. He brings in five major characters in the novel, A British, An American, A Russian and two Afghans. Each character faces their own struggle representing the turmoil of displaced lives in a foreign land. Here, Aslam brings in all his characters from diverse backgrounds altogether in Marcus's house, where they get to learn about their interrelationship with each other. Aslam in an interview narrates his intention behind writing the novel *The Wasted Vigil*. He enumerates



that “I wanted to write a novel which went back thirty years and explained how we have arrived at the current political and moral chaos that we see every time we pick up the newspaper” (Aslam and Sethi). Aslam brings in the century long saga of Afghanistan against British Colonialism, civil wars, Russian war, Talibanization, and American War on Terror. The persistent presence of conflicts and cruelty in the collective memory of a nation symbolizes the inescapable reality of a war- zoned nation like Afghanistan.

Deterritorialization refers to the process by which social, cultural or political practices, structures and geographical boundaries are blurred or disrupted, leading to displacement, reconfiguration of identities, traditions and meanings. Deterritorialization in *The Wasted Vigil* manifests in various forms, primarily through the characters’ physical and emotional displacements. Marcus himself is a poignant representation of deterritorialization. He is a British expatriate who lived in Afghanistan for many years. His house serves as a storehouse of memories and cultural artifacts. It is a sanctuary for lost souls, each seeking refuge from their pasts and the present world. This house is a central setting in the novel that becomes a miniature of deterritorialized world. Marcus himself embodies the loss of homeland and cultural dislocation. Marcus’s connections with the landscape around his home further exemplify his displacement. His deep connection to the Afghan land contrasts with his status as a foreigner creates a complex dynamic of belonging and estrangement. This duality is central to the novel’s exploration of identity, highlighting how personal and cultural identities are constantly renegotiated in response to changing environments.

Marcus had converted to Islam to marry his beloved, Qatrina. Their marriage was considered illegal and Qatrina was stoned to death by the Taliban. The cruel deaths of Qatrina left a psychological scar in the minds of Marcus since the day it took place. “A microphone had been placed close to her for her screams to be heard clearly by everyone” (Aslam 38). This shows the austerity of injustice that took place during the Taliban regime. Moreover Afghani women are the most helpless characters in the novel, as the most brutal things happen to them. They represent Afghanistan at the mercy of Russia, Afghan warlords, Taliban and now America receiving nothing but destruction from all sides. “This country has always been a hub of things moving from one point of the compass to another, religion and myth, works of art,

caravans of bundled Chinese silk flowing past camels loaded with glass from ancient Rome or pearls from the Gulf “(Aslam 9).

Lara’s journey to Afghanistan is driven by her search for her missing brother, a search that symbolizes her own need for closure and identity. She has already visited Afghanistan twice. Her experiences in Afghanistan are marked by encounters with other displaced individuals and underscore the invasive sense of loss and displacement. Lara’s interactions with the Afghan landscape and its people reveal the deep emotional and psychological impacts of deterritorialization. Her search takes her to various historical and cultural sites, each layered with memories of violence and commotion. These encounters highlight the ways in which personal and collective histories are intertwined, reflecting the broader theme of deterritorialization. Lara’s journey ultimately becomes a metaphor for the search for identity and belonging in a fractured world. She represents the personal and cultural fragmentation that accompanies deterritorialization. Her encounters with other characters reveal the shared yet diverse experiences of dislocation, each story adding a layer to the complex narrative of deterritorialization.

David’s character provides a critical perspective on the moral and ethical complexities of political and military interventions. His presence in Afghanistan, initially motivated by ideological convictions, evolves into a more personal quest for liberation. Through David, Aslam explores the impacts of geopolitical conflicts on individual identities and moral frameworks. David’s interactions with the Afghan landscape and its people reveal the deep-seated effects of deterritorialization. He is financing a school in Jalalabad proving his ability of adaptation and resilience to provide education to the people of this nation. His evolving relationship with the land and its history reflects the broader theme of displacement and the search for meaning in a world marked by conflict and instability. David’s character serves as a lens through which the novel examines the ethical dimensions of deterritorialization and the ways in which individuals navigate these complexities. Being an American, David represents the moral and ethical dilemmas associated with political and military interventions. The novel illustrates how his identity is continuously reshaped by his interactions with the land and its people, reflecting the broader theme of deterritorialization. On the whole all the major characters’ multifaceted lifestyle serves as a representation of deterritorialization.

The Cultural and Historical Deterritorialization of a country can be shaped by the culture and history associated with it. Aslam's usage of the narrative intertwining the past and the present highlights the sympathetic plight of various characters impacted due to its various socio-political disruptions. In the beginning Nadeem showcases Afghanistan as rich in culture and the calmness associated with the beauty of its past. "The City of Flowers. The City of Grain. It was transformed into a city filled with conjecture, with unprovable suspicions and frenzied distrust" (Aslam147).

Aslam depicts the country's landscape marked by historical invasions and contemporary conflicts. Marcus recalls the long lost past of Afghanistan where women were provided education and support in their country. There were no restrictions for wearing make-up and ornaments. Poets from different corners of the world were invited to recite poetry. Marcus recalls the time when women enjoyed painting and calligraphy. Singers were famous for their songs and inter-religion marriage was significantly allowed in the country. Various art forms had interconnectedness with everyone's lives. Marcus longs for peace and harmony associated with the incidents of the past. His displacement is associated with cultural oppressions and historical impacts of war in the present days. The historical layers of Afghanistan, from Buddhist relics to the Soviet occupation, create a complex tapestry of memories and identities. "This country was one of the greatest tragedies of the age. Torn to pieces by the many hands of war, by the various hatreds and failings of the world. Two million deaths over the past quarter-century" (Aslam14).

Aslam portrays Afghanistan as a stage of action for the international power players to use it as a battleground for their vested interests. Mining of gems, geographical position to access the minerals and oil rich states has invited British colonialism, giving way to Russian invasion, Civil war and American interest to outdo Russia and later to fight Al-Qaida and Taliban. Aslam explores the lifeless situation of Afghans and the reality of the destructed nation in detail. "The last excursion was to a city in the south of the country during the Taliban regime, and like the other times it was fruitless" (Aslam19). The poor people had a hard time surviving in the war-torn land. They underwent numerous difficulties, preceding the Cold War in Afghanistan. "The Cold War was cold only for the rich and privileged places of the planet" (Aslam36).

Aslam's writings present the cruelty of Afghanistan with various internal conflicts through his characters and their displacements. This has been highlighted through the physical and mental collapse due to socio-cultural practices and majorly through the impacts of war.

Afghanistan had collapsed and everyone's life now lies broken at different levels with the rubble. Some are trapped near the surface while others find themselves entombed deeper down, pinned under tons of smashed masonry and shattered beams from where their cries cannot be heard by anyone on the surface, only-and inconsequentially- by those around them.(Aslam38)

### **Conclusion**

The Wasted Vigil offers a compelling exploration of deterritorialization, weaving together the personal and the political lives of all the characters to depict the profound impacts of displacement. Each of Aslam's characters navigates their fragmented identities, illustrating the versatile nature of deterritorialization. "Even the air of this country has a story to tell about warfare" (Aslam56). The Wasted Vigil serves as a heartrending reminder of the enduring human quest for connection and belonging in the face of harsh upheaval. Through a detailed analysis of the characters and their journeys, this paper highlights the significance of deterritorialization as a central theme in Aslam's work, providing insights into the broader implications of geopolitical conflicts on individual and collective identities.

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**Nature's Echo: Survival and Eco-consciousness in Tsitsi  
Dangarembga's *This Mournable Body***

**A. Annie Divya Mahisha**

*Department of English, Holy Cross College (Autonomous), Nagercoil - 629004*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012*

Email: [anniemahisha@holycrossngl.edu.in](mailto:anniemahisha@holycrossngl.edu.in)

**Abstract**

This paper explores the themes of survival and eco-consciousness in Tsitsi Dangarembga's novel *This Mournable Body* through the lens of ecotourism. The novel presents a complex interplay between the protagonist's personal struggles and the environmental challenges faced in postcolonial Zimbabwe. By examining how ecotourism is portrayed in the narrative, this study highlights the tensions between economic development and environmental preservation. The paper argues that the novel uses the motif of ecotourism to critique the exploitation of natural resources while advocating for a harmonious relationship between humans and their environment. Through a close reading of key passages, this analysis reveals how Dangarembga's work prompts readers to reflect on the broader implications of ecological sustainability and cultural identity in a rapidly changing world.

**Keywords:** Ecotourism, Ecology, Identity, Survival, Exploitation

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Tsitsi Dangarembga is a celebrated Zimbabwean author, playwright, and filmmaker known for her insightful explorations of postcolonial African identity, gender, and societal issues. Born in 1959 in Mutoko, Zimbabwe, Dangarembga gained international acclaim with her debut novel *Nervous Conditions* (1988), which won the Commonwealth Writers' Prize and is regarded as a classic of African literature. Her works, including the sequels *The Book of Not* (2006) and *This Mournable Body* (2018), delve deeply into the struggles of African women navigating the complexities of personal and national identity amidst colonial and postcolonial legacies. Dangarembga became the first native Zimbabwean and first black woman to receive the German Peace Prize. She had also been the recipient of the PEN Pinter prize in 2021.

Dangarembga's novel *This Mournable Body* (2018) is actually an extension of her previous novels. Anne W. Gulick claims that *This Mournable Body* is one of the "novels we need rather than the novels we want in the twenty-first century" (465). In *This Mournable Body*, Tambu's misfortunes increase when she returns to her homeland, Zimbabwe. Decisions

and circumstances become worse for the protagonist when she stays back in her native land. It soon becomes an existence that touches the borderline of poverty. Her mind and body become burdensome because they need proper nourishment. In Zimbabwe, the aftermath of independence was a dangerous combination of colonialism and materialism. The ecotourism job does not suit Tambu and her ancestral roots also betray her because they have been corrupted by capitalism.

*This Mournable Body* deals with the mental attitude of the ambitious and educated war fighters who are oppressed by the patriarchal system in Zimbabwe at the end of the colonial period and at the initial stage of the liberated Zimbabwe. Dangarembga expresses the hope that even though these strong war fighters have met with some disastrous moments, their will to succeed will never cease. Tambu too longs to free herself from her social shackles and aims for a better life. In order to achieve her dreams, she must impress her teachers and bosses who are white. She gets 307odernize307d when she thinks of the plight of her poor mother and one-legged sister.

Tracey, the manager of the tourism farm decides to improve the quality of her farm to attract many tourists. Her Green Jacaranda Safaris is eco-friendly and she decides to 307oderni it for farm tourism on an exotic Zimbabwean farm, owned by her brother. She says to Tambudzai “Welcome, Tambu, to Green Jacaranda Getaway Safaris, the only exclusive ecotourism service on the whole continent. Which we happen to have thought up right here. There’s so much we could do for this country. In this country” (190). The tourism industry in Zimbabwe has taken innovative measures to attract the western tourists. It has resolved to glamorize and 307odernize the traditional, rural but charming African landscape along its flora and fauna.

Tambudzai excels in her job as a tour guide in Tracey’s farm. She suggests Tracey to add a touch of exoticism in her already exiting African mystique at the farm. The main concern of Tracey is profit and if she fails in her attempt, she will take some other business. As the farm turns out to be an unsafe tourist attraction for the whites, Tracey proposes that Tambudzai’s ancestral village can be changed as an authentic eco-village. Tracey also indulges in a few other business plans to earn profit by exploiting the poverty of the poor, rural people around.

The novel shows how new forms of tourism arise exploiting the poor villagers living in the city and the rural areas. Tracey plans to establish a new form of slum tourism in the high density area called ‘the Green Jacaranda Getaway Safaris’. According to this plan, Tambu’s traditional family house becomes the center of the tourism. Tambu is given the responsibility of explaining the customs of her village and make arrangements for their stay and facilitate them to meet the villagers. Since high density suburb tourism is a new adventure in Zimbabwe, none can predict how this will attract the western tourists who have not experienced such form of tourism in the particular country.

Tourist industry takes up the wilderness and makes it very attractive and thrilling package in the name of ecotourism. Ecotourism takes the tourists away from the famous holiday resorts to unknown places in the wilderness, hilly areas and water bodies. They take them to such strange and adventurous places to give them an extraordinary experience. Wild nature is bargained in the form of trips to deserts, mountains, lakes, jungles and boating in wild rivers etc. In this process, enormous amount is collected for tourist consumption. Thus huge business is undertaken and lovers of nature pay lot of money. In this way nature is abused to attract the lovers of nature for monetary profits.

When Tracey proposes arranging a trip to a village for tourists, Tambu takes it as an opportunity to help her villagers. She convinces her mother that it will benefit all of them. Since the foreign tourists expect authentic experiences, they want to stay there and enjoy the rural atmosphere directly. In that case lot of space will be needed even to construct temporary tents or huts. As a result, the people of the village have to abandon their homes and settle in strange areas. Due to a few bitter experiences involving the tourists and villagers force Tambu to relinquish the plan.

Through the work, Dangarembga exposes how eco-tourism causes tension in areas that are still reeling under the destructive effects of the war of liberation and industrialization. The new government forces the rural people to sacrifice their home lands for constructing building, offices and schools and hospitals. When nature is abused as an agent to acquire money, the genuine love that exists between men and nature ceases to exist. Green Jacaranda which is outwardly announced as a start up dealing in environmental friendly entrepreneurship has

started making profit revealing its interior motive and naturally it introduces the colonial structure in the economy.

The readers find that Green Jacaranda fails to fulfil its promises to Tambu village but its virtuous ethos is manipulated to attract the tourists for the ambitious aim of earning money. Thus the village and its traditional environment are abused by eco-tourism for the motto of achieving profit. Tracey says, “Green and eco are tautological ... That kind of promise doesn’t work these days either. It’s got to sound like fun, not under development, soil erosion and microfinance” (228).

When natural and rural spots become famous as tourist centers, big hotels, lodgings and other tourist related activities will spring up. These activities dislocate the local people from their homestead. The growth of industrial activities will collapse. The normal habits of the surrounding wildlife. Deforestation and sudden entry of the toxic waste and smoke will unsettle the animals and birds and they are forced to flee away from their original settlements. Increased foot traffic and constant use of motors will affect the soil quality disrupting the over all ecosystem of the area.

Dangarembga in her novel, *This Mournable Body* confirms the fact that eco-tourism affects the ecosystem because of many buildings, human interference and human consumption. History proves that the fall of civilization is linked with the environmental disaster and degradation. Even after knowing the significance of environment for human survival and sustenance, man continues to destroy nature.

This paper analyses the inseparable bond that exists between man and nature. The African young writers like Dangarembga try to harmonise human beings and the elements of nature, natives and the outsiders, and compel the readers to think of the rural and indigenous culture and their roles in the environment. Osundare says, “earth is // ours to work not to waste // ours to man not to maim // the earth is ours to plough not to plunder” (48). So it has become mandatory for human beings to deliberate about their attitude towards nature. Nature and humanity should lead a harmonious co-existing life so that both may be benefited.

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## **Muffled Voices in Nadia Hasini's *The Pearl that Broke its Shell***

**Steffi K.B. and J. Bhavani**

*Department of English, Holy Cross College (Autonomous) Nagercoil – 629004.*

### **Abstract**

In Nadia Hashimi's *The Pearl that Broke Its Shell*, the theme of muffled voices explores the suppressed and marginalized experiences of women in Afghan society. The narrative intertwines the stories of two women from different generations, Rahima and her great-great-grandmother Shekiba, who both grapple with the constraints imposed by a patriarchal culture. Through their struggles for autonomy and identity, Hashimi vividly portrays how societal norms and traditions stifle female voices. The novel highlights the resilience and courage of women who strive to break free from silence and assert their individuality despite overwhelming odds.

**Keywords:** Muffled, Marginalized, Afghan society, Patriarchal culture, Resilience.

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Oppression has become a common word associated with the lives of female counterparts in the human civilization. The female community has lost its identity. They remain vulnerable to all kinds of exploitations possible. This paper deals with the subjugation, violence and survival tactics of the female characters in the novel *The Pearl that Broke its Shell*. The author Nadia Hasini has beautifully written the story of an adolescent girl in the Taliban ruling part of Afghanistan. The story throws light not only on the social and cultural backdrop of the setting but also on the psychological trauma and violence the female community undergo in order to survive.

Rahima the female protagonist of the novel undergoes a tedious metamorphosis which forces her to change her identity, marry an elderly man, and bear the hardships, burdens and violence in married life. This tiresome transformation resulted in making her an independent woman. While describing her transformation, Rahima proclaims:

I was a little girl and then I wasn't

I was a bacha posh and then I wasn't

I was daughter and then I wasn't

I was a mother and then I wasn't

Just as soon as I could adjust, things changed. I changed. This last change was the worst. (385)

Yet she has to remain a fugitive. The price she pays for this is experiencing more of torture and emotional trauma. Rahima faces the challenges in her life drawing strength from the life history of her great great grandmother, the author says, “we would not be the first. It’s been done before (22).” This novel has got another plot which explores the story of Shekiba running parallel with the story of Rahima dated exactly a century before the times of Rahima. This second plot also throws light over the social, religious customs and practices.

Rahima manages to get a little education because of the age old custom of bacha posh. This education later aids Rahima in her escape from oppression and violence. Rahima, the protagonist is forced into marrying a man of her father’s age. She along with her two other siblings are being married into a war lord’s family for a huge sum of bride price. Rahima’s father and his family men claim the money even without a trace of shame. Rahima’s mother witnesses everything in silence, she cannot question her husband and his family men and is denied to have any word with them. On the day of her daughter’s marriage, Rahima’s mother spoke softly:

“My daughters, I prayed this day would not come so soon for you but it is here and I’m afraid there’s nothing I or Khala Shaima can do to stop this. I suppose this is God’s will for you. Now, I haven’t had much time to prepare you, but you are young women.” She said, hardly believing her own words. “Your husbands will expect things of you. As a wife, you have an obligation to your husband. It won’t be easy at first but ...but with time you’ll learn how to ...how to tolerate these things that Allah has created for us.” (148)

Raisa, the protagonist’s mother is so pathetic that she couldn’t help her daughters and bring change in their lives. She embraces them on the day of their weddings. She remains helpless against the men and as a mother she must have felt the loss and doom. What is more painful is the way she chooses to escape the loss of her daughters. She finds comfort in the odious fumes of opium. She lives her remaining life in an opium induced daze. In a way she abandons her younger daughter who may face with even worse fate. Rahima is shocked at her mother’s transformation and her heart cries out for her two younger siblings.

Parveen the third daughter of Rahima’s family tries to hide all her agonies behind her smile. Her eyes spoke the words which her mouth failed to express. Her life in her in laws place

was pathetic and she was over worked inspite of her lame leg. Rahima after a long struggle meets her sister Parveen and pours out her hardship in her in laws house:

Pawin, I've wanted to see you for so long but they wouldn't let me come! All they wanted me to do over there is work and work and I'm so tired of it! I scrub the floors and do the laundry and ... My voice tapered as I realized my sister's life was probably no different from mine (187).

Meanwhile Parveen finds escape through death by setting herself on fire. Her death shatters Rahima and could not forgive herself for not standing up for her beloved sister.

Rahima tolerates the abuses and violence for the sake of her son Jahanghir. Motherhood has pacified the heart of fourteen year old Rahima also helps her to avoid tortures. According to the review of *book reporter* regarding turmoil's of Rahima:

For Rahima, life with her new husband --- a warlord infamous throughout the region --- is anything but comfortable. Though she's surrounded by opulence, her duties as his fourth wife resemble those of a baby machine and slave. She soon bears him a son, but to a limited reprieve, and it's all Rahima can do make it through the day and avoid punishment, especially after Parwin sets herself on fire in protest.

The time spent with her son relaxes her heart and soul. Fate intervenes and she loses her son to fever that goes untreated because of her mother in law. After the tragic death of her son Rahima involved herself in other activities. She makes use of her trips to Kabul to learn more. This poses a threat to her life. When her husband learns of this he decides to put an end to Rahima's existence itself. She escapes the cruel hands of her husband by taking refuge in a home established for women like her. Now she is free but not totally safe. She must remain hidden throughout her entire life.

The paral'el plot of Shekiba speaks of the hardships and injustices faced by her only because of her gender. She is ill-treated by her own people. Though scared at her childhood she lives a happy life until the death of her family members. She loses her siblings to cholera. Her mother breathes her last in depression. Shekiba finds solace in the presence of her father. Real catastrophe strikes her when her uncles remove her from her house after her father's death. She is treated like an animal by her father's family. Shekiba means 'gift' but she is handled like a curse and is cast away from her relatives. She is sent away to work in another man's

house as a payment for their debt. She loses her status as a woman. Her condition is no better than a cattle. Again from the house of..... She is given away as gift to the king.

At the palace she is assigned the post of a guard in the Kings Harem. She is imprisoned for a no fault of hers. She is saved from being executed and made to marry a man for whom she feels nothing. Even in the marriage she is looked upon with contempt by her husband's first wife. She even faces her husband's wrath when she fails to give him a male heir. Shekiba is not happy in her married life.

Both Rahima and Shekiba are wronged individuals, they are victimised by their own families. They are both sold away to placate the greedy family men. Violence does not originate in streets. The seeds of violence against women are sown in their respective homes itself. Women lose their human status and are looked upon as commodities. A variety of factors account for the pathetic situation of women. Women are exploited for money and they suffer a lot of physical and mental abuse. Women who remain resistant are tolerated but women who try to resist are put out immediately. Any woman who is looked upon as a threat is soon annihilated by any means possible. This condition questions the status of women in the human community. Scientific advancements, social changes and other developments have not done anything for woman like Rahima. They are silenced by the society they live in. Women who manage to escape live the life of fugitives. But many lose their lives and identities in their struggle to set themselves free.

### **References**

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## தமிழ்க்குடியின் உணவுப் பண்பாடு

**ம. மேபல் எடல் குயின்**

*உதவிப்பேராசிரியர், தமிழ்த்துறை, ஹோலிகிறாஸ் கல்லூரி(தன்னாட்சி),  
நாகர்கோவில் - 629004.*

### முன்னுரை

பண்டைத் தமிழரின் வாழ்வியல் நிலம் சார்ந்த கட்டமைக்கப்பட்டது என்பதைத் பழந்தமிழ் இலக்கியங்கள் வழி அறியலாம். வாழ்வியல் குறிஞ்சி, முல்லை, மருதம், நெய்தல், பாலை, கைக்கிளை, பெருந்தினை அடிப்படையிலும் முதல்பொருள், கருப்பொருள், உரிப்பொருள் அடிப்படையிலும் வகுத்துரைக்கப்பட்டது.

### உணவுப்பண்பாட்டில் விலங்கினங்கள்

புலால் உணவுகள் சங்க இலக்கியங்களில் ஊன், புலால், புலவு, கொழுங்குறை (பொருள் 105) பைந்தடி (புறம். 14,12) பைந்துணி (புறம்.44) என பல்வேறு பெயர்களில் சுட்டப்பெற்றுள்ளன. உடும்பு கொளீஇ விரிணல் அகழ்ந்து நெடுங்கோட்டுப் புற்றத்து ஈயல் கொண்டி எல்லமுயல் எறிந்த வேட்டுவன் (நற் 59) எனும் நற்றிணைப் பாடல்களில் உடும்பு, நுணல், ஈயல், முயல் ஆகியவற்றை வேட்டையாடி வரும் வேட்டுவனின் செயல் பதிவு செய்யப்பட்டுள்ளது. விலங்குகளில் ஆட்டிறைச்சி (பொருநர் 103-140, புறம் 366:18-20, புறம் 267:8-9) ஆமான் என்றழைக்கப்படும் காட்டுப்பசு இறைச்சி (சிறுபாண் 175-177) முயல் இறைச்சி (புறம் 319:6-9) முளவு மா எனும் முள்ளூடைய பன்றி இறைச்சி (ஐங் 364:1-2, புறம் 177:13-15, மலை 175-177) மான் (இரலை, உழா, கடமா, நவ்வி மரையான்) இறைச்சி (புறம் 150:5-15, புறம் 152:25-27, மலை 175-185, அகம் 107:5-10 ஆமை (பட்64, புறம் 42, புறம் 176) போன்ற விலங்கினங்கள் உணவுப் பொருட்களாகப் பயன்படுத்தப்பட்டுள்ளன.

### உணவுப் பண்பாட்டில் பறவை இனங்களும் மீனினங்களும்

பறவைகளுள் அளவின் வாட்டு (கோழி இறைச்சி) பெரும்பாண் 255-256, ஐதல் எனப்படும் கௌதாரி இறைச்சி (புறம் 319:6-9) குறும்பூழ் எனப்படும் காடை இறைச்சி (குறுந் 369:1-2) புறா இறைச்சி (புறம் 3:6-9)

மீன் வகைகளுள் அயிலைமீன் (அகம் 70:2-4) ஆரல் மீன் (புறம் 212:3-4) இறால் மீன் (குறுந் 320:1-4) கெடிற்று மீன் (புறம் 384:8-9) சுறா மீன் (பட் 86-87, அகம் 10:10-12, நற் 103: 9-12) வரால் மீன் (நற் 60:3-6, அகம் 216:2-4) வாளை மீன் (புறம் 61:4-6, அகம் 320:1-4) போன்றனவும் உணவாக உட்கொள்ளப்பட்டுள்ளன.

அளவன், கள்வன், ஞெண்டு எனப்படும் நண்டு (சிறுபாண் 194-195) ஈயல் (அகம்-394) போன்றவையும் சங்ககால மக்களால் உண்ணப்பட்டன. இறைச்சியையும் மீன் வகைகளையும் பதப்படுத்தி உணவாக உண்ட நிலையையும் (அகம் 20:2 பெரும்பாண் 100-104) சங்க வரிகளில் காணமுடிகிறது.

புலால் உணவுகளைப் பச்சையாகவும் சுட்டும் வேகவைத்தும் சோறு சேர்த்தும் புலவு செய்தும் எனப் பல நிலைகளில் உண்டனர் என்பதற்கான குறிப்புகள் சங்கச் செய்யுட்களில் காணப்படுகின்றன. படிநிலை சார்ந்த நாகரிக வளர்ச்சியில் பின்புலத்தில் இவை நோக்கத்தக்கது.

சோற்றோடு ஆட்டின் இறைச்சியைச் சேர்த்து உண்ட முறையை

“எயிற்றியர் அட்ட இனபுளி வெஞ்சோறு

தேமா மேனிச் சில்விளை யாயமொடு

ஆமான் சூட்டின் அமைவரப் பெறுடுவர்” (சிறுபாண் 113)

எனும் பாடல் அடிகளாலும்

வெண்சோற்றோடு நண்டு கலந்து உண்ட செய்தியை

“அவைப்புமான் அரிசி அமலை வெண்சோறு

சுவைத்தாள் அலவன் கலவையோடு பெறுகுவீர்” (சிறுபாண் 194-195)

எனும் பாடல் அடிகளாலும் ஈயலை வைத்துப் புளிக்குழம்பு செய்ததை

“ஈயல்பெய் தட்ட இன்புளி வெஞ்சோறு” (புறம் 119-3)

என்ற பாடலடியாலும் அறிந்து கொள்ளமுடிகிறது.

### உணவும் திணையும்

தொல்காப்பியம் அன்பின் ஐந்திணைக்கும் உரிய கருப்பொருட்களுள் ஒன்றாகச் சுட்டிய உணவுப்பொருட்கள், குறிஞ்சி முதலாடிய ஒவ்வொரு திணைக்கும் எவையெவை என்பதை இளம்பூரணர் உரையும் நச்சினார்க்கினியர் உரையும் எடுத்துரைக்கின்றன. நிலத்தில் விளையும் தானியங்கள் பருப்பு வகைகள், கிழங்கு வகைகள், இயல்பாகக் கிடைக்கும் தேன், பண்டமாற்றால் வரும் பொருட்கள் ஆகியன உணவுப் பொருட்களாகக் குறிப்பிடப்பட்டுள்ளன. புலால் உணவுகள் பற்றிய குறிப்பு இருவர் உரைகளிலும் இல்லை. மீன் விற்று அதன் மூலம் வரும் பொருளை உணவுப் பொருளாகக் குறிப்பிடும் உரையாசிரியர்கள் மீனை உணவுப் பொருளாகக் குறிப்பிடவில்லை.

தொல்காப்பிய மூலநூலுக்கும் உரையாசிரியரின் காலத்திற்கும் இடையில் அகப்பொருள் தொடர்பாகத் தமிழில் இறையனார் அகப்பொருள், தமிழ் நெறிவிளக்கம், நம்பியகப்பொருள் போன்ற நூல்கள் தோன்றின. இறையனார் அகப்பொருள் மூலநூலில் கருப்பொருட்களின் பட்டியல் இல்லை. அதன் பிறகு தோன்றிய தமிழ் நெறி விளக்கம், நம்பியகப்பொருள் போன்ற நூல்கள் தோன்றின. இறையனார் அகப்பொருள் மூலநூலில் கருப்பொருட்களின் பட்டியல் இல்லை. அதன் பிறகு தோன்றி தமிழ்நெறிவிளக்கம் எனும் நூலில் கருப்பொருட்களின் பட்டியல் கொடுக்கப்பட்டதோடு ஒவ்வொரு திணைக்குமான பொருட்கள் வரையறுத்துக் கூறப்பட்டுள்ளன. உணவு பற்றி

“திணையே தருப்பண முதிரை செஞ்நெல்

விலைகோ ளினையன மேவிய வுனவே” (தமிழ்நெறி 10)

என்ற நூற்பா ஒவ்வொரு திணைக்குமான உணவுப் பொருட்களை எடுத்துரைத்தற்குச் சான்றாக உள்ளது. இந்நூலுக்குப் பிறகு இறையனார் அகப்பொருள் நூலுக்கான நக்கீரர் உரையில்

“குறிஞ்சிக்கு உணா இவன நெல்லும் தினையும்

நெய்தற்கு உணா மீன் விலையும் உப்பு விலையும்

பாலைக்கு உணா ஆறலைத்தனவும் ஊரெறிந்தனவும்

முல்லைக்கு உணா வரகும் சாமையும்

மருதத்துக்கு உணா செந்நெல்லும் வெண்ணெல்லும்”

(இறையனார் களவிய உரை ப.22-24)

என ஒவ்வொரு திணைக்குமான உணவுப் பொருட்கள் குறிப்பிடப்பட்டுள்ளன.

பெரும்பான்மையாக அந்தந்த நிலங்களில் விளைவிக்கப்பட்ட, உட்கொள்ளப்பட்ட உணவுப்பொருட்களாக இவற்றை எடுத்துக்கொண்டாலும் இதனுடன் பிற நில உணவுகளும், புலால் உணவுகளும் பழந்தமிழர் உணவுபழக்கங்களில் இடம் பெற்றன என்பது புலனாகிறது.

நீண்டகாலப் பரப்பையும் வெவ்வேறு நிலவியல் அமைப்பையும், நாகரிக வளர்ச்சி நிலைகளையும் தன்னகத்தே கொண்டனவாகக் காணப்படும். சங்கப்பாடல்கள் அனைத்து நிலப்பரப்புகளிலும் நாடோடி முதல் மூவேந்தர் வரையிலான அனைத்துத்தரப்பினரும் இயற்கை உணவுப் பொருட்களே அன்றி இறச்சிப் பொருட்களையும் உணவாக உண்டனர் என்பதைக் காட்டி நிற்கின்றது.

தே. நமசிவாயம் தமது ‘தமிழர் உணவு’ எனும் நூலில்

“குறிஞ்சி நிலத்தின் மூங்கிலரிசிச்சோறு, உடும்பின் இறைச்சி, கடமான் இறைச்சி, பன்றி இறைச்சி, நெற்கள், பலாக்கொட்டை, மோர், நெய், தேன் கிழங்குவகைகள் ஆகியனவும்.

முல்லை நிலத்தில் தினையரிசிச்சோறு, ஆட்டிறைச்சி, மான் இறைச்சி, முயல் இறைச்சி, வான்கோழி இறைச்சி, பால், தயிர், மோர், நெய், கும்மாயம் புளியங்கூழ் ஆகியனவும்

மருதநிலத்தில் செந்நெல் சோறு, வெண்ணெல் சோறு, கோழி இறைச்சி, ஆமை இறைச்சி, மான் இறைச்சி, பலாப்பழம், நூங்கு, வள்ளிக்கிழங்கு ஆகியனவும்

நெய்தல் நிலத்தில் வெண்சோறு, நிணச்சோறு, புல்லரிசிச்சோறு, புளித்த கள், பனங்கள் ஆகியனவும் உணவுப்பொருட்களாக பயன்படுத்தப்பட்டுள்ளதாக குறிப்பிடப்பட்டுள்ளன.

### நிறைவுரை

இயற்கையைச் சார்ந்தே வாழ்வியலை அமைத்திருந்த தொல்குடியினராகிய தமிழர்கள் அவ்வாழ்வியலின் மிகப்பெரிய கூறான தங்களின் உணவுப் பழக்கவழக்கங்களையும் இயற்கை சார்ந்தே கட்டமைத்திருந்தனர்.

### துணைநூற் பட்டியல்:

1. கோவிந்த ராஜ் முதலியார் கா. ர. இறையனார் அகப்பொருள் மூலமும் நக்கீரனார் உரையும் பவானந்தர் கழகம், சென்னை 1937



2. தட்சிணா மூர்த்தி அ., தமிழர் நாகரிகமும் பண்பாடும், ஐந்திணைப் பதிப்பகம், சென்னை 2011.
3. நமசிவாயம் தே. தமிழர் உணவு, உலகத் தமிழாராய்ச்சி நிறுவனம், சென்னை 1981.

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## சிறுபாணாற்றுப்படை காட்டும் ஊரும் பெயரும்

சி. ஆன்சி மோள்

உதவிப்பேராசிரியர், தமிழ்த்துறை, ஹோலிகிறாஸ் கல்லூரி(தன்னாட்சி),  
நாகர்கோவில் - 629004.

### ஆய்வுச் சுருக்கம்

பத்துப்பாட்டு என்பது சங்கத்துச் சான்றோர் எண்மரால் இயற்றப்பட்டுக் கடைச்சங்கத்தின் இறுதிக்காலத்தில் தொகுக்கப்பெற்ற பத்துப்பாடல்களைத் தன்னகத்துக்கொண்டே ஒரு நூலாகும். இதில் உள்ள ஆற்றுப்படை நூல்களில் மூன்றாவது அமையபெற்றது சிறுபாணாற்றுப்படையாகும். சிறுபாணாற்றுப்படையின் பாட்டுடைத் தலைவனாகிய நல்லியக்கோடன், ஓய்மாநாட்டின் அரசன். எயிற்பட்டினம், மாவிலங்கை, கிடங்கில் முதலிய ஊர்கள், இவனுக்கு உரியது என்று போற்றப்படுகிறான்.

நல்லூர் நத்தத்தனார், நல்லியக்கோடனுடைய தலைநகரமான கிடங்கில் என்னும் ஊருக்குச் சிறுபாணனை ஆற்றுப்படுத்திய வழியையும் எயிற்பட்டினம், மாவிலங்கை, கிடங்கில் என்ற ஊர்களின் இன்றைய பெயர்களைப் பற்றி ஆராய்ந்து காட்டுவதே இக்கட்டுரையின் நோக்கமாகும்.

### முன்னுரை

சிறுபாணாற்றுப்படை என்பது பத்துப்பாட்டில் ஒரு பாட்டாகும். நல்லூர் நத்தத்தனார் என்னும் புலவர், நல்லியக்கோடன் என்னும் வள்ளலைப் பாடியது சிறுபாணாற்றுப்படை. இவ்வாற்றுப்படை 269 அடிகளைக் கொண்டது. இதில் நல்லியக் கோடனிடம் சென்று பரிசு பெறும்படி நத்தத்தனார் ஒரு பாணனை ஆற்றுப்படுத்துகிறார். (ஆறு=வழி. ஆற்றுப்படுத்தல் = வழி கூறுதல்) சிறுபாணாற்றுப்படையில் வரும் ஊர்களும் அவற்றின் இன்றைய பெயர்களும் பற்றி இக்கட்டுரையில் சிறிது காண்போம்.

### எயிற்பட்டினம்

சிறுபாணாற்றுப்படை இவ்வூரை எயிற்பட்டினம் என்று குறிப்பிடுகிறது. எயில் என்றால் மதில் (Wall) என்று பொருள். மதிலைக் கொண்ட கடற்கரைப் பட்டணம் எயிற்பட்டினம் என்று ஆயிற்று. எரித்திரியக் (Periplus of the Erythraean Sea) என்ற கையெழுத்து ஆவணத்தில் (manuscript document) 22 எயிற்பட்டணம் சோபட்மா (Sopatma) என்று குறிப்பிடப்படுகிறது. பெரிப்ஸ் (Periplus) என்னும் இந்தப் படைப்பு ஒரு குறிப்பிட்ட ஆசிரியரால் எழுதப்பட்டதல்ல. கடற்பயணக் குறிப்புகள் கடல் சார்ந்த கிரேக்க மொழி பேசிய எகிப்திய வணிக மாலுமிகளால் எழுதப்பட்டிருக்கலாம் என்று ஆய்வாளர்கள் நம்புகிறார்கள். சோ என்றால் மதில் என்று பொருள். பட்டமா என்றால் பட்டினம் என்று பொருள். சோபட்மா என்றால் மதிலை உடைய பட்டணம் என்று பொருள். மரங்கள் நிறைந்திருந்த பகுதி என்பதால் மரக்காணம் என்ற பெயர்பெற்றது என்பது பெயர்க்காரணம் பற்றிய ஒரு கருத்தாகும். விக் கிரமசோழன் காலத்தில் விக் கிரமசோழசதுர்வேதி மங்கலம் என்று பெயர் பெற்றிருந்தது.

“பாடல் சான்ற நெய்தல் நெடுவழி

மணிநீர் வைப்பு மதிலொடு பெயரிய

பனிநீர் படுவிற்பட்டினம்

என்று இப்பட்டினம்” (சிறுபாண். 151-153) கூறப்படுகிறது.

கடல் ஓரமாக நெய்தல் நிலத்திலே இருந்த எயிற்பட்டினத்துக்கு மேற்கே குறிஞ்சி நிலத்திலே, நல்லியக் கோடனுடைய தலைநகரமான கிடங்கில் என்னும் ஊர் இருந்தது. இதனை,

“குறிஞ்சிக் கோமான் கொய்தளிர்க் கண்ணிச்

செல்லிசை நிலைஇய பண்பின்

நல்லியக் கோடன்” (சிறுபாண். 267 - 269) என்று ஆற்றுப்படை கூறுகிறது.

நெய்தல் நிலத்து எயிற்பட்டினத்துக்கும் குறிஞ்சி நிலத்துக் கிடங்கிலுக்கும் இடையிலே வேலூர், ஆமூர் என்னும் ஊர்கள் இருந்தன. இவ்வூர்கள் எல்லாம் ஓய்மா நாட்டில் அடங்கியிருந்தன. ஓய்மாநாடு என்பது இப்போதைய தென் ஆர்க்காடு மாவட்டத்தில் திண்டிவனம் தாலுகாவில் இருந்தது. இந்த எடக்கு (இடைக்கழி) நாட்டிலே இப்போதும் ஒரு நல்லூர் என்னும் சிற்றூர் இருக்கிறது. இந்த இடைக்கழி நாட்டு நல்லூரிலே நாட்டுக்கு அண்மையிலே, தெற்குப் பக்கத்திலே நல்லியக் கோடனுடைய ஓய்மா நாடு இருந்தது.

#### **மரக்காணம்**

ஓய்மா நாட்டின் கடற்கரைப் பகுதியாகிய பட்டின நாட்டிலே, (மாவிலங்கையிலே), கடற்கரை ஓரத்தில் எயில் (சோ) பட்டினம் இருந்ததென்று கூறினோம். பண்டைக் காலத்தில் இருந்த எயிற்பட்டினம் இப்போது மறைந்துவிட்டது. அந்த இடத்தில் இப்போது மரக்காணம் என்னும் ஊர் இருக்கிறது. மரங்கள் நிறைந்திருந்த பகுதி என்பதால் மரக்காணம் என்ற பெயர்பெற்றது என்பது பெயர்க்காரணம் பற்றிய ஒரு கருத்தாகும். விக்ரமசோழன் காலத்தில் விக்ரமசோழசதுர்வேதி மங்கலம் என்று பெயர் பெற்றிருந்தது. பி.எல். சாமி தனது ”மகாபலிபுரத்தில் 5” (Samy, P L (1976). Water Cult at Makapalipuram in Journal of Tamil Studies, issue 9-10. p 90) என்ற கட்டுரையில் எயிற்பட்டினமே தற்போதைய மரக்காணம் என்று அடையாளப்படுத்துகிறார். சிறுபாணாற்றுப்படையில் வருணிக்கப்படும் எயிற்பட்டினமும் பெரிபுள் சுட்டிக்காட்டும் சோபட்டமா என்ற சோபட்டினமும் ஒன்று என்று கருதலாம்.

மரக்காணம் ஊருக்கு வடக்கே சுமார் 2-3 கி.மீ. தொலைவில் கடல்நீரை உப்பளங்களுக்குக் கொண்டுசெல்லும் கழிமுகம் உள்ளது. கடற்கரைக்கும் உப்பளங்களுக்கும் இடைப்பட்ட நிலத்தில் உள்ள பல குப்பங்களில் இன்றும் பரதவர் வாழ்கின்றனர். சிறுபாணாற்றுப்படை இவற்றைக்

“கழி சூழ்ந்த ஊர்களையுடைய பட்டினம்” என்று சுட்டுகிறது.

மரக்காணம் உப்பு உற்பத்திக்குப் புகழ் பெற்ற ஊர். உப்பு விளையும் களத்துக்கு அளம் என்று பெயர். இங்கு உற்பத்தி செய்யப்படும் உப்பு தரமான உப்பு என்கிறார்கள். தமிழ்நாடு அரசுக்குச் சொந்தமான 3,000 ஏக்கர் பரப்பளவில், மிகப்பெரும் உப்பளம் உள்ளது. ஆண்டுதோறும் 75 ஆயிரம் டன் உப்பு உற்பத்தி செய்யப்படும் இப்பகுதியில் ஜனவரி மாதத்தின்

பிற்பகுதியில் தொடங்கி ஜூன் மாதம் வரை உப்பு உற்பத்தி நடைபெறுகிறது. சோழர்கள் ஆட்சியிலும் விஜய நகரப் பேரரசின் ஆட்சியிலும் மரக்காணம் உப்பு உற்பத்தியில் முதலிடம் வகித்துள்ளது. சோழ அரசு உப்பு உற்பத்தியைத் தன் கட்டுப்பாட்டில் வைத்திருந்தது. சோழர்கள் உப்புக்கு விதித்த வரி உப்பாயம் எனப்பட்டது. அளவில் பெரிய உப்பளங்களுக்குப் பண்டைய அரசர்களின் பட்டப் பெயர்கள் சூட்டப்பட்டன எ.கா. பேரளம், கோவளம் (கோ அளம்), மரக்காணம் பூமீசுவரர் கோவில், “மனக்காணமான இராசராசப்பேரளம்” என்று கல்வெட்டுகளில் குறிப்பிடப்பட்டுள்ளது.

இவ்வூரில் பிற்காலச் சோழர்களின் சாசன எழுத்துக்கள் காணப்படுகின்றன. இந்தச் சாசனங்களிலே, ‘ஓய்மா நாட்டுப் பட்டின நாட்டுப் மரக்காணம்’ என்றும் ‘ஓய்மா நாட்டுப் பட்டின நாட்டுப் பட்டினம்’ என்றும் “பட்டின நாட்டு எயிற்பட்டினம்” என்றும் இவ்வூர் கூறப்படுகிறது. எனவே, பழைய எயிற்பட்டினந்தான் பிற்காலத்தில் மரக்காணம் என்று பெயர் பெற்றது என்று கருதலாம்.

### ஓய்மா நாடு

இடைக்கழி நாட்டு நல்லூரிலிருந்து தெற்கே சென்றால், ஓய்மா நாட்டின் கிழக்குப்பகுதியாகிய பட்டின நாட்டை அடையலாம். பட்டின நாடு கடற்கரையைச் சார்ந்த நாடு. பட்டின நாட்டிலே கடற்கரை ஓரமாக எயில் (சோ) பட்டினமும் துறைமுகமும் இருந்தன. ஓய்மா நாட்டின் கடற்கரைப் பகுதியாகிய பட்டின நாடு, பெரும்பான்மையும் நீரும் நிலமுமாக அமைந்திருந்தபடியினாலே, அது மாவிலங்கை என்ற பெயர் பெற்றது.

“விரிகடல் வேலி வியலகம் விளங்க

ஒருதான் தாங்கிய உரனுடை

நோந்தாள் நறுவீ நாகமும் அகிலும்

ஆரமும் துறையாடு மகளிர்க்குத்

தோட்டிணை ஆகிய பொருபுனல்

தருஉம் போக்கறு மரபின் தொல்மா

இலங்கைக் கருவொடு பெயரிய

நல்மா இலங்கை மன்ன ருள்ளும்

முறுவின்றி விளங்கிய வடுஇல்

வாய்வாள் உறுபுலித் துப்பின் ஓவியர் பெருமகன்”

(சிறுபாணாற்றுப்படை 113 - 121)

கடற்கரை ஓரமாக நீரும் நிலமும் ஆக அமைந்த இடம் இலங்கை என்று பெயர் பெறும். ஆறுகள் கடலில் கலக்கிற இடத்தில் கிளைகளாகப் பிரிந்து இடையிடையே நீரும் திடலுமாக அமைவது உண்டு. அன்றியும் காயல் என்னும் பெயருள்ள நீர்த் தேக்கமும் கடற்கரை ஓரமாக அமைவதும் உண்டு. இவ்வாறு நீரும் திடலுமாக அமைந்த இடத்தை லங்கா (இலங்கை) என்று ஆந்திர நாட்டவர் இன்றும் வழங்குவர். நீரும் திடலுமாக அமைந்திருந்த பட்டின நாடு மாவிலங்கை என்றும் பெயர் பெற்றிருந்தது. (லங்கா அல்லது இலங்கை என்பது பழைய திராவிட

மொழிச்சொல் எனத் தோன்றுகிறது.) இப்போது ஓய்மா நாட்டு மாவிலங்கைப் பகுதியில் ஏரிகளும் ஓடைகளும் உப்பளங்களும் காணப்படுகின்றன.

### வேலூர்

இடைக்கழி நாட்டு நல்லூரிலிருந்து புறப்பட்டுச் சென்ற சிறுபாணன், ஓய்மா நாட்டுத் துறைமுகப் பட்டினமாகிய எயிற் பட்டினத்துக்குச் சென்றான். சென்றவன் அங்குத் தங்கினான். பிறகு அங்கிருந்து புறப்பட்டுத் தென்மேற்கே நெடுவழியே நடந்தான். நெடுந்தாரம் நடந்து வேலூர் என்னும் ஊரையடைந்தான். இது முல்லை நிலத்தில் இருந்த ஊர்.

“திறல்வேல் நுதியில் பூத்த கேணி

விறல்வேல் வென்றி வேலூர் எய்தின்

உறுவெயிற் குலைஇய வருப்பவிர் குரம்பை

எயிற்றியர் அட்ட இன்புளி வெஞ்சோறு

தேமா மேனிச் சில்வளை ஆயமொடு

ஆமான் சூட்டின் அமைவரப் பெறுகுவிர்” (சிறுபாண். 172-179)

என்று நத்தத்தனார் இந்த வேலூரைப் பாணனுக்கு அறிமுகப்படுத்துகிறார்.

நத்தத்தனார் கூறுகிற வேலூர், தென் ஆர்க்காடு மாவட்டத்தில் ஓய்மா நாட்டில் இருக்கிறது. சிறுபாணன் சென்ற வேலூர், தென்ஆர்க்காடு மாவட்டத்தில் திண்டிவனம் தாலுகாவில், கிடங்கிலுக்கும் எயிற்பட்டினத்திற்கும் இடைவழியில் இப்போது குக்கிராமமாக இருக்கிற வேலூரே என்பதில் சிறிதும் ஐயம் இல்லை. இந்த வேலூர் ஓய்மா நாட்டு வேலூர் என்று பெயர் பெற்றிருந்தது. இந்த வேலூரின் தலைவன் “ஓய்மா நாட்டு வேலூருடையான்” என்று ஒரு சாசனத்தில் கூறப்படுகிறான். இந்த ஊர் தற்போது விழுப்புரம் மாவட்டம் வானூர் வட்டத்தில் உள்ள உப்பு வெல்லூர் தான் சிறுபாணாற்றுப்படை குறிப்பிடப்படும் வேலூராகும்.

### ஆழார்

வேலூரில் தங்கிய சிறுபாணன், அவ்வூரிலிருந்து புறப்பட்டு வடமேற்காகச் செல்லும் பெருவழியே சென்றான். சென்று மருத நிலத்தில் உள்ள ஆழார் என்னும் ஊரையடைந்தான்.

“மருதஞ் சான்ற மருதத் தண்பனை

அந்தணர் அருகா அருங்கடி வியநகர்

அந்தண் கிடங்கின் அவனாமு ரெய்தின்

வலம்பட நடக்கும் வலிபுணர் எருத்தின்

உரன்கெழு நோன்பகட் டுழவர் தங்கை

பிடிக்கை யன்ன பின்னுவீழ் சிறுபுறத்துத்

தொடிக்கை மகடுஉ மகமுறை தடுப்ப

விழுங்கா லுலக்கை யிருப்புமுகந் தேய்த்த

வவைப்பு மாணரிசி யமலைவெண் சோறு

கவைத்தாள் அலவன் கலவையொடு பெருகுவிர்” (சிறுபாண். 186-195)

என்று சிறுபாணனுக்கு ஆமுரில் கிடைக்கக்கூடிய உணவைக் கூறுகிறார் நத்தத்தனார்.

இந்த ஆமுர் எது என்பது தெரியவில்லை.செய்யூர் தொகுதியில் அமைந்துள்ள சித்தாமூர் என்று பெயருள்ள ஊர்தான் ஓய்மா நாட்டு ஆமுர் என்று விக்கிபீடியா குறிப்பிடுகிறது.

#### கிடங்கில்

ஆமுரிலிருந்து புறப்பட்டு மேற்கே நெடுவழியே சென்றால், கடைசியில் நல்லியக்கோடனுடைய கிடங்கில் என்னும் ஊரையடையலாம் என்று சிறுபாணாற்றுப்படை கூறுகிறது.

திண்டிவனம் நகரின் ஒரு பகுதி என்று தற்போது அறியப்படும் கிடங்கில் ஓய்மா நாட்டின் தலைநகராக விளங்கியது.தற்போது நல்லிக்கோடன் நகர் என்று ஒரு பகுதி திண்டிவனத்தில் உள்ளது. கிடங்கு என்றால் அகழி என்று பொருள்.அகழிகள் சூழ்ந்த மிகவும் தொன்மையான ஊர் கிடங்கில்.

“கிளை மலர்ப் படப்பைக் கிடங்கில்

கோமான்” (சிறுபாண். 160) என்ற பாடல் வரிகள்

ஓய்மா நாட்டு நல்லிக்கோடன் மலர்க்கொத்துக்கள் நிறைந்த தோட்டங்களை உடைய கிடங்கில் என்னும் ஊர்க்கு மன்னன் ஆவான் என்று பாடல் வரிகள் கூறுகிறது.

“கிடங்கில் அன்ன இட்டுக் கரைக் கான்யாற்றக்

கலங்கும் பாசி நீர் அலைக் கலாவ” (நற்றிணை 65,2-3)

அகழியால் பாதுகாக்கப்படும் நகரம் கிடங்கில் ஆகும் என்று நற்றிணை குறிப்பிடுகிறது. எனவே, கிடங்கிலுக்குச் சிறுபாணன் சென்ற பெருவழி, அல்லது நத்தத்தனார் சென்ற பெருவழி இது இடைக்கழிநாட்டு நல்லூரிலிருந்து புறப்பட்டு, இப்போதைய மரக்காணமாகிய எயிற்பட்டினத்துக்குப் போய் அங்கிருந்து வேலூருக்குச் சென்று, அங்கிருந்து புறப்பட்டு ஆமுரை அடைந்து, ஆமுரிலிருந்து கிடங்கிலை அடைந்தார் என்பது தெரிகிறது.

#### முடிவுரை

சிறுபாணாற்றுப்படையில் கூறப்படுகின்ற ஊர்களைக் கொண்டும் அவ்வூர்களின் அமைப்பைக் கொண்டும் சிறுபாணாற்றுப்படையில் வரும் எயிற்பட்டினம், மாவிலங்கை, கிடங்கில் என்ற ஊர்களின் இன்றைய பெயர்களைப் பற்றியும் அவ்வூர்களின் சிறப்புகளைப் பற்றியும் அறிந்து கொள்ள முடிகிறது.

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2. நற்றிணை - திரு.பெ.வே. சோமசுந்தனார் சைவ சித்தாந்த நூற் பதிப்புக் கழகம், டிடி, கே சாலை, ஆழ்வார்பேட்டை சென்னை-18
3. பத்துப்பாட்டு ஆய்வுகள் - நைசி.கரிகாலன், பாவையிரிண்டர்ஸ், ராயப்பேட்டை,சென்னை-14

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## சங்க இலக்கியங்களில் விரிச்சி

சா. டெய்சிபாய்

உதவிப் பேராசிரியர், தமிழ்த்துறை, ஹோலிகிராஸ் கல்லூரி(தன்னாட்சி),  
நாகர்கோவில் - 629004.

### முன்னுரை

பழந்தமிழ் இலக்கியங்களான பாட்டும் தொகையும் ஈராயிரம் ஆண்டுகளுக்கு முற்பட்ட மானுட சமுதாயத்தின் அனைத்துக் கூறுகளையும் பிரதிபலிக்கும் கண்ணாடியாகத் திகழ்கின்றன. பண்டைத் தமிழர்களின் அறநெறிகள், பின்பற்றி வாழ்ந்த நெறிமுறைகள், நம்பிக்கைகள் ஆகிய எல்லாவற்றையும் சங்கப் பாடல்கள் புலப்படுத்துகின்றன. நாட்டார் வழக்காறு என்பது மக்களின் பழக்கவழக்கங்கள் மற்றும் நம்பிக்கைகள் சார்ந்தது ஆகும். பிறப்பு முதல் இறப்பு வரை மனிதன் பலவிதமான நம்பிக்கைகளை கொண்டிருப்பதைக் காண்கிறோம். இந்நம்பிக்கைகள் காலங்காலமாக ஒரு தலைமுறையினரிடமிருந்து மற்றொரு தலைமுறையினருக்குப் பரவி வருகின்றன. இன்று நாம் கடைபிடிக்கும் நம்பிக்கைகள் ஆதிகாலந்தொட்டே நம் தமிழ்ச்சமூகம் பின்பற்றி வரும் நம்பிக்கைகள் என்பதனை விளக்க பழந்தமிழ் இலக்கியங்கள் சான்றுகளாகத் திகழ்கின்றன.

### காகம் கரைதல்

காகம் கரைந்தால் விருந்தினர் வருவர் என்ற நம்பிக்கை இன்று பலரிடம் காணப்படுகிறது. காகம் கரைவது நன்னிமித்தம் என்பதற்கு காக்கை பாடினியர் நச்செள்ளையார் பாடிய குறுந்தொகைப் பாடல்களை உதாரணமாகக் கூறலாம். தலைவனைப் பிரிவுற்ற தலைவி மிகவும் வருந்துகிறாள். அந்நேரத்தில் காகம் கரைகிறது. பிரிவுற்ற தலைவனும் வந்து சேர்ந்தான். தலைவனின் வரவினைக் கண்ட தலைவி மகிழ்வுற்றாள். தலைவியின் பெருந்தோளை நெகிழ்ச்சியுடன் அவளின் துன்பத்தைப் போக்குதவற்கு விருந்தினர் (தலைவன்) வருவதைக் கரைந்து கூறிய காக்கைக்குத் தலைவி உணவு கொடுத்தாள் என்று தோழி கூறுவதாக இப்பாடல் அமைந்துள்ளது.

“..... என் தோழி

பெருந்தோள் நெகிழ்த்த செல்லற்கு

விருந்துவரக் கரைந்த காக்கையது பலியே”

(குறு:210)

விருந்தினர் வருவதைக் காக்கை கரைந்து கூறும் என்பதனை இவ்வடிகள் எடுத்தியம்புகின்றன. தெய்வத்தை வழிபட்டு இடப்படும் உணவு பலி உணவு ஆகும். தலைவிக்கு நன்னிமித்தமாகக் கரைந்த காக்கைக்குக் கொடுக்கப்படும் உணவினை ‘பலி’ என குறிப்பிடுகிறாள் தோழி. உணவு உண்ட பின்னர் விருந்தினர் வாழை இலையை உள்பக்கம் மடித்தால் மீண்டும் வந்து விருந்து உண்ணும் பாக்கியம் கிட்டும் என்றும் விருந்தினர்க்குச்

சேவல்கறியை உண்ண கொடுக்கக் கூடாது என்ற நம்பிக்கையும் பழந்தமிழரிடையே காணப்பட்டது.

### பல்லி சத்தம்

விரிச்சி என்பது நற்சொல் கேட்டல் ஆகும். பண்டைத் தமிழர் போருக்குச் செல்லும் முன் விரிச்சி கேட்டே செல்வர். ஏதோ ஒரு செயலைப் பற்றி எண்ணிக் கொண்டிருக்கும் போதோ அல்லது வேறு ஒருவருடன் பேசிக் கொண்டிருக்கும் போதோ பல்லிச் சத்தம் கேட்டால் 'சத்தியம்', 'உண்மை' பல்லி சத்தம் போடுகிறது என்று பெரியவர்கள் கூறுவதுண்டு. இப்பல்லி சத்தம் சங்ககால தலைவிக்கு விரிச்சியாக அமைந்ததை பழந்தமிழ் இலக்கியங்கள் பல இடங்களில் சுட்டிக்காட்டுகின்றன.

### நெஞ்சொடு கிளத்தல்

வினைமுற்றி மீண்டான் தலைமகன். விரைந்து செல்லும் தேரினை மேலும் விரைவுபடுத்துவதற்காக தேர்ப்பாகனிடம், தன் நெஞ்சம் தனக்கு முன்பே தலைவியைக் கூட தன் தலைவிபாற் சென்று விட்டது என்று நயமாகக் சொல்லுவதாய் இப்பாலைத்திணைப் பாடல் அமைந்துள்ளது. இதனை,

“நானொடு மிடைந்த கற்பின், வாற்றுதல்,  
அம்தீம் கிளவிக் குறுமகள்  
மென்தோள் பெற நசைஇச் சென்றான் நெஞ்சே?

(அகம்: 9-25:26)

என்று தலைவியின் பால் சென்ற நெஞ்சினைக் கூறிவிட்டு,

“பல் மாண்  
ஓங்கிய நல்இல் ஒருசிறை  
பாங்கர்ப் பல்லி படுதோறும் பரவி,  
கன்று புகுமாலை நின்றோள் எய்தி (அகம் : 9-17:20)

இவ்வடிகள், பசுவின் கன்றுகள் வீடு திரும்புகின்ற மாலை காலத்தில், பல அடுக்குகளால் மாண்புற்று விளங்கும் உயர்ந்த மாளிகையில் ஓரிடத்தில் நின்ற தலைவி, தலைவன் வரவினைக் கூறும் பல்லியினது சத்தத்தைக் கேட்டு அதனை வாழ்த்தியவாறு நிற்பாள் என்று தலைவன் தன் நெஞ்சிற்கு கூறுவதாய் அமைந்துள்ளது.

### நன்னிமித்தம்

பன்றியானது தினை கதிரை உண்பதற்கு பல்லி சத்தம் கேட்டு அதனை நல்நிமித்தம் என்று கருதி தினை உண்ணச் செல்லுதலும் உண்டு. இதனை அகநானூற்றுக் குறிஞ்சித்திணைப் பாடல் குறிப்பிடுகிறது.

“முதைச் சுவற் கலித்த மூரிச் செந்தினை  
ஓங்கு வணர்ப் பெருங் குரல் உணீகிய பாங்கர்ப்  
பகுவாய்ப் பல்லிப் பாடு ஓர்ந்து. (அகம் 88-1:3)



திறந்த வாயையுடையப் பல்லி என்பதனை 'பகுவாய்ப் பல்லி' என்று குறிப்பிட்டுள்ளார்.

### உறுவது கூறும் பல்லி

தலைவன் பொருளீட்டும் பொருட்டுத் தலைவியைப் பிரிந்து செல்கிறான். அவன் செல்லும் வழியோ காட்டுவழி. தலைவனை நினைத்து உடல் மெலிவுறுகிறாள் தலைவி. அவ்வேளையில் தலைவி தோழியை நோக்கி,

“பதுக்கைத்து ஆய செதுக்கை நீழல்

கள்ளி முள்அரைப் பொருந்தி, செல்லுநர்க்கு

உறுவது கூறும், சிறுசெந் நாவின்

மணிஓர்த் தன்ன தெண்குரல்

கணிவாய், பல்லியகாடு இறந் தோரே!” (அகம் 151-11-15)

என்று தலைவன் செல்லும் காட்டு வழியின் தன்மையினை எடுத்தியம்புகிறாள். அக்காட்டுவழிச் செல்வோர், அங்கு இடம் பெறும் பதுக்கையின் நிழலில் வளர்ந்துள்ள முட்கள் பொருந்திய கள்ளிச் செடியின் அடியில் தங்கிச் செல்வர். அப்போது பல்லியானது வழி செல்வோர்க்கு உண்டாகும் நிகழ்ச்சிகளை முன்னதாக அறிந்து கூறும். இதனை 'உறுவது கூறும்' என்னும் அடி குறிப்பிடுகிறது. மேலும் சிவந்த நாவின்மேலும், பல்லியின் குரல் மணியோசையைக் கேட்டாற் போன்ற தெளிந்த குரலினையும் உடையது என்று தலைவி தலைவன் கடந்து செல்லும் கானகம் வழிச் செல்வோர்க்கு நிமித்தம் கூறும் பல்லிகள் காணப்படும் நாடு என்று குறிப்பிடுகின்றாள்.

### உள்ளுதொறு படுஉம் பல்லி

தலைவனைப் பிரிந்த தலைவி அவன் பிரிவுற்ற நாளிலிருந்து சுவரில் வட்டமிட்டு தலைவனின் பிரிவினை எண்ணிக் கொண்டிருக்கிறாள். மேலும், தலைவனின் பிரிவாற்றாமையைப் பொறுக்கமாட்டாமல் கன்னத்தில் கைஊன்றி தலையணையை அணைத்து அழுதவண்ணம் காணப்படுகிறாள். தலைவனின் கண்களிலிருந்து வழிகின்ற கண்ணீரானது அவனது மகரக்குழை அணிந்த காதுகளில் பட்டு மழைத்துளி போன்று தெறித்து வீழ்கிறது. தலைவனைப் பிரிந்த தலைவி மெலிவினைப் போக்கும் மருந்து தலைவன் என நினைக்கும் பொழுதெல்லாம் பல்லியானது ஒலிக்கிறது. பல்லியின் நன்னிமித்தத்தைப் போற்றித் தொழுது வாழ்ந்தாள். இதனை,

“தோற்றிய

செய்குறி ஆழி வைகல் தோறு எண்ணி,

எழுதுசுவர் நினைந்த அழுதுவார் மழைக்கண்

விலங்குவீழ் அரிப்பனி பொலங்குழைத் தெறிப்ப,

திருந்து இழை முன்கை அணல் அசைத்து ஊன்றி

இருந்து அணை மீது பொருந்துழிக் கிடக்கை,

வருந்துதோள் பூசல் களையும் மருந்துஎன,

உள்ளுதொறு படுஉம் பல்லி”

(அகம் 351:9-16)

என்னும் அடிகள் குறிப்பிடுகின்றன.

### தீய நிமித்தங்கள்

தும்பிகள் நடுப்பகலில் பறப்பது, கூகைகள் குழறல், பெருந்தூக்கம், விளக்குகள் இரவில் நில்லாமை ஆகியவைகள் தீய நிமித்தங்களாகக் கருதப்பட்டன.

“என்னை மார்பில் புண்ணும் வெய்ய

நடு நாள் வந்து தும்பியும் துவைக்கும்

நெடு நகர் வரைப்பின் விளக்கும் நில்லா

துஞ்சாக் கண்ணே துயிலும் வேட்கும்

அஞ்சுவரு குராஅல் குரலும் தூற்றும்” (புறம் : 280 )

### பேய்மகள்

தமிழரிடையே பேய்கள் குறித்த நம்பிக்கை இருந்தது. அவற்றின் உருவம், இருப்பிடம், செயல்கள் முதலானவற்றைப் பற்றி பலவிதமாக கற்பனை செய்திருந்தனர். நெருப்புத் தொங்கும் நாக்கு, குருதிப்பூசிய செம்பட்டையான தலைமயிர், முருங்கைக்காய் போன்ற விரல், புலால் வீசும் உடல் இவ்வாறாகப் பலவாறு நம்பினர்.

“இனத்தடி விராய வரிக்குடர் அடைச்சி

அமுகுரற் பேய்மகள் அயர்”

(புறம் : 370 )

பேய்கள் பிணத்தைத் தழுவிக்கொண்டும் கைகளை விலாப் பகுதியில் அடித்துக் கொண்டும் மகிழ்ச்சியோடு போர்க்களத்தில் கூத்தாடும் என்றும் குருதியைக் கொண்டு கூழ்க் காய்ச்சி வீரர் வாயில் ஊற்றி மகிழுமென்றும் நம்பினர்.

### முடிவுரை

காலங்கள் மாறலாம், காட்சிகள் மாறலாம், ஆனால் கருத்துக்களை என்றும் வாழையடி வாழையாய் இச்சமூகத்தில் நிலைத்திருக்கும் என்பதற்கு இக்கட்டுரை உதாரணமாகத் திகழ்கின்றது. பண்டைத் தமிழரின் நம்பிக்கைகளில் ஒன்றான ‘நிமித்தம் பார்த்தல்’ (பல்லி சத்தம், காக்கை கரைதல்) மூட நம்பிக்கை என்று பலராலும் வாதிக்கப்படலாம். ஆனால், ஈராயிரம் ஆண்டுகள் தாண்டியும் அவை வாழ்ந்து கொண்டிருப்பதை இக்கட்டுரை விளக்கி நிற்கிறது.

### பார்வை நூற்கள்

1. சங்க இலக்கியம், நியூ செஞ்சரி புக்கவுஸ் (பி) லிட், சென்னை-600 098.
2. திருக்குறள், பரிமேலழகர் உரை, சாரதா பதிப்பகம்.
3. பதினெண் கீழ்க்கணக்கு நூல்கள் (மூலமும் உரையும்), சாரதா பதிப்பகம்.
4. தமிழ் இலக்கிய வரலாறு, மு.வரதராசன், சாகித்திய அகாதமி வெளியீடு.

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## சங்க கால மகளிரின் கூந்தல் அலங்காரம்

ம. ஜாஸ்மின் வினோஜா

உதவிப்பேராசிரியர், தமிழ்த்துறை, ஹோலிகிறாஸ் கல்லூரி(தன்னாட்சி),  
நாகர்கோவில் - 629004.

### முன்னுரை

மனிதனின் சிறப்பு மிக்கப் பண்புகளில் ஒன்று அழகுணர்வு ஆகும். அழகுணர்வானது அறிவுடன் நெருங்கியத் தொடர்பு கொண்டதாக விளங்குகிறது. மனிதன் தன்னையும், தான் வாழ்ந்த இடத்தையும், பயன்படுத்தியப் பொருட்களையும் அற்புதமாக அழகுபடுத்திப் பார்த்து அவற்றில் அளவற்ற மகிழ்ச்சியைக் கண்டிருக்கிறான். அந்த மகிழ்வுணர்வே, கலைக்கு அடிப்படையாக அமைந்துள்ளது. அழகுணர்ச்சியும் அலங்காரமும் ஒன்றோடு ஒன்று தொடர்பு கொண்டவை. சங்ககால சமுதாயத்தில் பெண்கள் மிகவும் சிறப்புப் பெற்று விளங்கினர். ஆணும் பெண்ணும் இணைந்துதான் வாழ்க்கை என்றாலும் இருவருக்கும் என்று தனித்தனி கலைகள் உண்டு. ஆண்களின் கலைகள் பெரும்பாலும் வீரத்தோடு தொடர்பு கொண்டதாகவும், பெண்களின் கலைகள் நுணுக்கமான அழகுக்கலைகளோடு தொடர்பு உடையதாகவும் விளங்கின. ஆயக்கலைகள் அறுபத்து நான்கு என்பதில் ஒப்பனைக் கலைகளும் ஒன்று. பெண்கள் தங்களை ஒப்பனை செய்து கொள்ளக்கூடிய கலைகளில் கூந்தல் அலங்காரம் என்பது மிக சிறப்பு வாய்ந்த கலையாகப் பார்க்கப்படுகிறது.

### கூந்தல் அலங்காரம்

மகளிர் தங்களைப் பல்வேறு விதங்களில் ஒப்பனை செய்து கொண்டதாக இலக்கியங்கள் இயம்புகின்றன. அவற்றில் ஆடை, அணிகலன்களைப் போன்றே கூந்தல் அலங்காரமும் முக்கியத்துவம் பெறுகிறது. அழகாகப் பின்னி முடிக்கப்பட்டக் கூந்தல் காண்போரைக் கவர்ந்திழுக்கிறது. ஒவ்வொரு பின்னலிலும் பல்வகையான மலர்களைச் சூடி மகளிர் ஒப்பனை செய்து கொள்வர். கூந்தலை, விரித்த நிலையில் தலைவி நடந்து சென்றால் கார்மேகம் என்று நினைத்து மயிலானது தோகையை விரித்து ஆடுகின்ற செய்திகளை சங்க இலக்கியங்கள் சுட்டுகின்றன. கூந்தலின் அழகை மேலும் மெருகேற்ற பல்வகை வாசனைப் பொருட்களைப் பயன்படுத்துகின்ற தன்மை காணப்படுகிறது. கூந்தலைக் காய வைப்பதற்காக அகில் போன்ற மணம் தருகின்ற பொருட்களால் புகையூட்டப்படுகிறது. கருமையான கூந்தலை இருளுக்கு ஒப்பிட்டு புலவர்கள் செய்யுளில் பாடியுள்ளனர். வெண்மையான நரைத்தக் கூந்தலை சங்கிற்கு உவமையாகப் பாடியுள்ளனர். நீண்ட கூந்தல், அளவான கூந்தல், குட்டையான கூந்தல் என கூந்தல்கள் பலவகைகளில் வளர்க்கப்படுகின்றன. கூந்தலை வெட்டி சரி செய்வதற்கு கத்தரிக்கோலைப் பயன்படுத்தி உள்ளனர் என்று சங்க இலக்கியங்கள் எடுத்துக் கூறுகின்றன.

பெண்களின் கூந்தலை சங்க இலக்கியம் பல்வேறு பெயர்களில் குறிப்பிடுகிறது. அளகம், கூந்தல், பித்தை, முச்சி, ஓதி, கதுப்பு, குழல் என பலபெயர்கள் சங்க இலக்கியத்தில் கூந்தலுக்குக் குறிப்பிடப்படுகின்றன. 'ஐம்பால்' என்னும் சொல்லும் சிறப்பாக இடம் பெறுகிறது.

“கண்மணிச் சிலம்பின் சில்மொழி ஐம்பால்  
பின்னொரு கெழீஇய” (கலி.125)

“மகளிர் முடித்த மண்ணா முச்சி  
நெய்கனி வீழ் குழல் அகப்படத் தைஇ” (அகம்.73)

“நறுமலர் அணிந்த நூறு இரு முச்சிக்  
குறமகள்” (ம.ப.182)

பெண்கள் தங்களின் கூந்தலை நீளமாக வளர்ந்திருந்தார்கள். பின்னப்பட்ட அந்தக் கூந்தல் சடையானது யானையின் தும்பிக்கை போல் நீண்டும் தாழ்ந்தும் வளைந்தும் கிடந்தது என்று சிறுபாணாற்றுப்படை குறிப்பிடுகிறது.

“பிடிக்கை அன்ன பின்னுவீழ் சிறுபுறுத்து” (சி.பா.191)

பெண்கள் தங்களுடைய கூந்தலை நறுமணமுட்டி ஒப்பனை செய்கிறார்கள். பின்னர் அதனை எடுத்து முன்புறமாக பரவவிட்டார்கள் என்று மலைபடுகடாம் கூறுகிறது.

“வதுவை நாரும் வண்டுமழ் ஐம்பால்  
மடந்தை மாண்ட நுணங்கு எழில் ஆகத்து  
அடங்கு மயிர் ஒழுகிய அவ்வாய் கடுப்ப  
அகடு சேர்ப்பு பொருந்த அளவினில் திரியாது” (நெ.வா.137)

‘கதுப்பு’ என்னும் கூந்தலை குறிப்பிடுவர். இது பொதுவான பெயராக இல்லாமல் பின்னி முடிக்கப்பட்ட கூந்தலைக் குறிப்பிடுவதாக இருக்கிறது.

பின்னப்பட்ட கூந்தலின் கடைசிப்பகுதி குழன்று இருக்கும்போது அதனை ‘பித்தை’ என்று குறிப்பிடுவர். இத்தகைய ‘பித்தை’-யில் மன்னன் கரிகாலன் தாமரை மலரைச் சூடி உபசரித்தான் என்று பொருநராற்றுப்படை குறிப்பிடுகிறது.

“எரி அகைந்தன்ன ஏடுகல் தாமரை  
கரி இரும்பித்தை பொலியச் சூடி” (பொ.பா.160)

### கூந்தலை வடிவமைத்தல்

தேவைக்கும் முகபாவத்திற்கும் ஏற்ப முடியை வெட்டி அதனை அழகுபடுத்தும் கலையில் கைதேர்ந்தவர்களாக அக்கால மகளிர் விளங்கியுள்ளனர். ஒவ்வொருவருடைய கூந்தல் அலங்காரமானது அவர்களது முகபாவனையை வேறுபடுத்திக் காட்டுகிறது. நெற்றிக்கும், தலைமுடி அலங்காரத்திற்கும் நெருங்கியத் தொடர்பு உண்டு. முன்பகுதியில் உள்ள முடி சுருண்டு நெற்றியில் தவழ்ந்தால் அதன் அழகே தனி அழகுதான். இந்த அழகைப் பெற அக்கால மகளிர் பல்வகை முயற்சிகளைச் செய்துள்ளனர். பதிற்றுப்பத்து இத்தகைய அலங்காரத்தை,

“ஒடுங்ககீரோதி ஒண்ணுதல்” (ப.பத்து 81)

எனக் குறிப்பிடுகிறது. தோளின் மேல் தாழ்ந்து இருள்படக் கிடந்த கூந்தலைக் குறித்து அகநானூறும் கூறுகிறது. தற்காலப் பெண்களும் நீளமான முடியைக் குட்டையாக வெட்டி இத்தகைய அலங்காரத்தை மேற்கொள்வதைக் காணமுடிகிறது. கூந்தல் அலங்காரத்தில் பெண்களின் ஆசைக்கும், கற்பனைக்கும் அளவே இல்லை. முடி அடர்த்தியாகவும், சுருளாகவும், கருமையாகவும் இருந்தால் மட்டுமே இவ்வலங்காரம் நன்றாக அமையும். இன்றைய பாப் கட்டிங்

அமைப்புடன் இது தொடர்புடையதாக இருக்கும் என எண்ணத் தோன்றுகிறது. கூந்தலுக்குப் பலவகை அலங்காரங்களையும் செய்து அதனை முன்பகுதியில் பரவவிட்டு பார்ப்பவர்களைப் பரவசமுட்டும் செய்தியை மலைபடுகடாம் தெரிவிக்கிறது.

பின்னல், பெரும்பான்மை மகளிராலும் பின்பற்றப்பட்ட அலங்காரமாகும். பின்னல் நீளமாகவும், அடர்த்திக் கூடியதாகவும் இருப்பதில் அக்கால மகளிர் அக்கறை செலுத்தினர் என்பதை

“பிடிக்கை அன்ன பின்னு வீழ் சிறு புறம்” (சி.ப. 191)

என்ற வரி புலப்படுத்துகிறது. முதுமகளிர் தம் கூந்தலை நன்கு கோரி பின்னே முடிந்து இட்டனர். இது வெண் சங்கின் வடிவில் இருந்ததாக மதுரைக்காஞ்சி குறிப்பிடுகிறது.

சிலர் தம் கூந்தலை வாழைப்பூவின் வடிவில் முடித்து தொங்கவிடுவர். இதற்குப் பனிச்சைக் கொண்டை என்று பெயர். கூந்தலில் முடி குறைவாக இருப்பின் முடிச்சு இடுவதற்கும் பின்னுவதற்கும் உகந்ததாக இருக்காது. அதற்காக அக்கால மகளிர் செயற்கை முடிகளைப் பயன்படுத்தினர். சங்ககால மகளிர் கவரிமான் முடியைக் கலந்து முடித்துள்ளனர். கவரிமான் முடி கிடைப்பது அரிது. அதைத் தலைமுடியில் அணிவது என்பது பெருமிதத்திற்கும் அழகுக்கும் சான்று பகர்வதாக அமைகிறது. பதிற்றுப்பத்து இவ்வாறு அலங்கரிக்கப்பட்ட கூந்தலை

“கவரி முச்சிக் கார்விரி கூந்தல்” (ப.பத்து. 43)

என்கிறது.

‘ஐம்பால் கூந்தல்’ என்று கூந்தலைப் பற்றிக் கூறும் பொருள் மயக்கத்திற்கு இடம் நல்குவதாகவே உள்ளது. ஐந்து வகைகளாக அதாவது முடி, கொண்டை, சுருள், குழல், பனிச்சை என்று செய்யப்படும் என்றும் பலர் கருதுகின்றனர். ஐந்து சடைகளாகப் பின்னி முடிக்கப்பட்ட கூந்தல் எனக் கருதுவதற்கும் இடம் உள்ளது.

### கூந்தல் அலங்காரத்தில் மலர்கள்

மலர்கள் என்பது மக்களின் வாழ்வியலோடு கலந்த ஒன்றாகும். மகளிர்தம் வாழ்வியல் நிழ்வுகளோடும் மலர்களுக்கும் உள்ள தொடர்பு மிக முக்கியமானது, ஆழமானது, அர்த்தமானது. இயற்கையழகும், மணமும் நிறைந்த தங்கள் கூந்தலுக்குப் பண்டைத் தமிழ் மகளிர் பூக்களால் ஒப்பனை செய்தது அவர்களது கலைத்திறனை நன்கு வெளிப்படுத்துகிறது. அவர்கள் செய்த அலங்காரம் அழகுக்கு அழகு சேர்ப்பதாகவே உள்ளது.

பூக்களால் ஒப்பனை செய்வதால் கூந்தலின் அழகு மெருகூட்டப்படுவதுடன், அதற்கு நல்ல மணமும் கிடைக்க ஏதுவாகிறது. இதற்கெல்லாம் மேலாகத் தங்களை அடையாளப்படுத்திக் கொள்வதற்கும் வாய்ப்பளிக்கிறது. திருமணமான பெண்களும், காதல் உறவு பூண்ட பெண்களும் தான் மலர் அணிந்திருந்ததாக சங்க இலக்கியம் சான்று பகர்கின்றது. போருக்குச் செல்லும் போது சேர, சோழ, பாண்டிய மன்னர்கள் தங்கள் அடையாளப் பூவைச் சூடி சென்றமையை இலக்கியங்கள் குறிப்பிடுகின்றன.

“கோட்டுப்பு, கொடிப்பு. நீர்ப்பூ, நிலப்பூ என்ற நால்வகைப் பூக்களையும் பயன்படுத்தி அவர்கள் மூவகை அலங்காரங்களைச் செய்துள்ளனர். விடுபூ ஆகவும், தொடைப்பு ஆகவும், கட்டுப்பு ஆகவும் பூக்களைக் கூந்தலுக்குப் பயன்படுத்தியமையே மூவகை அலங்காரங்களாகும்” என்று சங்ககால மகளிர் கூந்தல் அலங்காரம் என்ற கட்டுரையில் பக்கம் 67-ல் பேராசிரியர் சொர்ணராஜ் குறிப்பிட்டுள்ளார். பூக்களால் நன்கு அலங்கரிக்கப்பட்ட கூந்தலில் அழகுக்காகப் பொருத்தமான மலர்களை இடையிடையே செருகி வைப்பது அல்லது மாலைகளால் அலங்கரிக்கப்பட்ட கூந்தலில் அம்மாலைகளின் வண்ணங்களுக்குப் பொருந்தும் வண்ணம் நிறமும் மணமும் உள்ள பூக்களின் மெல்லிதழ்களைத் தூவி விடுவது விடுபூ அலங்காரமாகும். விடுபூக்களாகப் பல மலர்களையும் பயன்படுத்திக் கூந்தலை அலங்கரித்த செய்தியை மதுரைக்காஞ்சி அறிவிக்கிறது.

“காதல் இன் துணை புணர்மார் ஆய் இதழ்த்  
தண் நறுங் கழுநநீர் துணைப்ப இழை புனையுஉ  
நல் நெடுங் கூந்தல்” (ம.கா.550-552)

தொடைப்பு என்பது மாலையையே சுட்டுகிறது. மாலையாகவோ, அல்லது வேறு வகைகளிலோ பூக்களைத் தொடுத்து தனித்தன்மை விளங்கும்படி குண்டாக ஓரிடத்தில் வைப்பது கட்டுப்பு ஆகும்.

மலைப்பகுதிகளில் உள்ள ஆழமான சுனைகளுக்குச் செல்லும் குன்ற மகளிர், அங்குப் பூத்துக் குலுங்கி நிற்கும் செடிகளிலிருந்து மலர்களைக் கொய்யாமல் அரும்புகளைப் பறித்துக் கொணர்கின்றனர். பின் அவற்றை விரல்களால் தடவி மலர வைத்து மாலைகளாகக் கட்டித் தங்கள் கூந்தல்களில் சூடியுள்ளனர்.

“விரல் உவர்ப்பு அவிழ்ந்த வேறுபடு நறுங்கான்  
குண்டு சனை பூத்த வண்டு படுகண்ணி  
இணைத்த கோதை அணைத்த கூந்தல்” (திரு.ப.198-200)

இவ்வாறு செயற்கையாக மலர வைத்த மலர்களுக்கு வண்டுகள் அவாவும் வேறுபாடான நாற்றம் உண்டு என்பதை அறிந்தவர்கள் அவர்கள் மட்டுமல்ல, தங்கள் கூந்தலை மொய்க்க வரும் வண்டு வேறு வண்டால் நுகர்ந்து பார்க்காத புதிய மலரின் நாற்றத்தை அனுபவிக்க வேண்டும் என்ற அவாவும் தான் என்றால் அது மிகையாகாது.

நல்ல மணம் வீசும் செண்பக மலர்களைக் கொண்டையில் சூடியுள்ள மகளிர், அதன்மீது மருதின் பூங்கொத்துக்களை வைத்து அலங்கரித்துள்ளனர். மஞ்சள் நிறமுடைய செண்பகக் கொத்துகளின் நடுவில் இருக்கும் மருது மிகவும் எடுப்பாகக் காட்சியளிக்கும் என்பது இயல்பு. இவ்வளவு அலங்காரத்திற்குப் பிறகு மேலும் அக்கொண்டையை அழகுபடுத்த அதனைச் சுற்றி ஒப்புமை உடைய பொருத்தமான பூக்களால் தொடுக்கப்பட்ட மாலையை அணிந்துள்ளனர். பலவிதமான மலர்களால் தங்கள் கொண்டையை அலங்கரித்துள்ள பெண்கள் நிற ஒப்புமையையும், பொருத்தத்தையும் பார்த்தே அவற்றைத் தேர்ந்தெடுத்துள்ளனர் என்பது

புலனாகிறது. இத்தகைய அலங்காரம் தமிழகத்தில் அன்று பெரு வழக்கமாக இருந்துள்ளது. மலர்களைச் சூடுவதற்கு முன் மஞ்சள் நீர் இட்டுக் கூந்தலைக் கழுவி நெய்ப்புத் தன்மையாக்குவது அன்றைய மரபு.

இவ்வாறு நெய்ப்புத்தன்மையாக்கி வெட்சி மலர்களைக் கூந்தலில் விடுபுவாக இட்டு அவற்றின் நடுவில் குவளை மலர்களைச் சூடியதாகத் திருமுருகாற்றுப்படை நவில்கிறது. கூந்தல் நெய்ப்புத்தன்மை உடையதாக இருந்தால்தான் விடுபுக்களைப் பொருத்தமாக இட இயலும்.

“செங்கால் வெட்சிச் சீறதழ் இடை இடுபு

பைந்தாட் குவளைத் தூ இதழ் கிள்ளி” (திரு.ப.21-22)

தனிப்பட்ட மலர்களைக் கொண்டு கட்டிய மாலைகளை விட வெவ்வேறான மலர்களையும் சேர்த்துக் கட்டிய மாலைகளையே அக்கால மகளிர் விரும்பியுள்ளனர். இத்தகைய மாலைகளில் குவளை மலருக்குத் தனி இடம் உண்டு. குளிர் கலத்தில் அதிகமாகக் கூந்தலில் மாலைகளை அணிவதில்லை. எனினும் மங்கலம் கருதி ஒருசில மலர்களை அணிந்துள்ளனர்.

“கூந்தல் மகளிர் கோதை புனையார்

பல் இருங் கூந்தல் சில் மலர் பெய்ம்மா” (நெ.வா.53-54)

கொல்லி மலையில் கிடைத்த மலைப் பச்சையை அக்கால மகளிர் விரும்பிக் கூந்தலில் அணிந்துள்ளனர். பெண்களின் கூந்தலை அவர்களோ, தாயோ, தோழியோ அலங்கரிப்பது செய்தி அன்று. அ.து இயற்கை. ஆனால் பண்டைத் தமிழ் மகன் தன் தலைவியின் கூந்தலை அழகுபடுத்தி ரசித்ததில் ஒப்பாரும். சூமிக்காரும் அற்று விளங்கியுள்ளான். அவன் செய்த அலங்காரம் இயல்பானது, எளிமையானது, அறிவுப்பூர்வமானது. தொடைப்பூ அலங்காரத்தையோ, கட்டுப்பூ அலங்காரத்தையோ அவன் செய்யவில்லை. தனக்குத் தெரிந்த ‘இடுபு’ அலங்காரத்தையே பின்புலத்திற்கு ஏற்பச் செய்துள்ளான். முதுகுப் பகுதியில் சாய்ந்து கிடந்த தலைவியின் கூந்தலில் ஒளி பொருந்திய பாதிரி மலர்களுடன், காட்டு மல்லியைக் கலந்து செருகி, அத்துடன் வெண்கடம்ப மரத்தின் பூங்கொத்தையும் சூடி ஓய்யாரமாக அலங்கரித்து அவளை நடக்கச் சொல்லி ரசித்துத் தன்னை இழந்த தலைவனைப் பற்றி அகநானூறு தெளிவுபடுத்துகிறது.

வரைவின் மகளிர் தங்களை எப்பொழுதும் ஒப்பனை செய்து கொண்டு அழகுக்கு அழகு சேர்த்த வண்ணம் இருப்பார். பலருடன் புணர்ந்த நேரத்தில் நிலை குலைந்த ஒப்பனைகளை மீண்டும் நன்மையுண்டாக ஒப்பனை செய்வார். வானம் எல்லாம் பரவி மணம் கமழ நீர் திரண்டாற் போன்ற வெண் மலர் மாலைகளை வரைவின் மகளிர் தலையில் சூடிக் கொண்டனர். செங்கழுநீர் மலர்களையும் மற்ற பூக்களையும் மழையால் மலர்ந்த சிறு புதர் போல் விளங்கச் சூடிக் கொண்டனர் என்று மதுரைக்காஞ்சி எடுத்துக் கூறுகிறது.

“போது அவிழ் புது மலர் தெரு உடன் கமழ

மேதகு தகைய மிகு நலம் எய்தி

பெரும்பல் குவளைச் சுரும்பு படுபல்மலர்

திறந்து மோந்தனை சிறந்து கமழ் நாற்றத்து

கொண்டல் மலர்ப் புதல் மானப்பூ வேய்ந்து” (ம.கா. 564-568)

தலைவியும் தலைவனும் அசோகின் அணி நிழலில் வீற்றிருந்த நேரத்தில் தலைவியானவள் பல்வேறு நிறம் கொண்ட அழகமைந்த பூமாலைகளை மென்மையான கரிய முடியிலே அழகு பொருந்த சூடியிருப்பாள் என்பதை,

“மெல் இரு முச்சி கவின் பெறக் கட்டி

எரி அவர் உருவின் அம் இழைச் செயலை” (கு.பா.104-105)

என்ற பாடலடிகள் விளக்குகின்றன. காவிரிப்பும்பட்டினத்தில் கணிகையர் குலத்திற் தோன்றிய மாதவி ஆடல், பாடல், அழகு என்னும் மூன்றிலும் சிறந்து விளங்கினாள். அவள் அழகை வர்ணிக்கும் போது தாதுவிரியும் பூக்களையணிந்த கடை குழன்று சுருண்ட கூந்தலையுடைய மாதவி என்று அரங்கேற்று காதையில் ஆசிரியர் குறிப்பிடுகிறார்.

“தாதவிழ் புரிமுழல் மாதவி தன்னை” (சிலம்பு. அ.கா. 7)

இவ்வாறு பூக்களால் தங்கள் கூந்தலைப் பல்வகைத் தன்மைகளால் அழகுபடுத்தி அலங்காரக் கலைக்கே அழகு சேர்த்துள்ளனர் தமிழக மகளிர்.

#### கூந்தல் பாதுகாப்பும் அலங்காரமும்

மனிதன் தன் வாழ்க்கையின் இறுதிவரை கூந்தலை பாதுகாப்பதிலும், அலங்காரம் செய்வதிலும் தன்னை ஈடுபடுத்தி வந்தான். கூந்தலுக்கு இயல்பாகவே இருக்க வேண்டிய நெடுமை, அறப்படல், ஒளியுடைமை, அடர்வு, கடை குழலுதல், கருமை போன்ற பண்புகளைத் தக்க வைத்துக் கொள்ளவும், மேம்படுத்தவும் வேண்டி முறையாக மேற்கொள்ளும் வழிமுறைகளைப் பாதுகாப்பில் உட்படுத்தலாம். மேற்கூறப்பட்ட பண்புகளை உடைய கூந்தல் நீலமணியின் நிறத்தை ஒத்திருக்கும் எனச் சங்க இலக்கியம் சான்று பகர்கிறது. தற்காலத்தில் கூந்தல் பாதுகாப்பிற்காகவும், அலங்காரம் செய்யவும் இரசாயனக் கலவைகளும், அறிவியல் கருவிகளும் வந்துவிட்டன. இவை ஒன்றுமே இல்லாத அக்காலத்தில் தமிழக மகளிர் மேற்கொண்ட வழிமுறைகள் சிறப்புக்குரியது.

#### எருமண் இடல்

முடியைப் பாதுகாப்பது என்பது ஒரு தனிக்கலை. தலைமுடி நெய்ப்புத்தன்மை உடையதாக இருந்தால் மட்டுமே அதனை நன்கு சீவி ஒழுங்குபடுத்த இயலும். இடுபூக்களை இட முடியும். இல்லாவிட்டால் முடிகள் கொத்துக் கொத்தாக திரண்டு சடைபிடித்து விடும். பின் அதைச் சரிசெய்வது என்பது சற்றுக் கடினம். சூரர மகளிர் தன் தலையில் வெட்சிப்புவை சூடும் போது அத்தலை நெய்ப்புத் தன்மை உடையதாகக் காணப்படும்.

“துணையோர் ஆய்ந்த இணை ஈர் ஒதி” (திரு.ப.20)

அதற்காக முடியை எப்போதும் நெய்ப்புத் தன்மை உடையதாக வைத்துக் கொள்ள இயலாது. அது முடியின் நலத்திற்குக் கேடு. நெய்ப்புத் தன்மை உடைய முடியின் ஈரம் எளிதில் உலராது. அப்படிப்பட்ட முடியில் ‘முடிக்காய்’ உண்டாகும். அது முடியின் இயற்கை



அழகைக் கெடுத்து விடுவதுடன் பொடுகு ஏற்படவும் வழிவகுக்கிறது. பேய் மகள் நெய்ப்பு இல்லாத தலைமயிரை உடையவள் என திருமுருகாற்றுப்படை குறிப்பிடுகிறது.

“சூர் முதல் தடிந்த சுடர் இலை நெடு வேல்

உலறிய கதுப்பின் பிறழ் பல் பேழ் வாய்” (மேலது.46-47)

தலைமுடியில் பொடுகு போன்ற பிரச்சனைகளைப் போக்குவதற்கு இன்றைய மகளிர் ஷாம்பு போன்ற இரசாயனப் பொருட்களைப் பயன்படுத்துகின்றனர். பண்டையத் தமிழ் மகளிர் எருமண்ணைப் பயன்படுத்தினர். குடியிருப்புகளுக்குப் புறமே இருக்கும் மக்கள் வழக்கற்றபொழில்களிலிருந்து களி மண்ணின் மேற்பகுதியை எடுத்து ஷாம்பாகப் பயன்படுத்தினர். பொழில்களில் இலைகளும், பல்வேறு பூக்களும் விழுந்து அழுகி, மட்கி மண்ணுடன் நன்கு கலந்திருக்கும். அந்த மண்ணின் மேல்பகுதி பசை போன்ற இன்றைய ஷாம்பை விட மென்மையாக இருக்கும். இதனை எடுத்துக் கொணர்ந்து தலைக்கு இட்டு அழுக்கு, நெய்ப்பு ஆகியவற்றைப் போக்கினர். இச்செய்தியைக் கூழை பெய் எக்கர் என்கிறது குறுந்தொகை,

“எருமண் இடுவதால் முடி”

1. பட்டுப்போல் மென்மை உடையதாகிறது.
2. ஒளியுடைமை பெறுகிறது.
3. வளமை பெறுகிறது.
4. அழகு பெறுகிறது.

### உலர்த்துதல்

எருமண் இட்டுக் கூந்தலைக் கழுவிக்க குளித்தபின் அதனைப் பிழிந்து உலர்த்துவார். வெள்ளையாடையைச் சுற்றிக் கூந்தலின் ஈரத்தைப் போக்கியதாகப் பரிபாடல் நவில்கிறது. கூந்தலைப் பராமரிப்பதில் அதனை உலர்த்துவதற்கு முக்கிய இடமுண்டு. நன்றாக உலர்ந்த பிறகே முடியைப் பின்னி கட்ட வேண்டும். முடியில் எண்ணெய் பசையும், ஈரமும் இருந்தால் பொடுகு கூடும். பிறவகை அலங்காரங்களை மேற்கொள்ள வேண்டுமென்றால் தலைமுடி உலர்ந்திருக்க வேண்டும். எனவே, இதனை முடி அலங்காரத்தின் முதற்படி என்று கூறுவர்.

### அரைப்பு தேய்த்தல்

ஊஞ்சை என்னும் மரத்தின் இலைகளைப் பறித்து நன்றாக உலர வைத்து, இடித்துப் பொடி ஆக்கி, தலையில் தேய்த்து எண்ணெய்ப் பசையைப் போக்கினர் அக்கால மகளிர். இன்றையச் சீயக்காய் பொடியைப் போன்றதே அன்றைய ஊஞ்சைப் பொடியாகும்.

### நறும் புகையூட்டல்

கூந்தலுக்கு நறும் புகையூட்டல் அக்கால மரபு. இது கூந்தலுக்கு ஆரோக்கியத்தை நல்குவதுடன் நல்ல மணத்தையும் நல்குகிறது. இன்றைய Hair Protein Treatment-ன் இன்னொரு வடிவமே நறும்புகையூட்டல் என்று கூறலாம். சந்தனத்தைக் கங்குலாக்கி அதில் அகிற்பசையை இட்டுப் புகைத்துள்ளனர்.கூந்தலை உலர்த்த புகையூட்டியதாகச் சிறுபாணாற்றுப்படை கூறுகிறது.

தகர விறகால் நெருப்புமுட்டி அதில் அகிற்கட்டை, அயிரை ஆகியவற்றை இட்டு கூந்தலுக்குப் புகையூட்டியுள்ளனர். வெண்மேகம் மலையிடை தவழ்கிறது. மயில்தன் தோகையை அவ்வெண் மேகத்தின் இடையே விரிக்கிறது. அது மகளிர் தங்கள் கூந்தலுக்கு அகில் புகையூட்டுவதைப் போல் விளங்கியது என்று சிறுபாணாற்றுப்படை குறிப்பிடுகிறது.

“அகல் உண விரித்த அம் மென் கூந்தலின்” (சி.ப.263)

பலமுறை எண்ணெய் தடவப்பெற்றதால் கூந்தலானது சுருண்டு வளர்ந்து நல்ல கருநிறத்தில் காணப்படும். நறிய மயிற்சந்தனம் பூசப்பெற்று முழுகி அந்த ஈரம் புலரும்படி விரலால் அலைத்துப் பிணிப்பு விடுவிப்பர். கூந்தலைச் சிக்கறுத்த பின்பு அகில் புகையூட்டி மணம் ஏற்றுவர் என்பதை,

“எண்ணெய் நீவிய சரி வளர் நறுங் காழ்

தண் நறுந் தகரம் கமழ மண்ணி

ஈரம் புலர விரல் உள்ள்ப்பு அவிழா

காழ் அகில் அம்புகை கொளீஇ” (கு.பா.107-110)

என்ற பாடலடிகள் விளக்குகின்றன. அகிற்புகையூட்டலால் கூந்தல் தன் ஈரத்தன்மையை இழப்பதோடு அழகிய மணத்தையும் தருகிறது. இன்றும் மகளிர் பலவகையான வாசனை புகையைக் கூந்தலுக்கு ஊட்டுகின்றனர்.

**சாந்து, குழம்பு, சுண்ணம், நெய் பூசுதல்**

இயற்கைப் பொருட்களைப் பயன்படுத்திப் பலவகைச் சாந்துகளையும், குழம்புகளையும் உருவாக்கிக் கூந்தலுக்குப் பயன்படுத்தியுள்ளனர். சந்தனம், அகில், தகரம், நறைக்கொடி, புழுகு, கத்தூரி போன்றவற்றுடன் பனநீர், கற்பூரம், மணநெய் ஆகியவற்றைச் சேர்த்து மேற்குறிப்பிட்டுள்ள கலவைகளை உருவாக்கியுள்ளனர்.

அகிலின் நெய்யை உலர்ந்த முடிக்குப் பூசி இடுபு இட ஏதுவாகியுள்ளனர். தகரம் என்ற மரத்தின் பகுதிகளை எடுத்துக் கரியாக்கிப் பொடி செய்து கூந்தலுக்குப் பூசி அதன் நிறத்திற்கு வலு சேர்த்துள்ளனர். இந்தக் கலவைக்கு மயிர்ச்சந்தனம் என்று பெயர். இந்த தகரத்தைப் பற்றி அறியும் போது இந்தக் கால கருநிற மைதான் நினைவுக்கு வருகிறது. மகளிர் தகரச்சாந்தைப் பூசுவதற்கு வேறு காரணங்களும் உள்ளன. அது தலைக்குக் குளிர்ச்சியை நல்குவதுடன் கூந்தலுக்கு மணத்தையும் நல்குகிறது. வைரம் பாய்ந்த சந்தனக் கட்டையுடன், கத்தூரியைச் சேர்த்து அரைத்து உருவாக்கிய சாந்து மணச்சாந்து எனப்பட்டது. இதனைப் பசங்கூட்டு என்றும் கூறினர். குங்குமம், அகில், பச்சைக் கற்பூரம் ஆகியவற்றைச் சேர்த்து அரைத்துச் சாந்தாகப் பயன்படுத்தியுள்ளதை பரிபாடல் பக்குவமாகச் சுட்டுகிறது. அச்சாந்து நெருப்பைப் போன்ற நிறத்தில் இருந்ததாகவும் இலக்கியங்கள் மூலம் அறிய முடிகிறது.

முல்லை நில ஆயர் மகளிர் பால், வெண்ணெய், நெய் ஆகியவற்றைச் சேர்த்து, தடவித் தலைமுடியைப் பாதுகாத்தச் செய்தியை முல்லைப்பாட்டு அறிவிக்கிறது. இலவங்கம் பச்சிலை, நன்னாரி, கத்தூரி, வேரி இலாமிச்சை, வெண்ணெய், நெல்லி போன்றவையால் கூந்தலுக்கு சாந்து

பூசுவதும் அகிற்புகையால் ஈரம் உலர்த்துவதும் மகளிரின் ஒப்பனைத்திறன் என்று கடலாடுகாதையில் சிலப்பதிகாரம் விளக்குகிறது.

“முப்பத்திருவகை ஓமாலிகையினும்  
ஊறின நன்னீர் உரைத்த நெய்வாசம்  
நாறிருங் கூந்தல் நலம் பெற ஆட்டிப்  
புகையிற் புலர்த்திய பூமென் கூந்தலை” (சிலம்பு.77-80)

மாலை நேரம் நெருங்கும் வேளையில் புணர்ச்சியை மனத்தால் விரும்பிய மகளிர் காதல் மிகுந்த இனிய கணவருடன் கூடும் நேரத்தில் அழகிய மாலைகளை கட்டியும், நல்ல அணிகலன்களை அணிந்தும் இருப்பார். இத்தருணத்தில் கூந்தலில் பூசிய நறுமண மயிர்ச்சாந்தை அலைத்து நீக்குவர். கத்தாரியை அரைப்பார், நறிய சந்தனத்தை அரைத்துப் பூசுவர் என்று மதுரைக் காஞ்சி குறிப்பிடுகிறது.

“நல் நெடுங் கூந்தல் நறு விரைகுடைய  
நரந்தம் அரைப்ப நறுஞ் சாந்து மறுக” (ம.கா.552-553)

#### கரிய கூந்தல்

பெண்மையின் அழகுக்கு அழகு சேர்ப்பது கூந்தல். கூந்தலின் நிறத்தை வைத்து வயது, வாழ்விடச் சூழல் ஆகியவற்றை நம்மால் உணர முடியும். தான் எப்போதும் இளமையுடையவராக இருக்க வேண்டும் என்று ஒவ்வொருவரும் விரும்புகின்றனர். அதனால்தான் கூந்தலானது முதுமையின் காரணமாக வெள்ளை நிறத்தில் இருந்தால் அதை கருமையாக்குவதற்குப் பல கலவைகளைப் பூசுகின்றனர். கரிய கூந்தலானது வயதைக் குறைத்து மதிப்பிடுவதற்கு ஒரு காரணியாக அமைகிறது. சங்க கால மகளிர் கரிய கூந்தலோடு சிறந்து விளங்கினர். அந்த கரிய கூந்தலைப் பாதுகாக்க நறுமண சாந்து பூசி அகில்புகை ஊட்டி அலங்காரப்படுத்தினர். பாடினியின் இயல்பை வர்ணிக்கும் போது ஆற்றின் கருமணலைப் போன்ற கூந்தலை உடையவள் என்று பொருநராற்றுப்படை குறிப்பிடுகிறது.

“அறல் போல் கூந்தல்” (பொ.ப.25)

மேலும் மகளிரின் அழகிய கூந்தல் கருமையால் இவை கருமேகங்களோ எனக் கண்டவர் மயக்கம் அடைவதற்குக் காரணமான கூந்தல் என்றும் வர்ணிக்கின்றார் ஆசிரியர்.

“மழை என மருளும் மகிழ் செய் மாடத்து” (மேலது.84)

ஆண்களுடைய தலை மயிர் பித்தை என அழைக்கப்படுகிறது. கரிகால் பெருவளத்தானிடம் பொருநன் பரிசு பெற செல்லும் போது அவனுடைய கரிய தலைமயிரில் பொன்னால் செய்யப்பட்ட தாமரை மலரை அம்மன்னன் குடுவான் என்று குறிப்பிடப்பட்டுள்ளது.

“எரி அகைந்தனை ஏடு இல் தாமரை  
கரி இரும்பித்தை பொலியச் சூட்டி” (மேலது. 159 - 160)

மகளிர் தம் கூந்தலை விரித்தாற் போன்று காட்டாற்று நீர் இழுத்து வருகின்ற மணல் கரிய மணலாய் காட்சி அளிக்கிறது என்பதை

“கதுப்பு விரித்தன்ன காழி அக நுணங்கு அறல்” (சிறு.ப.6)

என்ற பாடலடி குறிப்பிடுகிறது. மெல்லியதாய் வீழ்ந்து தாழ்கின்ற மேகத்தின் அழகைத் தன்னிடத்தே கொண்டு மேலும் எண்ணெயிலே நிரப்பப்பெற்ற இருண்ட கூந்தலை உடைய விறலியர் என்று குறிப்பிடப்பட்டுள்ளது.

“ஐது வீழ் இகு பெயல் அழகு கொண்டு அருளளி

நெய் கனிந்து இருளிய கதுப்பின் கதுப்பு என” (மேலது.13-14)

தலைவி இயற்கையான அழகை உடையவளாய் இருந்ததால் நீண்ட கரிய கூந்தலை பெற்றிருப்பாள். அக்கூந்தலில் ஒப்பனைக்காக அணிகளை அணிவது செயற்கையழகு என்பதை,

“வார் இருங் கூந்தல் வயங்கு இழை ஒழிய” (பட.பா.219)

என்ற பாடலடி குறிப்பிடுகிறது.

### தொகுப்புரை

மனித இன வரலாற்றில் தன்னை அழகுபடுத்தி பார்ப்பதில் ஒவ்வொருவரும் மிகுந்த ஆர்வத்துடன் இருந்திருக்கின்றனர். தன்னை பிறர் பார்க்க வேண்டும் என்பதற்காகப் பலவிதமான ஒப்பனைகளை மக்கள் செய்திருக்கிறார்கள். ஆடைகள், அணிகலன்கள், கூந்தல்கள் என அனைத்திலும் மக்களின் ஒப்பனைத் திறன் வெளிப்படுகிறது. பெண்களின் கூந்தலைப் பார்த்து கார்மேகம் என்று மயில் வெட்கப்படும் அளவிற்குக் கருமையான கூந்தலையுடையவர்களாக பெண்கள் திகழ்ந்துள்ளனர். இக்கூந்தல்கள் கருமை நிறம் அடைய பலவிதமான சாயங்களைப் பூசியுள்ளனர். இயற்கைச் சார்ந்த பொருட்களால் மனிதர்களின் உடலுக்கு எந்தவிதமான பின்விளைவுகளும் ஏற்படவில்லை. ஆனால், நவீன காலத்தில் செயற்கை சார்ந்த ஒப்பனைகளால் உடலுக்குப் பலவிதமான கேடுகள் ஏற்படுகின்றன. பழங்காலம் முதல் நவீன காலம் வரை ஒவ்வொரு செயலிலும் மனிதர்களின் ஒப்பனைத் திறம் வெளிப்படுவதை நம்மால் உணர முடிகிறது.

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1. சோமசுந்தரனார், பொ.வே.,(பத்துப்பாட்டு) திருநெல்வேலி,தென்னிந்திய சைவசிந்தாந்த நூற்பதிப்புக் கழகம் லிமிடெட் 79, பிரகாசம் சாலை, சென்னை 600001.
2. நாராயணன் வேலுப்பிள்ளை, எம்.,(பத்துப்பாட்டு), முல்லை நிலம், 43, புதுத்தெரு, மண்ணடி, சென்னை - 1.
3. மோகன், இரா.,பத்துப்பாட்டு மூலமும் உரையும் நியூ செஞ்சரி புக் ஹவுஸ் (பி) லிட்-41-பி.சிட்கோ இண்டஸ்டிரியல் எஸ்டேட்,அம்பத்தூர்,சென்னை 600098.

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## கலித்தொகையில் கவியின்பம்

செ. தேன்மொழி

இணைப் பேராசிரியர், தமிழ்த்துறை, ஹோலிகிராஸ் கல்லூரி(தன்னாட்சி),  
நாகர்கோவில் - 629004.

### ஆய்வுச்சுருக்கம்

உலகின் மூத்த மொழி என்ற பெருமைக்குரிய தமிழ் மொழியில் கிடைக்கப் பெற்ற முதல் இலக்கிய வகைமையான சங்க இலக்கியங்களுள் பாவகையால் பெயர் பெற்ற நூல்கள் இரண்டு. அவற்றில் ஒன்று கலித்தொகை. இந்நூல் காதலரின் இன்ப துன்ப உணர்ச்சிகளை இயற்கைச் சூழலுடன் எடுத்துக் கூறுகிறது. அவற்றுள் கபிலரின் குறிஞ்சிக்கலி இயற்கை வருணனை நிரம்பப் பெற்றதாகும். அது கவியின்பம் நல்குவதாக அமைந்துள்ளதை இக்கட்டுரை எடுத்துரைக்கிறது.

### முன்னுரை

சங்க இலக்கியங்களுள் கற்றறிந்தோரால் ஏதப்பப்படும் நூல் எனும் சிறப்புக்குரியது கலித்தொகை. இதில் ஐந்து புலவர்களால் பாடப்பெற்ற 150 பாடல்கள் இடம் பெற்றுள்ளன. இதன் பாடல்கள் நாடகப் பாங்கு அமையப் பெற்றவையாகும். கலித்தொகை பாலைக்கலி, குறிஞ்சிக்கலி, முல்லைக்கலி, நெய்தல்கலி, மருதக்கலி என ஐந்து திணைப் பிரிவுகளை உடையதாக அமைந்துள்ளது. மேலும் இது சொற்சுவையும் பொருட்சுவையும் அழகுணர்வும் ஒலியினிமையும் கருத்து மதிப்பும் ஒருங்கே கொண்ட நூலாகும். உரிய சொற்களை உரிய இடத்தில் பொருத்தி மொழியில் அழுத்தத்தையும் தெளிவையும் உருவாக்கும் போது கவியின்பம் கிடைக்கப் பெறுகிறது. கலித்தொகையில் காணலாகும் கவியின்பம் தரும் இயற்கைப் புனைவுகளை இக்கட்டுரை எடுத்துரைக்கிறது.

### செங்காந்தள்

அழகிய மலைச்சாரலிலே தன் இனிய பிடியோடு பாறையின் மேல் கூடியிருந்தது ஒரு களிற்று. அப்போது அந்தப் பிடியை விரும்பி மற்றொரு களிற்றும் அவ்விடத்திற்கு வரவே அதற்குக் கோபம் வந்தது. வந்த களிற்றின் நெற்றியிலே தன் கொம்புகள் புதையுமாறு குத்தி அதனைத் துரத்திற்று அதன் கொம்பு முனைகள், எதிர் வந்த யானையின் செந்நீரால் சிவந்து தோன்றின. அதுபோலக் காந்தளின் புதுப் பூக்கள் எங்கும் சிவப்பாக மலர்ந்து காட்சியளிக்கிறது.

“உயர் முகை நறுங்காந்தள் நாள்தோறும் புதிது ஈன  
அயம் நந்தி அணிபெற அருவி ஆர்த்து இழிதரும்  
பயமழை தரலஇய பாடுசால் விறல் வெற்பா!” (124)

### மலையழகு

தலைவன் நாட்டின் மலையை வருணிக்கும் போது, சந்திரன் மலை மீது இருப்பது மலை மீது தேனடை இருப்பது போல தோன்றுகிறது. அந்த மலையைத் தொடுமளவு மூங்கில்கள் வளர்ந்திருக்கின்றன. அந்த மூங்கில்கள் மலை மீது இருக்கும் தேனடையை எடுப்பதற்கு ஏணி வைத்தது போன்று கபிலருக்குக் காட்சியளிக்கிறது.

“வானூர் மதியம் வரைசேரின் அவ்வரை  
தேனின் இறால் எனஏணி இழைத்திருக்கும்  
கான் அகல் நாடன் மகன்” (3)

இது வாசிப்பவருக்கு இன்பம் நல்குகின்றது.

யானை

குறிஞ்சிக்கலியில் மலையில் யானைகள் தழைகளைத் தின்று விட்டு நடந்து செல்கின்ற காட்சியைக் கண்ட கபிலருக்குக் காட்டில் மலைகளே நடந்து சென்றது போல இருந்தது என்று உவமையைப் பதிவு செய்திருக்கிறார்.

“புணர்நிலை வளகின் குளகு அமர்ந்துஉண்  
புணர்மருப்பு எழில்கொண்ட வரைபுரை செலவின்து” (2)

வேங்கை மரம்

குறிஞ்சி நில மக்களின் கருப்பொருள்களில் ஒன்றான வேங்கை மரம் தலைவன் தலைவி வாழ்க்கை நிகழ்வுகளில் உவமையாக எடுத்துக் கூறப்பட்டுள்ளது. குறிஞ்சிக்கலியில் இடம் பெற்றுள்ள தோழிக்கூற்றுப் பாடல் ஒன்றில் மலை நாடனை விளித்துக் கூறுமிடத்து வேங்கை மரத்தை புலியுடன் ஒப்பிட்டுப் புலவர்கள் கூறியுள்ளனர்.

“உறுபுலி உருஏய்ப்பப் பூத்த வேங்கையைக்  
கறுவு கொண்டு அதன் முதல் குத்திய மதயானை  
நீடு இருவிடர் அகம் சிலம்பக் கூய்இ தன்  
கோடு புய்க்கல்லாது உழக்கும் நாட!” (38)

எனும் வரிகளில் வேங்கை மலர்கள் மலர்ந்த மரத்தைப் புலி என்று நினைத்து மதயானை வேங்கை மரத்தின் அடிப்பகுதியில் குத்தி வருத்தம் அடையும் என்று கூறப்பட்டுள்ளது.

“வேங்கையஞ் சினைஎன விறற்புலி முற்றியும்  
பூம்பொறி யானைப்புக்கர் முகம் குறுகியும்  
வலிமிகு வெகுளியான் வான்உற்ற மன்னரை  
நயன் நாடிநட்பு ஆக்கும் வினைவர்போல்...” (10)

என்ற பாடல் வரியில் வேங்கை மலர் என்று எண்ணிப் புலியின் மீதும், யானைகள் மீதும் மாறிமாறி வண்டுகள் மொய்க்கின்றன. ஏனென்றால் இரண்டு விலங்குகளின் முகத்திலும் புள்ளிகளிருக்கின்றன. அதை வேங்கை மலர்கள் என்று நினைத்த வண்டுகள் அறியாமையால் அங்கு தேன் குடிக்கச் செல்கின்றன. ஆனால் அங்கு தேனில்லை. இது வாட்போரில் ஈடுபட்ட இரண்டு மன்னர்களுக்கிடையில் தூது செல்வது போல உள்ளது என்கிறார் புலவர்.

மற்றொரு பாடலில் மலை நாட்டில் புலி ஒரு யானையின் பின்புறம் சென்று தாக்குகிறது. உடனே எச்சரிக்கையான யானை புலியைக் கீழே தள்ளி, தன் தந்தத்தால் குத்திப் பிளக்கும் காட்சியை முன்வைத்த புலவர் அது பாரதப் போரில் வீமன் துரியோதனின் தொடையைப் பிளந்து இரத்தம் குடித்தது போல இருந்தது என்பதை

“முறஞ்செவி மறைப்பாய்வு முரண்செய்த புலிசெத்து

மறந்தலைக் கொண்ட நூற்றருவர் தலைவனைக்  
குரங்கு அறுத்திடுவான் போல்கூர் நுதிமடுத்து அதன்  
நிறம்சாட முரண்தீர்ந்த நீள்மருப்பு எழில்யானை”. (16)

எனும் பாடலில் கூறுகின்றார் கபிலர்.

**தலைவி**

கலித்தொகையில் தலைவன் தலைவியின் அழகைப் புகழ்ந்து கூறுமிடத்து  
இயற்கையோடு ஒப்பிட்டுப் புகழ்கிறான்.

“அணிமுகம் மதி ஏய்ப்ப, அம்மதியை நனி ஏய்க்கும்.

மதிமுகம், மாமழை,நின்பின், ஒப்ப பின்னின்கண்

விரிநுண் நூல் சுற்றிய ஈர்இதழ் அலரி

அரவுக்கண் அணி உறழ் ஆரல் மீன்தகை ஒப்ப” (64)

தலைவியின் அழகிய முகம் மதியை ஒத்துள்ளது. மணிகள் விளங்கும் பின்னிய கூந்தல்  
மழையை ஒத்திருந்தது. கூந்தலில் சூடியுள்ள பூவோ, நுண்ணிய நூலால் கட்டப்பட்டு  
தேனால் ஈரமான இதழை ஒத்திருந்தது. மேலும் கரிய பாம்பினிடத்தே கிடந்து அதன் கரிய  
நிறத்தோடு மாறுபட்ட ஆரல் மீனின் அழகைப் போன்று பின்னிய கூந்தலில் கட்டிய பூ  
திகழ்ந்தது என்று கூறப்பட்டுள்ளது. இவ்வாறு தலைவியின் கை, கால், முகம், கண், நுதல்,  
இடை, கூந்தல் என ஒவ்வொரு உறுப்புகளையும் இயற்கையோடு ஒப்பிடுகிறான்  
தலைவன்.

“ஐ தேய்ந்தன்று பிறையுமன்று மைதீர்ந்தன்று, மதியும் அன்று

வேய் அமன்றன்று, மலையும் அன்று பூஅமன் றன்று, சுனையும் அன்று,

மெல்ல இயலும் மயிலும் அன்று, சொல்லத் தளரும், கிளியும் அன்று” (55)

என்று தலைவன் பாராட்டியதைத் தலைவி தன் தோழியிடம் கூறுவதாக  
இப்பாடலடிகள் அமைகின்றன.

தலைவியின் நெற்றி கண்டார் வியக்குமாறு தேய்ந்தது ஆனால் பிறை அன்று. முகம்  
மறுவுள்ளது ஆனால் மதியன்று, தோள்கள் மூங்கில் போல் உள்ளன ஆனால் தலைவி அது  
பிறக்கும் மலையுமல்ல. கண் மலர் போன்றுள்ளது. ஆனால் தலைவி அது பிறக்கும்  
சுனையுமல்ல. சாயல் மெல்லென அசைகிறது ஆனால் மயிலுமல்ல. சொற்கள் சொல்லுக்குத்  
சொல் தரும் ஆனால் கிளியுமல்ல என்று பிறை, மதி, சுனை, மலை, மலர் போன்ற  
இயற்கைச் சார்ந்த பொருட்கள் இடம்பெற்றிருப்பது சிறப்பிற்குரியது.

தலைவனின் மலைநாட்டு வளத்தைச் சிறப்பாகக் கூற விரும்பிய புலவர்  
அம்மலையின் கண் விழும் அருவி பலவித மலர்களைக் கொண்டு வந்து அங்குத் தாமரை  
மலரில் வீற்றிருக்கும் திருமகள் மீது சொரிவதாகக் காட்சிப் படுத்துகின்றார். இதனை,

“அதிர் இசை அருவிதன் அம்சினைமிசை வீழ்,

முதிர் இனர் ஊழ்கொண்ட முழவுத்தாள் எரிவேங்கை,

வரிநுதல் எழில்வேழம் பூ நீர் மேல் சொரிதர.

புரிநெகிழ் தாமரை மலர்அம்கண் வீறு எய்தி.

திருநயத்து இருந்தன்ன தேம் கமழ் விறல் வெற்ப" (44)

என்ற பாடல் வரிகள் மூலம் தெரிந்து கொள்ள முடிகின்றது.

#### **முடிவுரை**

இவ்வாறு குறிஞ்சி கலி மட்டுமல்லாது கலித்தொகை முழுவதுமே சிறந்த சொற்சுவையும் பொருட்சுவையும் நிரம்ப பெற்று கற்பவர்களுக்கு கவியின்பம் நல்குவதாக அமைந்துள்ளன.

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## தமிழிலக்கியத்தில் கற்றல் திறன்கள்

ம. ஜஸ்டின் பியுலா

இணைப்பேராசிரியர், தமிழ்த்துறை, ஹோலிகிராஸ் கல்லூரி (தன்னாட்சி),  
நாகர்கோவில் - 629004.

### ஆய்வுச்சுருக்கம்

மனிதன் எண்ணங்களைப் பேச்சாலும் எழுத்தாலும் வெளியிடவும், அவனின் சிந்தனைத்தாக்கங்களை உணர்வாக படைக்கவும் மொழி பயன்படுகிறது. அம்மொழிகளுள் தமிழ்மொழி மிகவும் பழமையானதும் பாரம்பரியமானதுமான இலக்கியங்களையும், இலக்கணங்களையும், கலை அறிவியலையும், பண்பாட்டு இலக்கியங்களையும் உள்ளடக்கி பல்வேறு துறைகளில் வளர்ச்சியடைந்து வருகிறது. ஒருவன் கல்விக்கேள்விகளில் சிறந்த அறிஞனாகத்திகழ வேண்டுமெனில் அவன் அவனது தாய்மொழிக்கற்றலில் சிறந்தவனாகவேண்டும். வேதகாலத்திலிருந்த கல்வி, மரத்தடி கல்வியாகவும் திண்ணைக்கல்வியாகவும் மாறி தற்போது ஊரில் தனிக்கட்டிடம்பெற்று பள்ளிக்கூடமாக, கல்லூரியாக வடிவம் பெற்று பல்துறை அறிஞர்களை உருவாக்கி வருகிறது. தாய்மொழியாம் தமிழிலேயே அனைத்துப்பாடங்களும் போதிக்கப்பட்டன. தமிழிலக்கியங்களிலுள்ள சொற்கலை, பொருட்சுவை, எழில் உணர்வு, ஒலி இனிமை, கருத்து மதிப்பு, நல்லியல்புகள் ஆகியவற்றினைத் தாய்மொழியான தமிழ் மொழி மூலமே சுவைத்துணை முடியும். தமிழ் கற்பித்தல் ஓர் தமிழரால் தாய்மொழியான தமிழ்மொழி மூலமாகபயிற்றுவிக்கப்படும் போது, கல்வி கற்கும் மாணவர்களும் பல்துறை நூல்களையும் கற்றுத் தெளிய வாய்ப்பு ஏற்படுகிறது. மனிதன் சமுதாயத்துடன் இணைந்து வாழத்தேவையான அடிப்படைப்பண்பு களான பெரியோரை மதித்தல், பிறருக்கு தீங்கு செய்யாமை, வேற்றுமை பாராட்டாமை, கூடிவாழ்தல், இனியவை பேசுதல், ஒழுக்கம் போன்ற மனித நேய பண்புகளை தாய்மொழியான தமிழ் மொழியின் மூலமே கற்க இயலும். எனவே மொழியின் அடிப்படைத்திறன்களைப் பெறுதல், ஆக்கப் படைப்புகளை உருவாக்குதல், இலக்கியச் சுவையுணர்வுதல் பண்பாடுள்ள சமுதாய வாழ்க்கைக்கு உதவுதல் போன்ற உயர் பண்புகளை ஒவ்வொரு தனி மனிதனும் பெற்றுச் சமுதாய உயர்வுக்கு வித்திடப் பயன்படுவதே ஒருவரின் தாய்மொழி. அதுவே தாய்மொழியாகிய தமிழ்மொழி கற்பித்தலின் அடிப்படை நோக்கமுமாகும். இத்தகைய தமிழ் மொழி கற்பித்தல் திறன்களை ஆராய்வதே இக்கட்டுரையின் நோக்கமாகும்.

### முன்னுரை

கல்வி என்பது மனிதர்களின் உடல், உள்ளம், அறிவு ஆகிய மூன்றினையும் வளர்ச்சி பெறச்செய்வதேயாகும். ஒரு குழந்தை, தான் பிறந்தது முதல் கேட்டும், பேசியும் வரும் தாய்மொழியானது அக்குழந்தையின் அக வளர்ச்சிக்கும், புற வளர்ச்சிக்கும் துணை புரிந்து வருகின்றது. ஒருவர் மற்றவரோடு தொடர்பு கொள்ளவும், கருத்துகளை ஒருவருக்கொருவர் பரிமாறிக் கொள்ளவும், பிறரைப்பற்றி நன்கு புரிந்து கொள்ளவும் அடிப்படைக் காரணியாவது மொழியேயாம். ஒவ்வொருவரது அறிவையும், மொழி மற்றும் இனப்பற்றை வளர்க்கவும் தாய்மொழி உதவுகின்றது. எனவே தனிமனிதனின் அகவளர்ச்சிக்கும், புறவளர்ச்சிக்கும், ஆளுமை வளர்ச்சிக்கும் நம் தாய்மொழியாகிய தமிழே முக்கிய காரணியாகிறது. மாணவர்களின் தெளிவான பேச்சு, எழுத்து, சிந்தனையாற்றல் ஆகியவற்றை மொழியாசிரியர்களே வளர்த்தெடுக்க முடியும். தமிழ் முதன்மைமொழியாகவும், ஆட்சிமொழியாகவும் பயன்பட்டு வரும்

இன்றைய காலகட்டத்தில் தமிழ் மக்கள் மட்டுமின்றி உலகளாவிய நிலையில் பரந்து நிற்கின்ற தமிழர்கள் தமிழ்மொழியை கற்கின்றனர். தமிழைக் கற்பிப்பதற்குப் புதிய அணுகுமுறைகளும் கணினி போன்ற கருவிகளின் பயன்பாடும் வளர்ந்து பெருகி வருகிறது. இத்தகைய தமிழ் மொழி கற்பித்தல் திறன்களை ஆராய்வதே இக்கட்டுரையின் நோக்கமாகும்.

### அடிப்படைத்திறன்களை வளர்த்தல்

தமிழ் மொழியை நுட்பமாகவும், துல்லியமாகவும் கேட்கும் திறனை வளர்த்தல், ஆழமாகப் புரிந்துகொள்ளுதல், ஒலிப்புமுறை, உணர்வுகளுடன் பேசும் திறன் ஆகியன கற்றல் திறன்களில் மிகவும் அடிப்படையானவையாகும். மொழியைப் படிக்கும் போது பொருளுணர்ந்து படித்தல், பிழையின்றி படித்தல் பிழையின்றி எழுதுதல் ஆகிய திறன்களும் கேட்டல், பேசுதல், படித்தல், எழுதுதல் ஆகியவற்றை வளர்ப்பதே தமிழ் மொழியின் முதன்மை நோக்கமாகும். ஒரு மொழியின் அடையாளமான தாய் மொழியை மாணவர்கள் சரியான முறையில் எழுதவும் வாசிக்கவும் மொழி வளத்தைப்பெருக்கவும் தங்களது எண்ணங்களையும் கருத்துக்களையும் தெரிவிக்கவும் உந்துதல் பெறுவர்.

செல்வத்துள் செல்வம் செவிச்செல்வம் அச்செல்வம்

செல்வத்துள் எல்லாம் தலை 1 (குறள் 411)

என்ற வள்ளுவரின் வாக்கிற்கேற்ப தாய்மொழி கற்றல் திறனில் கேட்டலும் பேசுதலும் மிகவும் இன்றியமையாததாகும். இதனை அடியொற்றியே பேச்சுத்தமிழ் வகுப்பறைகளில் பெரிதும் ஊக்குவிக்கப்படுகிறது. இத்தகைய வாய்மொழித் திறன்களை நன்முறையில் வளர்த்துக்கொண்ட மாணவர்களால் படித்தல் திறனையும் எழுதுதல் திறனையும் நன்கு வளர்த்துக்கொள்ள இயலும். இதனையே வள்ளவர் எண்ணும் எழுத்தும் ஆகிய இரு கலைத்திறன்களும் அறமாகிய உயிருக்கு அடிப்படையானவை என்பதை

எண்ணென்ப ஏனை எழுத்தென்ப இவ்விரண்டும்

கண்ணென்ப வாழும் உயிருக்கு 2(குறள் 392)

என்றுரைப்பதன் மூலம் அடிப்படைத்திறன்கள் கற்றலில் தேவை என்ற கருத்து தெளிவாகும்

### சிந்தனையை வளர்த்தல் திறன்

சிந்தனையை வளர்க்க தாய் மொழி அடிப்படையாகிறது. சிந்தனை வளர்ச்சி தாய்மொழியின் மூலம் சிறப்படைகிறது. பல அறிவியல் அறிஞர்களும் ஆய்வியல் அறிஞர்களும் தாய்மொழி மூலமே கண்டுபிடிப்புக்களைச் செய்திருக்கின்றனர். நாடக நூலான மணோண்மணியம், கவிமணியின் ஆசியஜோதி, கம்பரின் கம்பராமாயணம் எனப்படும் பாளிகள் பலர் தம்படைப்புகளை தாய்மொழியிலேயே படைத்திருக்கின்றனர். துறவிகளும் தாங்கள் உணர்ந்த உண்மைகளை தமது தாய்மொழியிலேயே கூறியுள்ளனர். வீடு, ஆலயம், பொதுஇடங்கள், பல்வேறு கூட்டங்கள், கருத்தரங்குகள் என தாய்மொழியறிவைப் பெறுமிடங்கள் பலவாக இருப்பினும் தாய்மொழித் திறனை, அதுவும் சிந்தனை வளர்ச்சிக்கான தாய்மொழித்திறனைப் பெறுமிடங்கள் கல்விக்கூடங்கள் எனலாம்.

கலையென்றால் உணர்ச்சிகளைக் கவர வேண்டும்  
களிப்பூட்டி அறிவினைப்போய்கவரவேண்டும்  
நிலைகொள்ளார் சிந்தனையை நிற்கச் செய்து  
நீதிநெறி தெய்வத்தினைப் பூட்டற் கன்றோ?  
விலையில்லாப் பெருமைபல உடையதேனும்  
விளங்காத பாஷையிலே பாட்டைக் கேட்டுத்  
தலையெல்லாம் சுளுக்கேற அசைத்திட்டாலும்  
தனக்கதுவோர் கலையின்பம் தருவ துண்டோ? 3

என நாமக்கல் கவிஞர் தனது தாய்மொழிப்பற்றினை இசைத்தமிழ் எனும் நூலில் எடுத்துக்கூறியுள்ளவை இங்கு ஒப்புநோக்கத்தக்கது.

எண்ணங்களும் எண்ணங்களை வெளிப்படுத்துகின்ற பேச்சுக்களும் ஒன்றிற்கொன்று மிகவும் நெருங்கிய தொடர்புடையன. எண்ணங்கள் எழுத்தாக மாறும். எழுத்து செயலாக மாறும். செயல் சமூக வளர்ச்சிக்கு உதவும். எனவே மொழி வளர்ச்சிக்கும் மன வளர்ச்சிக்கும் பள்ளிகளில் தாய்மொழிப் பயிற்சி அளித்தலே முதன்மையான தேவையாகும். மொழி நூல்களைக்கற்பதன் வாயிலாகக்கருத்துக்கள் பல தோன்றும். சிந்தனைகள் தெளிவு பெறும். சிந்தனைகள் விளக்கமடைவதுடன், கற்ற செய்திகளைப் பிறர்க்கும் புலப்படுத்த தாய்மொழி உதவுகின்றது. திறனாய்வு செய்யவும், இனம் மதம் சார்ந்த கொள்கைகளை அறிந்து கொள்ளவும், எண்வகை உணர்ச்சிகளை வெளிப்படுத்தவும் மொழி பயன்படுகின்றது சிந்தனையற்ற செயல் சிறப்புறுவதில்லை அது போன்று மொழி இல்லையேல் சிந்தனை இல்லை என்ற கருத்து தெளிவாகும்.

### எண்ணத்தை வெளியிடும் திறன்

மனிதன் பேசக்கற்றுக்கொண்ட காலம் முதல் மொழியின் வாயிலாகத் தான் எண்ணங்களையும், கருத்துக்களையும், உணர்ச்சிகளையும் பேச்சாலும், எழுத்தாலும் பரிமாறிக்கொள்கிறான். தாய்மொழியை கற்கும் மாணாக்கர்கள் திறமையுடன் கற்க ஆசிரியர்கள் எளியமுறையில் ஒரு பொருளைக் குறித்துத் தெளிவாகப் பேசி, எளியமுறையில் பொருளுணர்வும் செய்தல் வேண்டும். தெளிவான முறையில் படிக்கவும், படித்துப் பொருள் உணரவும் செய்து நுண்ணிய எண்ணங்களும் தெளிவான கருத்துக்களும் மாணாக்கர்களிடம் தோன்றுவதற்கு செயல்பட வேண்டும் “சொல்லில் உயாவு் தமிழ்ச்சொல்லே - அதை தொழுது படித்திடுப் பாப்பா” என பாரதியாரும் “எண்பொருளாகச் செலச்சொல்லித் தான் பிறர்வாய் நுண்பொருள் காண்ப தறிவு” என வள்ளுவரும் பிறர் உணரும் வண்ணம் எளிமையாகச் சொல்ல வேண்டும் எனவும் பிறர் நுட்பமாகக் கூறினாலும் அதனை நன்குணர்ந்து அறிதல் வேண்டும் எனவும் எடுத்தியம்பியுள்ளனர். தான் கற்ற கல்வி எவ்வளவு பெரிதானாலும், ஆராய்ந்து இடம் அறிந்து உய்த்துணரும் பண்பு இல்லை என்றால் அக்கல்வி பயனற்றதாகும். தாய்மொழியில் நல்ல புலமை பெற்ற ஒருவரால் தம் உணர்ச்சிகளைத் தெளிவாகக் கட்டுப்படுத்த முடியும்.

தாய்மொழியிலுள்ள சிறந்த இலக்கியங்கள் கூறும் தலையாய பண்புகள் மனம், ஒழுக்கம் முதலிய ஆளுமையை வளர்க்கும். மனத்தை விரிவடையச் செய்து அவர்களுடைய தனித்தன்மையையும் வளர்க்கும் தாய்மொழியறிவு ஆட்சி, நிர்வாகம் போன்ற துறைகளில் தேவை என்பதில் ஐயமில்லை.

#### கருத்துக்களைப் பகிர்ந்துகொள்ளும் திறன்

தனிமனித வாழ்வில் ஒவ்வொருவரும் பெற்ற அனுபவங்களை உணர்வுப்பூர்வமான கருத்துக்களோட எடுத்தியம்பும் ஆற்றலைத் தருவது தாய்மொழியே. இன்பத்தையும், துன்பத்தையும், பொருட்கவையும், சொற்கவையையும் தாய்மொழி மூலமே வெளிப்படுத்த இயலும். உள்ளத்தில் எண்ணும் எண்ணங்களை எடுத்தியம்பும் ஆற்றலைத் தாய்மொழி அளிக்கவல்லது. அதற்கு ஒளவையார் விநாயகப் பெருமானை வேண்டிப்பாடும் பாடலையும், பாரதிதாசன் பாடலையும் சான்றாகக் கூறலாம். “பாலுந் தெளிதேனும் பாகும் பருப்புமிவை நாலுங் கலந்துனக்கு நான் தருவேன் கோலஞ்செய்துங்கக் கரிமுகத்துத் தூமணியே நீயெனக்குச் சங்கத்தமிழ் மூன்றும் தா”<sup>4</sup> என்று ஒளவையாரும் ஏழை யென்றும் அடிமை யென்றும் எவனும் இல்லை ஜாதியில் இழிவு கொண்ட மனிதரென்பது இந்தியாவில் இல்லையே. வாழி கல்வி செல்வம் எய்தி மனம்மகிழ்ந்து கூடியே மனிதர் யாரும் ஒருதிகாச மனிதர் மான மாக வாழ்வமே! என பாரதிதாசன் தனது விடுதலை எனும் கவிதையில் கூறுவது இங்கு பொருத்தமானதாகும்.

#### கற்பனைத்திறன்

“உள்ளத்து உள்ளது கவிதை இன்ப உருவெடுப்பது தெள்ளத் தெளிந்த தமிழில் தெரிந்துரைப்பது கவிதை”. இலக்கியத்தின் முக்கியக் கூறுகளுள் ஒன்று கவிதை. கவிதைக்கு இன்றியமையாததாக வேண்டுவது கற்பனை. கற்பனைத்திறன் தாய்மொழியாம் தமிழில் எடுத்துரைப்பது மிகச்சிறந்தது. இது கவிதைகளைக் கற்போரின் மனத்தை விரிந்த பார்வையில் கவிதையின் பிற பண்புகளுக்கெல்லாம் அடிநிலமாய் அமைகிறது. ரஸ்கின் என்ற கவிஞர் “கற்பனைத் தத்துவம் அறிவுக்கு எட்டாதது. சொற்களால் உணர்த்த முடியாதது. அது அதன் பலன்களை மட்டும் கொண்டே அறியப் பெறுவதென்பதாகும்” என்று கூறியுள்ளார். நம் முன்னோர்களின் கற்பனைக்குச் சான்றுகளாகவே சிற்பங்களை, சின்னங்களை, ஓவியங்களை, காவியங்களை, மாடங்களை, கூடங்களை, இன்று நாம் கையாளும் பொருள்களை, நம்மை, நம் வரலாற்றை, ஏன் உலகத்தையே காண்கிறோம். இலக்கியங்களைப் படிக்கும் போது, எண்ணற்ற கற்பனைக் காட்சிகளைக் காண்கிறோம். காக்கைச் சிறகினிலே நந்தலாலா! நின்றன் கரியநிறத் தோன்றுதையே நந்தலாலா! பார்க்கும் மரங்களெல்லாம் நந்தலாலா! நின்றன் பச்சைநிறத் தோன்றுதையே நந்தலாலா! கேட்கும் மொழியிலெல்லாம் நந்தலாலா! நின்றன் கீதமிசைக்குதடா நந்தலாலா! தீக்குள் விரலை வைத்தால் நந்தலாலா! நின்னைத் தீண்டுமின்பந்தோன்றுதடா நந்தலாலா! என்ற பாரதியாரின் பாடல் வரிகள் மூலம் அவரின் கற்பனைத்திறனை அறியலாம்.

### படைப்பாற்றல் திறன்

மாணவர்கள் பயிலும் காலத்தில் பெறுகின்ற இலக்கிய ஆர்வம், தான் படித்ததைப் போன்ற ஒன்றைத் தானும் உருவாக்க வேண்டும் என்ற உந்தல்களை உருவாக்க வேண்டும். ஆசிரியர் கற்பிக்கும் இலக்கிய ஆர்வத்தைப் பொறுத்தே அவரிடம் கற்கும் மாணவர் தம் இலக்கிய ஆர்வமும் அமையும். ஆசிரியர் தம் இலக்கிய நோக்கில் மாணவர்களையும் அது வழங்கும் செய்தி, உயர்ந்த பொருள், வகைப்பாடு, மொழித்திறன் வளர்க்கும் கூறுகள் ஆகிய நோக்குடன் இலக்கியத்தை அணுகி நோக்கிக் கற்க வழி செய்ய வேண்டும். இவ்வாறு கற்கும்போது உணர்வு மேலோங்கிப் பாராட்டும் மனப்பாங்கு உண்டாகும். பாடுபொருள், மொழிநடை ஆகியவை அவரிடம் தாக்கத்தை விளைவிக்கும். அத்தாக்கம் இலக்கியங்களைப் படிக்கும் எண்ணத்தை தூண்டும். இலக்கியப் படிப்பின்போது காணும் பொருள் மொழிநடையும் மாணவர் தம் உள்ளத்தில் பதிந்து கொண்ட தற்கேற்ப புதிய படைப்பு வடிவமாக வெளிப்படும். இது 'போலச் செய்தல்' என்னும் பழக்கத்தால் உண்டாவதாகும். எண்ணிய முடிதல் வேண்டும் நல்லவே எண்ணல் வேண்டும் திண்ணிய நெஞ்சம் வேண்டும் தெளிந்த நல்லறிவு வேண்டும். என பாரதியார் பாடலில் தந்த நல்லெண்ணங்களை ஆசிரியர்கள் மாணவர்களுக்கு ஊட்டி, உயர்ந்த எண்ணத்தோடு கட்டுரைகள், சிறுநாடகங்கள், சிறுகதைகள், செய்யுள்கள், சொற்பொழிவுகள் முதலியவற்றை படைக்க பயிற்சி அளித்தல் வேண்டும். இவ்வாறு படைக்கும் போது இலக்கிய நயமுணர்ந்து இன்புறுவர். பண்பாடு என்பது சமூகத்தோடு ஒட்டி வாழும் உயிரின் நோக்கமாகக் கருதப்படல் வேண்டும். இதனையறிந்து செயல்படுவதற்கு வாயிலாகத் தமிழ்மொழி இலக்கியமே உதவும். தனிமனிதனுக்குத் தேவையான சமுதாய மரபுகளையும், மனப்பான்மையையும் தமிழ் இலக்கியமே அளிக்கிறது.

### ஒழுக்கப்பண்புகளை வளர்க்கும் திறன்

ஒழுக்கப் பண்புகளை தாய்மொழிப்பாடம் வாயிலாகத்தான் மாணவர்களுக்கு வலியுறுத்த முடியும். ஏனெனில் வாழ்க்கையும், தமிழ் இலக்கியமும் பின்னிப் பிணைந்தவை, பிரிக்க முடியாதவை. இலக்கியம் வாழ்க்கையிலிருந்தே தோன்றுகிறது. பிற பாடங்களில் கோட்பாடுகளையும், கொள்கைகளையும் மட்டுமே மாணவர்கள் கற்றுக் கொள்ளுகின்றனர். ஆனால் வாழ்க்கைக்கு தேவையான அன்பு, பண்பு, பொறுமை, விடாமுயற்சி, விருந்தோம்பல், பிறரை மதித்தல், ஏழைகளுக்கு உதவும் அறநெறி, நலிந்தவர்களுக்கு நல்வாழ்வு தருதல், பிற சமயத்தினரை மதித்தல் ஆகிய ஒழுக்கப்பண்புகளை தமிழ்மொழிப் பாடம் மூலமே மாணவர்களுக்குக் கற்றுத்தர முடியும். சிறுவகுப்பிலிருந்தே மாணவர்களுக்கு இறைவாழ்த்துப் பகுதி மூலம் இறையுணர்வு ஊட்டப்படுகிறது. சங்க இலக்கியங்கள் தமிழர்களின் வாழ்வியல் நெறிகளை ஒழுக்கப் பண்புகளை வளர்க்கின்றன. சமய, இன, மொழி, சாதி வெறியைத் தூண்டாத வகையில் அனைத்து சமயப் பொதுமைக் கருத்துகளை வலியுறுத்தக்கூடிய நல்லொழுக்கப் பண்புகளை நம் தாய்மொழியாகிய தமிழ்மொழி கற்பிக்கிறது. பிறர் அறவழியை

அறிந்து நடப்பதற்காகச் சிறந்த நூல்களைச் செய்தலும், பிறரிடம் பேசும்போது இனிமையாகப் பேசுதலும் இன்பந் தருவன என்பதாம். இவை மூன்றும் நல்லொழுக்கமாகும்.

“ஒழுக்கத்தின் எய்துவர் மேன்மை இழுக்கத்தின்

எய்துவர் எய்தாப் பழி” 5 குறள்-137

தன்குல வளர்ப்பும் தமிழ் இன வளர்ப்பு எனும் வன்மொழித் தத்துவம் வழங்குவர்க்குரைப்பேன் என்குல மென்பது இதயத்து இடம்பெறின் தன்மொழி, என குலோத்துங்கனின் பாடல்களும் கற்றல் திறன்களில் காணப்படும் ஒழுக்க விழுப்பத்தை எடுத்துரைப்பதை காணமுடிகிறது.

### முடிவுரை

மனிதனின் நடத்தையில் கல்வியால் மட்டுமே மாற்றங்களைக் கொண்டு வரமுடியும். கல்வியும், கற்றலும் பிரிக்க இயலாதவை. எனவே கற்பித்தலுக்கான உளவியல் கொள்கைகளை ஆசிரியர்கள் கடைபிடிக்க வேண்டியது இன்றியமையாததாகும். பேட்டர்சன் என்பவரின் கூற்றுப்படி கற்பித்தலில் ஒருங்கிணைப்பை உளவியல் கொள்கைகளே அளிக்கின்றன. கற்பித்தலுக்குத் தேவையான முறைகளைக் கையாள உதவுகின்றன. ஆராய்ச்சிக்கும் அவையே படிநிலைகளை அமைத்துக் கொடுக்கின்றன. 1963-ம் ஆண்டு ஜெரோம் புருனர் முதன் முதலில் கற்பித்தல் கொள்கைகள் என்ற சொல்லை உருவாக்கினார். பின்னர் 1965-ல் இச்சொல் பிரபலமடையத் தொடங்கியது. கற்பித்தல் வளர்ச்சிக்குக் கற்பித்தலுக்கான உளவியல் கொள்கைகள் அடித்தளமிட்டுள்ளன. தற்போதுள்ள பாடத்திட்டங்களில் அரசு மாணவர்களின் வாழ்வியல் திறன், வகுப்பறைத்திறன், தன்னையறிதல் திறன் போன்றவற்றையும் இணைத்து ஆர்வமுடன் புரிந்துகொள்ளும் வகையில் தயாரித்து வருவது குறிப்பிடத்தக்கதாகும்.

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வ. ஆன்றனி பிரகாஷ் பபிலா

உதவிப்பேராசிரியர், தமிழ்த்துறை, ஹோலிகிராஸ் கல்லூரி(தன்னாட்சி),  
நாகர்கோவில் - 629004.

### ஆய்வுச்சுருக்கம்

குருகுலக் கல்வி பயின்ற காலம் மாறி இன்று ஆசிரியரில்லா வகுப்பறை என்ற நிலைக்கு நாம் முன்னேறி விட்டோம். தொழில்நுட்ப வளர்ச்சியின் விளைவாக இன்றைய சூழலில் கற்பித்தல் கோட்பாடுகள் மாறிவிட்டன. மாறிவரும் சமூகத்தேவைகளால் கல்வித்துறைகளும், கற்பிக்கும் முறைகளும், கற்கும் வழிகளும் புதுமை பெற்றுள்ளன. இன்றைய வகுப்பறைகளில் மேற்கொள்ளப்பட்டு வரும் புதுமையான அணுகுமுறைகளை, கற்பித்தல் மற்றும் கற்றல் வழி இக்கட்டுரை ஆராய்கிறது. இந்தப் புதுமையான நடைமுறைகளைப் பின்பற்றுவதன் மூலம் கல்வியாளர்கள் மாணவர்களின் பல்வேறு தேவைகளை நிவர்த்தி செய்யும் மற்றும் எதிர்கால சவால்களுக்கு அவர்களைத் தயார்படுத்தும் மிகவும் ஆற்றல்மிக்க மற்றும் பயனுள்ள கற்றல் சூழலை உருவாக்க முடியும்.

### முன்னுரை

தொழில்நுட்ப முன்னேற்றங்கள் வளர்ந்து வரும் இக்கால கட்டத்தில் கற்பித்தல் கோட்பாடுகள் மற்றும் மாறிவரும் சமூகத்தேவைகள் ஆகியவற்றால் உந்தப்பட்டு சமீபத்திய ஆண்டுகளில் கல்வியின் நிலப்பரப்பு உருமாறும் மாற்றங்களை அனுபவித்துள்ளது. நவீன வகுப்பறை இப்போது கற்றல் விளைவுகள் மற்றும் மாணவர் ஈடுபாட்டை மேம்படுத்த வடிவமைக்கப்பட்ட மாறுபட்ட மற்றும் புதுமையான அணுகுமுறைகளால் வகைப்படுத்தப்படுகிறது. சமகால கல்வியில் நான்கு முக்கிய புதுமையான அணுகுமுறைகளை இக்கட்டுரை ஆராய்கிறது. தொழில்நுட்ப ஒருங்கிணைப்பு கூட்டுக்கற்றல் தனிப்பயனாக்கப்பட்ட கல்வி மற்றும் அனுபவ கற்றல் ஒவ்வொரு அணுகுமுறையும் கற்பித்தல் மற்றும் கற்றலில் தன் தாக்கத்திற்காக பகுப்பாய்வு செய்யப்படுகிறது. இந்த முறைகள் எவ்வாறு பயனுள்ள கல்விச்சூழல்களை உருவாக்கமுடியும் என்பதற்கான நுண்ணறிவுகளை வழங்குகிறது.

### 1. தொழில்நுட்ப ஒருங்கிணைப்பு

தொழில்நுட்ப ஒருங்கிணைப்பு நவீன கல்வியில் மிக முக்கியமான முன்னேற்றங்களில் ஒன்றாகும். இது பாரம்பரிய வகுப்பறையை ஒரு ஊடாடும் பல்லூடகங்கள் நிறைந்த வகுப்பறையாக மாற்றியுள்ளது.

### மின்னணு கருவிகள் மற்றும் தளங்கள்

மின்னணு கருவிகள் மற்றும் தளங்கள் நவீன வகுப்பறைகளுக்குத் தேவையான மற்றும் ஒருங்கிணைந்தவையாக மாறிவிட்டன. இது பலவிதமான கல்வி நடவடிக்கைகளை எளிதாக்குகிறது. கூகுள் வகுப்பறை, முடுல் மற்றும் கேன்வா போன்ற தளங்கள் கல்வியாளர்களைத் தகவல்தொடர்பு பணி விநியோகம் மற்றும் கருத்துக்களை நெறிப்படுத்த அனுமதிக்கின்றன. இந்தத் தளங்கள் கல்வி வளங்களுக்கான மையப்படுத்தப்பட்ட இருப்பிடத்தை வழங்குகின்றன. இது மாணவர்களுக்கு எப்போது வேண்டுமானாலும் எங்கும் கல்வித்தகவல்களை

அணுக உதவுகிறது. காணொலிகள், வினாடிவினாக்கள் கலந்துரையாடல்கள் மற்றும் திறன்பலகைகள் உள்ளிட்ட பல்வேறு பல்லாடக வடிவங்களையும் அவை ஆதரிக்கின்றன. இது கற்றலை மிகவும் ஈர்க்கக் கூடியதாகவும் பல்துறை ரீதியாகவும் ஆக்குகிறது.

### **திறன்பலகை மற்றும் ஊடாடும் காட்சிப்படுத்தல்கள்**

திறன்பலகை மற்றும் ஊடாடும் காட்சிப்படுத்தல்கள் பல வகுப்பறைகளில் பாரம்பரிய வெள்ளைப் பலகைகளை மாற்றியமைத்து மேம்பட்டகாட்சி மற்றும் ஊடாடும் திறன்களை வழங்குகின்றன. இந்தக் கருவிகள் கல்வியாளர்களைப் பல்லாடக உள்ளடக்கத்தை வழங்கவும், மாணவர்களை நிகழ்நேர நடவடிக்கைகளில் ஈடுபடுத்தவும், பலகையில் நேரடியாக கருத்துக்களைக் குறிப்பிடவும் அனுமதிக்கின்றன. ஊடாடும் காட்சிகள் மற்றும் தொட்டுணரக்கூடிய கற்றல் அனுபவங்களை வழங்குவதன் மூலம் காட்சி மற்றும் செவிவழி முதல் இயக்கவியல் வரை பல்வேறு கற்றல் பாணிகளுக்கு இடமளிக்கமுடியும்.

### **மெய்நிகர் யதார்த்தம் மற்றும் அதிகரித்த யதார்த்தம்**

மெய்நிகர் யதார்த்தம் மற்றும் அதிகரித்த யதார்த்தம் ஆகியவை ஆழமான கற்றல் அனுபவங்களை வழங்கும் அதிநவீன தொழில்நுட்பங்களைக் குறிக்கின்றன. மெய்நிகர் யதார்த்தம் மாணவர்களை வரலாற்று நிகழ்வுகள், அறிவியல் சூழல்கள் அல்லது இலக்கிய அமைப்புகளுக்குக் கொண்டு செல்லமுடியும் இது பாரம்பரிய முறைகள் செய்யமுடியாத வழிகளில் உள்ளடக்கத்தை ஆராய்ந்து தொடர்பு கொள்ள அனுமதிக்கிறது. அதிகரித்த யதார்த்தம் நுண்ணறிவு மேலடுக்குடன் நிஜ உலக சூழலை மேம்படுத்துகிறது. புரிதலை ஆழப்படுத்தக் கூடிய ஊடாடும் கூறுகளை வழங்குகிறது. இந்த தொழில் நுட்பங்கள் சுருக்கமான கருத்துக்களை உயிர்ப்பிப்பதன் மூலம் மிகவும் ஈர்க்கக்கூடிய மற்றும் மறக்கமுடியாத கற்றல் அனுபவங்களை உருவாக்க உதவுகின்றன.

## **2. கூட்டுறவு கற்றல்**

கூட்டுறவு கற்றல் என்பது ஒரு கல்வி அணுகுமுறையாகும். இது வகுப்பறை செயல்பாடுகளை கல்வி மற்றும் சமூகக்கற்றல் அனுபவங்களை ஒழுங்கமைப்பது ஆகும். கூட்டுறவு கற்றல் மாணவர் தொடர்பு மற்றும் குழுப்பணியின் முக்கியத்துவத்தை வலியுறுத்துகிறது. இந்த அணுகுமுறை பொதுவான இலக்குகளை அடைய மாணவர்கள் ஒன்றிணைந்து செயல்பட இதமான கற்றல் சூழலை வளர்க்கிறது.

### **திட்ட அடிப்படையிலான கற்றல்**

திட்ட அடிப்படையிலான கற்றல் என்பது ஒரு திட்டத்தில் நீண்ட காலத்திற்கு பணிபுரியும் மாணவர்களை உள்ளடக்கியது. இதற்கு அவர்கள் பல்வேறு பாடங்களில் அறிவையும் திறனையும் பயன்படுத்த வேண்டும். உலக சவால்களில் மாணவர்கள் ஈடுபடுத்துவதன் மூலம் விமர்சன சிந்தனை, படைப்பாற்றல் மற்றும் சிக்கலைத் தீர்ப்பதை திட்ட அடிப்படையிலான கற்றல் ஊக்குவிக்கிறது. கூட்டு முயற்சிகள் மூலம் மாணவர்கள் தங்கள் பணிகளை நிர்வகிக்கவும், திறம்பட தொடர்பு கொள்ளவும், அவர்களின் கற்றல் செயல்முறையைப்



பிரதிபலிக்கவும் கற்றுக்கொள்கிறார்கள். திட்ட அடிப்படையிலான கற்றல் கல்வித்திறன்களை மேம்படுத்தோடு மட்டுமல்லாமல் உலக சூழ்நிலைகளைப் பிரதிபலிப்பதன் மூலம் எதிர்கால வாழ்க்கைக்கு மாணவர்களைத் தயார்படுத்துகிறது.

### குழுக்கற்றல் மற்றும் கற்பித்தல்

குழு கற்றல் மற்றும் கற்பித்தல் என்பது மாணவர்கள் ஒருவருக்கொருவர் கற்றல் மற்றும் கற்பித்தல் ஆகியவற்றை உள்ளடக்கியது. இந்த முறை புரிதலை வலுப்படுத்தலாம் மற்றும் தகவல் தொடர்புத்திறன்களை உருவாக்கலாம். ஜிக்சா செயல்பாடுகள் போன்ற நுட்பங்கள், மாணவர்களை ஒரு தலைப்பின் குறிப்பிட்டப் பகுதிகளில் நிபுணர்களாக மாற்றுகிறது. அவர்கள் தங்கள் அறிவை குழுவினருடன் பகிர்ந்து கொள்கிறார்கள், சுறுசுறுப்பான பங்கேற்பு மற்றும் ஒத்துழைப்பை ஊக்குவிக்கிறார்கள். குழு கற்பித்தல் மாணவர்கள் உள்ளடக்கத்தை வெவ்வேறு கண்ணோட்டங்களில் பார்க்க அனுமதிக்கிறது மற்றும் பொருள் பற்றிய தங்கள் சொந்தப்புரிதலை வலுப்படுத்துகிறது.

### குழுப்பணி மற்றும் கலந்துரையாடல் மன்றங்கள்

கட்டமைக்கப்பட்ட குழு வேலை மற்றும் நிகழ்நிலை கலந்துரையாடல் மன்றங்கள் கூட்டுக்கற்றலின் இன்றியமையாத கூறுகளாகும். குழு நடவடிக்கைகள் கருத்துக்களைப் பகிர்ந்து கொள்ளவும், கருத்துக்களை விவாதிக்கவும். ஒருவருக்கொருவர் அறிவை வளர்க்கவும் மாணவர்களை ஊக்குவிக்கின்றன. நிகழ்நிலை மன்றங்கள் வகுப்பறைக்கு அப்பால் ஒத்துழைப்பை விரிவுப்படுத்துகின்றன. இது மாணவர்கள் கலந்துரையாடல்கள் மற்றும் கூட்டுப்பணிகளில் ஒத்திசைவாக ஈடுபட உதவுகிறது. இந்த முறைகள் குழுப்பணி மற்றும் சிக்கலைத் தீர்ப்பதற்குத் தேவையான சமூக மற்றும் அறிவாற்றல் திறன்களின் வளர்ச்சியை ஆதரிக்கின்றன.

### 3. தனிப்பயனாக்கப்பட்ட கல்வி

தனிப்பயனாக்கப்பட்ட கல்வி தனிப்பட்ட மாணவர்களின் தேவைகள், பலம் மற்றும் ஆர்வங்களைப் பூர்த்தி செய்ய கற்றல் அனுபவங்களை வடிவமைக்கிறது. இந்த அணுகுமுறை ஒவ்வொரு மாணவருக்கும் தனித்துவமான கற்றல் விருப்பங்களும் திறன்களும் இருப்பதை அங்கீகரிக்கிறது.

### தகவல் கற்றல் தொழில்நுட்பங்கள்

தகவல் கற்றல் தொழில்நுட்பங்கள் மாணவர்களின் செயல்திறனின் அடிப்படையில் தனிப்பயனாக்கப்பட்ட கற்றல் அனுபவங்களை வழங்க வழிமுறைகளைப் பயன்படுத்துகின்றன. கான் அகாடமி மற்றும் ட்ரீம்பாக்ஸ் போன்ற தளங்கள் ஒவ்வொரு மாணவரின் வேகம் மற்றும் தேர்ச்சிக்கு ஏற்ப, உள்ளடக்கத்தின் சிரமம் மற்றும் வகையை நிகழ்நேரத்தில் சரிசெய்கின்றன. தகவல் கற்றல் இலக்கு ஆதரவு மற்றும் வளங்களை வழங்குவதன் மூலம் கற்றல் இடைவெளிகள் மற்றும் சவால்களை தீர்க்க உதவுகிறது.

### கற்றல் பகுப்பாய்வு

கற்றல் பகுப்பாய்வு என்பது மாணவர் மதிப்பீடுகள், தொடர்புகள் மற்றும் நடத்தைகளிலிருந்து தரவை சேகரித்துப் பகுப்பாய்வு செய்வதை உள்ளடக்கியது. கற்றல் முறைகள், பலம் மற்றும் முன்னேற்றம் தேவைப்படும் பகுதிகளை அடையாளம் காண கல்வியாளர்கள் இந்தத் தரவைப் பயன்படுத்துகின்றனர். கற்றல் பகுப்பாய்வு அதிக தகவல் அறிந்து முடிவெடுப்பதற்கும் இலக்கு வைக்கப்பட்ட தலையீடுகளுக்கும் அனுமதிக்கிறது. ஒவ்வொரு மாணவரும் வெற்றிபெற பொருத்தமான ஆதரவைப் பெறுவதை உறுதிப்படுத்த உதவுகிறது. இந்த அணுகுமுறை கல்வியாளர்களுக்கு காலப்போக்கில் முன்னேற்றத்தைக் கண்காணிக்கவும், கற்பித்தல் உத்திகளில் தரவு சார்ந்த மாற்றங்களைச் செய்யவும் உதவுகிறது.

### வேறுபடுத்தப்பட்ட அறிவுறுத்தல்

வேறுபடுத்தப்பட்ட அறிவுறுத்தல் என்பது மாணவர்களின் மாறுபட்ட தேவைகளின் அடிப்படையில் உள்ளடக்கம், செயல்முறை மற்றும் தயாரிப்புகளை மாற்றியமைப்பதை உள்ளடக்கிய ஒரு கற்பித்தல். அணுகுமுறையாகும். பல்வேறு கற்றல் பாணிகள் மற்றும் திறன்களுக்கு இடமளிக்க ஆசிரியர்கள் வெவ்வேறு அறிவுறுத்தல் முறைகள், பொருட்கள் மற்றும் மதிப்பீட்டு உத்திகளைப் பயன்படுத்தலாம். அனைத்து மாணவர்களும் தங்கள் தேவைகளுக்கு ஏற்ப சவால்களை எதிர்கொள்வதையும் ஆதரிப்பதையும் உறுதிசெய்கிறது. மேலும் அனைத்தையும் உள்ளடக்கிய மற்றும் சமமான கற்றல் சூழலை ஊக்குவிக்கிறது.

### 4. அனுபவ ரீதியான கற்றல்

அனுபவக் கற்றல் அனுபவம் மற்றும் பிரதிபலிப்பு மூலம் கற்றலில் கவனம் செலுத்துகிறது. நடைமுறைப் பயன்பாடு மற்றும் உலகத் தொடர்புகளை இது வலியுறுத்துகிறது. களப்பயணமும் வெளிப்புறக் கற்றல் வாய்ப்புகளும்

களப்பயணங்கள் மற்றும் வெளிப்புறக் கற்றல் வாய்ப்புகள் மாணவர்களுக்கு உலக சூழல் மற்றும் அவர்களின் வகுப்பறைக்கற்றலுக்கான பயன்பாட்டை வழங்குகின்றன. அருங்காட்சியகங்கள், வரலாற்றுத்தலங்கள் அல்லது உள்ளூர் அமைப்புகளுக்குப் பார்வையிட செல்வது மாணவர்கள் தத்துவார்த்த அறிவை நடைமுறை அனுபவங்களுடன் இணைக்க அனுமதிக்கிறது. இந்த நடவடிக்கைகள் புரிதலை மேம்படுத்தலாம். ஆர்வத்தைத் தூண்டும் மற்றும் பொருள் விஷயத்தில் ஆழமான பாராட்டை வழங்கலாம்.

### உருவகப்படுத்துதல் மற்றும் பங்கு வகித்தல்

உருவகப்படுத்துதல் மற்றும் பங்கு வகிக்கும் நடவடிக்கைகள் மாணவர்களுக்கு சிக்கலான சூழ்நிலைகளை ஆராய்வதற்கும் கட்டுப்படுத்தப்பட்ட சூழலில் சிக்கல் தீர்க்கும் திறன்களை வளர்ப்பதற்கும் வாய்ப்பளிக்கின்றன. எடுத்துக்காட்டாக உருவகப்படுத்துதல் விளையாட்டுகள் வரலாற்று நிகழ்வுகள் அல்லது அறிவியல் சோதனைகளைப் பிரதிபலிக்கலாம். இது மாணவர்களை அனுபவக்கற்றலில் ஈடுபட அனுமதிக்கிறது. ரோல் பிளேமிங் பயிற்சிகள்

மாணவர்கள் வெவ்வேறு கண்ணோட்டங்களை எடுக்கவும் முடிவெடுப்பது தகவல் தொடர்பு மற்றும் விமர்சன சிந்தனை திறன்களைப் பயிற்சி செய்யவும் உதவுகின்றன.

### கற்றல் சேவை திட்டங்கள்

கற்றல் சேவை சமூக சேவையை கல்வி அறிவுறுத்தலுடன் ஒருங்கிணைக்கிறது. மாணவர்களுக்குத் தங்கள் அறிவைப் பயன்படுத்துவதற்கான வாய்ப்புகளை வழங்குகிறது. கற்றல் சேவை திட்டங்கள் மாணவர்களை உலகப் பிரச்சினைகளுக்குத் தீர்வு காணவும், அவர்களின் வட்டார சூழலுடன் இணைந்து செயல்படவும் ஊக்குவிக்கின்றன. இந்த அணுகுமுறை குடிமைப்பொறுப்பை வளர்க்கிறது. சமூக உணர்ச்சித்திறன்களை மேம்படுத்துகிறது மற்றும் கல்வி உள்ளடக்கத்தை அர்த்தமுள்ள, அனுபவங்களுடன் இணைக்கிறது.

### முடிவுரை

நவீன வகுப்பறைக் கல்வியில் புதுமையான அணுகுமுறைகள் கற்பித்தல் மற்றும் கற்றல் நிலப்பரப்பை மறுவடிவமைக்கின்றன. தொழில்நுட்ப ஒருங்கிணைப்பு, கூட்டுக்கற்றலில், தனிப்பயனாக்கப்பட்ட கல்வி மற்றும் சாதனையை மேம்படுத்தும் முக்கிய முறைகள் ஆகும். இந்த புதுமையான நடைமுறைகளைத் தழுவுவதன் மூலம், கல்வியாளர்கள் மாணவர்களின் பல்வேறு தேவைகளை நிவர்த்தி செய்யும் மற்றும் எதிர்கால சவால்களுக்கு அவர்களைத் தயார்படுத்தும் மிகவும் ஆற்றல்மிக்க மற்றும் பயனுள்ள கற்றல் சூழலை உருவாக்க முடியும். கல்வி நடைமுறைகள் தொடர்ந்து உருவாகி வருவதால், கல்வியாளர்கள் தழுவிக் கொள்ளக் கூடியவர்களாகவும், மாணவர் வளர்ச்சி மற்றும் வெற்றியை ஆதரிக்கும் புதிய முறைகளுக்கு திறந்தவர்களாகவும் இருப்பது அவசியம்.

இந்த புதுமையான அணுகுமுறைகளின் ஒருங்கிணைப்பு வகுப்பறை அனுபவத்தை மாற்றுவது மட்டுமல்லாமல், மாணவர்கள் வாழ்நாள் முழுவதும் கற்பவர்கள், விமர்சன சிந்தனையாளர்கள் மற்றும் தங்கள் சமூகங்களில் செயலில் பங்கேற்பாளர்களாக மாறவும் அதிகாரம் அளிக்கிறது. எப்போதும் மாறிவரும் உலகில் அனைத்து மாணவர்களும் செழிக்க வாய்ப்பு இருப்பதை உறுதிசெய்து, இந்த முற்போக்கான உத்திகளைத் தொடர்ந்து ஆராய்ந்து செயல்படுத்துவதில் கல்வியின் எதிர்காலம் உள்ளது.

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செ. சுனிதா

உதவிப் பேராசிரியர், தமிழ்த்துறை, ஹோலிகிறாஸ் கல்லூரி(தன்னாட்சி),  
நாகர்கோவில் - 629004.

### ஆய்வுச் சுருக்கம்

சங்ககாலத்தில் தமிழ் பயிற்று முறைகள் எவ்வாறு இருந்தன என்பதை பற்றி தெளிவாக அறிந்து கொள்ளும் முறைகள் எதுவும் இடம்பெறவில்லை. ஆனால் தமிழ் நூல்களில் இருந்தும் இலக்கண நூற்பாக்கள் மூலமாகவும் உரையாசிரியர்கள் மேற்கோளாக காட்டிய நூற்பாக்கள் மூலமாகவும் கல்வி பயிற்றுமுறைகள் பற்றிய சில செய்திகளை யூகத்தால் அறிந்து கொள்ளலாம். மக்கள் கல்விக்குச் சிறப்பு அளித்தனர். கற்றோரைப் போற்றினர் என்பதை இலக்கியங்களின் மூலம் அறிகிறோம். தொடக்க கால கல்வி முறையில் ஆசிரியர் சிறப்பிடம் பெற்றிருந்தார். பாடப்பொருள் முதலிடம் பெற்றிருந்தது. ஆனால் தற்காலத்தில் மாணாக்கர் மையக் கல்வியாக கொள்ளப்பட்டு மாணாக்கரே சிறப்பிடமும் முதலிடமும் பெறுகிறார். எனவே மாணவரை மையமாகக் கொள்ளாத முறைகள் பண்டைய முறைகள் என்றும் எவை கற்போரை மையமாகக் கொண்டனவோ அவற்றை தற்கால முறைகள் என்றும் வகைப்படுத்தப்பட்டுள்ளன.பதினெட்டாம் நூற்றாண்டின் பிற்பகுதியில் இருந்து கல்வியாளர்கள் உளவியல் அடிப்படையில் கற்போரை மையமாக இருத்தவே உண்மை கல்வியாகும் என்னும் கருத்தினை உலகினுக்கு தந்தனர். அம்மாற்றங்கள், அவற்றின் விளைவுகள், சங்க காலம் முதல் தற்காலம் வரை தமிழ் கற்பிக்கும் முறைகள் ஆகியவற்றைப் பற்றி ஆய்வதே இக்கட்டுரையின் முதன்மை நோக்கமாகும்.

### முன்னுரை

சங்க காலத்தில் மக்கள் கல்விக்கு சிறப்பு அளித்தனர். கற்றோரைப் போற்றினர் என்பதை இலக்கியங்களின் மூலம் அறிகிறோம். "கேடில் விழுச்செல்வம் கல்வி ஒருவருக்கு மாடல்ல மற்ற யவை" என வள்ளுவர் வாக்கினாலும் "கற்கை நன்றே கற்கை நன்றே பிச்சை புகினும் கற்கை நன்றே" என வெற்றிவேற்கை பாடலினாலும் மக்கள் கல்விக்கு சிறப்பிடம் அளித்தனர் என்பதை நாம் நன்கு அறியலாம்.இன்றுள்ள அச்ச உரைநடை நூல்கள் அன்று இல்லாததால் கற்பித்தலில் மனப்பாடம் செய்து ஒப்புவித்தல் சிறப்பிடம் பெற்றிருந்தது.இக்காலத்தில் உள்ளவை போல பல ஆயிரக்கணக்கான கல்வி நிலையங்கள் அக்காலத்தில் இருந்தன என்று திடமாக சொல்லக்கூடிய சான்றுகள் கிடைக்கப்பெறவில்லை. கல்வி கற்றவர்கள் பெரும்பாலும் ஆசிரியர் வீட்டிலே தங்கியிருத்தல் வேண்டும். இதனால் ஆசிரியர் ஒவ்வொரு மாணாக்கரையும் நன்கு அறிந்து அவருடைய இயல்புகள், குணநலன்கள், செயல்கள் முதலியவற்றைக் கண்டுணர்ந்தனர். நீக்க வேண்டியவற்றை கடிந்து கூறி நீக்கினர். வளர்க்க வேண்டியவற்றை போற்றி வளர்த்தனர். அவர்களை பொறுப்பு மிக்க சிறந்த குடிமக்களாக உருவாக்கினர். இது பற்றிய செய்திகளை தொல்காப்பியத்துக்கு உரை எழுதிய நச்சினார்க்கினியர் மேற்கோள் நூற்பாக்களின் மூலமும் நன்னூல் பொதுப்பாயிர நூற்பாக்கள் மூலமும் அறிந்து கொள்ளலாம். அக்காலத்தில் மாணாக்கர் பெற்ற ஆழ்ந்த இலக்கண அறிவு தாமாகவே பல இலக்கியங்களை நயம் உணர்ந்து கற்க துணையாக

இருந்தன. ஆசிரியரும் மாணாக்கரும் உடன் உறைந்து பயின்றது கற்றலில் சிறந்த கூறு என்று எல்லோரும் ஒப்புக்கொண்டனர்.

### பண்டைக்கால பாடம் கற்பிக்கும் முறை

தமிழ் இலக்கண மரபின் முதல் இலக்கண நூல் தொல்காப்பியமாகும். இந்நூல் கி.பி இரண்டாம் நூற்றாண்டில் இயற்றப்பட்டது. அல்லது தொகுக்கப்பட்டது எனலாம். தொல்காப்பியம் கற்றலை ஓதல் என்று குறிப்பிடுகின்றது. தொல்காப்பியர் காலத்தில் கல்வி அந்தணர்க்கும் அரசர்க்கும் உரியதாக இருந்திருக்கின்றது. வணிகர்க்கும் வேளாளர்க்கும் கல்வி மறுக்கப்பட்டுள்ளது. இவ்விரண்டு வர்மத்தாரும் பிற்காலத்தில் சமண சமயத்தின் ஆதரவோடு சமூகத்தில் தமக்குரிய இடத்திற்காக போராடினர். கல்வியைப் புதுமைப்படுத்திய சமண பௌத்த சமயங்களை வணிகவர்க்கமும் வேளாளர் வர்க்கமும் ஆதரித்தன. தொல்காப்பியம் இயற்றப்பட்டு பத்து நூற்றாண்டுகளுக்குப் பிறகு கி.பி 13ம் நூற்றாண்டில் நன்னூல் இயற்றப்பட்டது. அரசியல், சமய, மொழிச் சூழல் ஆகிய சமூகச் சூழல்களில் மிகப்பெரிய மாற்றங்கள் நிகழ்ந்த காலகட்டத்தில் நன்னூல் உருவாக்கப்பட்டது. வடமொழி கலப்பும் வடமொழிக் கல்வியும் இக்காலகட்டத்தில் சிறப்பிடம் பெற்றிருந்தன. ஆசிரியராய் இருத்தலுக்கு தேவையான தகுதிகளும், நன் மாணாக்கரின் இலக்கணமும் வகுக்கப்பட்டன. கல்வியில் மேன்மை போற்றப்பட்டது. கல்வி அறிவுடையோர் சமூகத்தில் மிக உயர்ந்த நிலையில் போற்றப்பட்டனர். நன்னூலார் சிறப்பு பாயிரத்தில் நூலின் இயல்பு, அதன் வகைகள், நல்லாசிரியரின் இலக்கணம், நல்லாசிரியர் அல்லாதார், நன்மாணாக்கர் அல்லாதவர் யாவர் போன்றவற்றை மிகச் சிறப்பாக விளக்கியுள்ளார். நல்லாசிரியர் என்பவருக்கு நன்னூலார் கூறும் இலக்கணமாவது,

“ குலன் அருள் தெய்வங் கொள்கமேன்மை

கலைப்பயில் தெளிவு கட்டுரை வன்மை

நிலம் மலை நிறைகோல் மலர்நிகர் மாட்சியும்

உலகியல்அறிவோடுஉயர்குண இனையவும்

அமைபவன் நூல் உரை ஆசிரியன்னே” ( நன்னூல் 26 )

என்பதாகும். நல்லொழுக்கமுடைய குலத்தில் பிறந்து உயிர்களிடத்து அன்பும் இரக்கமும் கொண்டு இறை உணர்வுடன் பல நூல்களை கற்ற தேர்ச்சி அடைந்து தியாக உள்ளத்துடன் உலகியல் அறிவும் பெற்று பிறருக்கு கற்பிக்கும் திறன் உடையவனே ஆசிரியன் ஆவான் என நன்னூலார் குறிப்பிடுகிறார். நிலம், மலை, நிறைகோல், மலர் ஆகியன ஆசிரியருக்குரிய சின்னங்களாக கூறப்படுகின்றன. நிலம் பொறுமைக்கும், மலை உயர்வுக்கும், துலாக்கோல் நடுநிலைமைக்கும், மலர் தூய நெஞ்சத்திற்கும் குறியீடுகளாக சொல்லப்படுகின்றன. ஒரு ஆசிரியர் தன் மாணவர்களிடம் பாடம் கற்பிக்கும் போது நிலம் போன்ற பொறுமை குணத்துடனும், மலை போன்ற உயர்ந்த அறிவுடனும், துலாக்கோல் போன்ற நடு நிலையுடனும், புதிதாக பூத்த மலர் போன்ற தூய நெஞ்சத்துடனும் திகழ வேண்டும் என்பதே மேற்கண்ட ஒப்புமையினால் அறிந்து கொள்ள முடிகிறது. நல்லாசிரியர் அல்லாதவர்களைப் பற்றி பின்வரும் நூற்பா விளக்குகிறது.

“மொழிக்குணம் இன்மையும் இழிகுண இயல்பும்

அழுக்காறு அவா வஞ்சம் அச்சம் ஆடலும்

கழற்குடம் மடப்பனை பருத்தி குண்டிகை சிந்தையும்  
முடத்தெங்கு ஒப்பென முரண்கொள்  
உடையோர் இலர் ஆசிரியர் ஆகுதலே”

(நன்னூல் 31)

நல்லாசிரியர்க்கு வேண்டாத குணங்களைக் குறிப்பிடுகிறது. பாடம் சொல்லும் திறம் இல்லாமை, இழி குணங்களான பொறாமைப்படுதல், பேராசை, வஞ்சனை, அதிர்ந்து பேசுதல் போன்ற குணங்களை உடையவர் ஆசிரியராய் இருப்பதற்கு தகுதி இல்லாதவர்கள் ஆவர். உயர்ந்த குணங்களை உடையவரே ஆசிரியராக இருத்தல் வேண்டும் என்பதை இதனால் அறிந்து கொள்ள முடிகிறது. மடல் பனை, பருத்தி குண்டிகை, முடத்தெங்கு ஆகியவை நல்லாசிரியர் அல்லாதார்க்கு ஒப்புமையாக கூறப்படுகின்றன. மடல் நிறைந்த பனை பயன் தராது. அந்த பனையினால் பயன்பெற நினைத்தால் துன்பப்பட நேரும். ஏனெனில் கருக்குகள் உடம்பில் கீறி துன்புறுத்தும். ஆசிரியர் மடல் பனைப் போல் இருக்கக் கூடாது. பருத்திக்குண்டிகை என்பது பஞ்சு வைக்கும் சிறிய வாயினை உடைய இடம் ஆகும். அதிலிருந்து பஞ்சினை எடுப்பது சிரமமான செயல் ஆகும். ஆசிரியர் மாணவர்களுக்கு எளிமையானவராக இருக்க வேண்டும் என்பதை இதனால் அறியலாம். முடத்தெங்கு என்பது வழியில் போவோருக்கும் வருவோருக்கும் பயன் தரும். தென்னை மரத்தின் உரிமையாளருக்குப் பயன்படாமல் போய்விடும். அது போல் ஆசிரியன் நன் மாணாக்கர்களுக்கு பயன்பட வேண்டும். கயவர்களுக்கு பயன்படக்கூடாது என்பதே இதனால் உணர முடிகிறது. நல்லாசிரியராய் திகழ்பவர்களுக்கு மத்தியில் தகுதி குறைபாடு மிக்க பல ஆசிரியர்கள் தற்காலத்திலும் இருக்கின்றனர். அத்தகையோருக்கு அறிவுரை கூறும் நோக்கிலே நன்னூலர் ஆசிரியருக்கு வேண்டிய தகுதிப்பாடுகளை பல நூற்றாண்டுகளுக்கு முன்னரே பதிவு செய்திருக்கிறார். கல்விக்கும் கல்வி கற்பிக்கும் ஆசிரியருக்கும் அக்கால சமூகத்தில் எத்தகைய உயர்வான இடம் இருந்தது என்பதை இதனால் அறிந்து கொள்ள முடிகிறது. நன்னூல் தமிழ் இலக்கண மரபின் மூன்றாம் தலைமுறை சார்ந்தது.

சங்க கால கல்வி என்பது மக்களிடையே மாற்றம் ஏற்படுத்திய காலகட்டம் ஆகும். ஏனெனில் கல்வி கற்றவன் அதிகாரம் பெற்றவனாய் திகழ்கின்றான். கல்லாதவன் அதிகாரத்திற்கு உட்பட்டவனாய் ஆகின்றான். இதனை சங்ககாலப் புலவர் மரபில் இருந்து காண முடிகின்றது. பாடம் சொல்லுதல் முறையைப் பற்றி நன்னூல் ஆசிரியர்

“ஈதல் இயல்பே இயம்பும் காலைக்  
காலமும் இடனும் வாலிதின் நோக்கி  
சிறந்துழி இருந்து தன் தெய்வம் வாழ்த்தி  
உரைக்கப்படு பொருள் உள்ளத்தமைத்து  
விரையாம் வகுளான் விரும்பி முகமலர்ந்து  
கொள்வோன் கொள்வகை அறிந்து அவன் உளங்கொளக்  
கோட்டமில் மனத்தின் நூல் கொடுத்தல் என்ப”

என்று கூறியுள்ளார். கல்வியில் வல்லார் கூறும் பயிற்றுமுறை நல்லியல்பு பயிற்றுமுறை நல்லியல்புகளை நன்னூலர் தொகுத்துக் கூறியிருப்பதிலிருந்து அக்காலத்து ஆசிரியர் பயிற்றுமுறைகளில் எத்துணை சிறந்து விளங்கினார் என்பது தெரிகிறது. சங்ககாலத்தில் பல்துறை கல்வி, இலக்கணம், இலக்கியம், இசை, நாடகம், மருத்துவம், வாணிகம் நுண்கலை ஆகியவை சிறப்புற்று விளங்கின. அடுத்த தலைமுறையினருக்கும் பரம்பரையாகவே தரப்பட்டன. முழுமையையும் செய்யுளாகவே அமைந்திருந்தன. கற்பார் மனதில் நிறுத்தும் வண்ணம் எதுகை, மோனை அமைப்புகளுடன் வரிவடிவமான பனை ஓலைகளில் பரிணமித்தன. சுருங்கச் சொல்லல் ஆழமுடைமை என்னும் அடிப்படையில் செய்யுள்கள் காணப்பட்டன. உரை நூல்கள் தோன்றிய பிற்பாடு கற்பித்தல் சிறப்பாக நடைபெற்றுள்ளது என்பதை அறிய முடிகிறது. பின்னாளில் அச்சுக்கலை மின்சார மயமாகி நவீன கருவிகளால் பெரும் புரட்சியே கல்வியில் நிகழ்ந்துவிட்டது.

### இடைக்காலத்தில் தமிழ் பயிற்றுவிக்கும் முறை

இடைக்காலத்தில் ஆசிரியருடைய வீட்டுத் திண்ணைகளே பள்ளிகளாக திகழ்ந்தன. மாணாக்கர்களுக்கு முதலில் எழுதவும், படிக்கவும், கற்பிக்கப்பெற்றது. எழுத்துக்கள் ஒன்று சேர்ந்து சொற்களாதலையும் சொற்கள் பல சேர்ந்து சொற்றொடர்களாகி ஒரு கருத்தை விளக்குதலையும் கண்டு காரண காரிய முறைப்படி எழுத்து, சொல், தொடர் மொழி என்ற முறையில் கற்பித்தல் நடைபெற்றது. இம்முறையில் சில சொற்களையும் சொற்றொடர்களையும் படிக்கத் தெரிந்ததும் மூதுரை, நீதி நூல் போன்ற சிறிய அறநூற்களை படிப்படியாக கற்பிப்பர். பின்னர் நிகண்டு, நன்னூல், அந்தாதி, கலம்பகம் முதலியவற்றையும் கற்பிப்பர். நாளடைவில் பெரிய இலக்கண இலக்கியங்கள் கற்பிக்கப்படும். செய்யுளை சொற்பொருள், பொழிப்புரை, கருத்துரை என்ற முறையில் ஆசிரியர் எடுத்துக் கூறுவர். இலக்கணப் பாடம் விதிவிளக்க முறையில் தனி பாடமாகவே கற்பிக்கப்பட்டது. எழுத்து, சொல், பொருள், யாப்பு, அணி என்ற முறையில் இலக்கணம் கற்பித்தல் நடைபெற்றது. சிறுவயதிலேயே இலக்கணத்தைக் கற்பித்தனர். மனப்பாடம் செய்யும் பழக்கம் எல்லா நிலைகளிலும் வற்புறுத்தப்பட்டது. பாடத்திட்டம் முக்கிய இடம் பெற்றதே அன்றி படிக்கும் மாணவர் நிலையினை ஒருவரும் சிந்திக்கவில்லை. ஆசிரியர்கள் உளவியல் அறிவு பெறாததால் கற்போர் மனநிலைக்கு அப்பாற்பட்ட செய்திகளை அவர்கள் உள்ளத்தில் புகுத்தினர். வாய்மொழி பயிற்சி, வினா விடை, கற்பிக்கும் துணைக்கருவிகள், விளையாட்டுகள்,

விளையாட்டு முறை ஆகிய கூறுகள் அக்கால கற்பித்தலில் இல்லை. மாணாக்கர் அடைந்த தண்டனைக்கு செல்வாக்கு இருந்தது.

### தற்கால பயிற்றுவிக்கும் முறைகள்

தற்காலத்தில் கல்வி மாணாக்கர் மையக் கல்வியாக கொள்ளப்பட்டு மாணாக்கரே சிறப்பிடமும் முதலிடமும் பெறுகிறார். 18 ஆம் நூற்றாண்டின் பிற்பகுதியிலிருந்து கல்வியாளர்கள் உளவியல் அடிப்படையில் கற்போர் மையமாக இருத்தலே உண்மை கல்வியாகும் என்னும் கருத்தினை உலகுக்கு தந்தனர்.

### **கல்வியாளர் கருத்துக்கள்**

ரூசோ - புலன்கள் வழியாகத்தான் கற்பித்தல் நிகழ வேண்டும். அதுவே இயற்கையாகும் என்பதை வலியுறுத்தினார்.

பெஸ்டலாசி - உற்று நோக்கலை வளர்க்க வேண்டும் எனும் கருத்தை எடுத்துரைத்தார்.

ஹெர்பர்ட் என்பவர் கற்பித்தலில் அமைய வேண்டிய படிநிலைகளைக் குறிப்பிட்டார். அவை மனத்தைத் தயாரித்தல், எடுத்துக்கூறல், ஒப்பிடல், பொதுவிதிக்காணல், விதியைச் செயல்படுத்துதல் என்பவையாகும். பிரோபெல் என்னும் அறிஞர் "இயற்கையை ஒட்டிக் கல்வி இருத்தல் வேண்டும்" என்றார்.

ஜான்டூயி என்பவர் "மாணாக்கர் பிற்கால வாழ்க்கையை கண்டுகொள்ள வேண்டும்" என்ற கருத்தை கூறினார். இத்தகைய கல்வி கருத்துகளால் கல்வியில், கற்பித்தலில் மாணாக்கருக்கு முக்கிய இடம் தரப்பட்டது.

### **தமிழ் கற்பித்தலில் தற்கால பயிற்று முறைகள்**

விளையாட்டு முறை, நடிப்பு முறை, சொற்பொழிவு முறை, உரையாடல் முறை, செயல் திட்ட முறை, மேற்பார்வை படிப்பு முறை, கட்டுரை படித்தல், பலர் கருத்துத்திரட்டல், செய்முறைக் கருத்தரங்கு, சொற்போர் போன்றவற்றின் மூலம் தமிழ் மொழியை கற்பிக்கலாம்.

### **நடிப்பு முறை**

நடிப்புமுறை விளையாட்டு முறையை அடிப்படையாகக் கொண்டது. நடிப்பு முறையில் மாணவர்களுக்கு நேர்முக பங்கு ஏற்படுகிறது. வகுப்பில் அனைத்து மாணவர்களுக்கும் வாய்ப்பு நல்கலாம். நடித்தலில் பங்கு பெறுபவர் நேர்முக பயனும், பார்ப்பவர் மறைமுக பயனையும் பெறுவர். சான்றாக காப்பிய இலக்கியங்களில் இடம்பெற்றிருக்கும் கதாபாத்திரங்களான கண்ணகி, மணிமேகலை, சீவகன், குண்டலகேசி அவர்களின் வாழ்வியலை மாணவர்களுக்கு நடிப்பதற்கு வழங்கலாம். இம்முறையால் மாணவர்களுக்கு தேர்ந்தெடுத்தல், திட்டமிடல், பங்கேற்றல், சீர்தூக்கி ஆராய்தல் என்று கற்றலில் நான்கு படிகள் வளர்கின்றன. இதை ஆயத்த நடிப்பு, ஆயத்தமில்லாத நடிப்பு, தனி நடிப்பு என மூவகைப் படுத்தலாம். விளையாட்டு முறையில் கற்பதால் கற்றலில் ஈடுபாடும், பற்றும், ஏற்படும். மொழித்திறனான பேச்சு உரையாடல் முதலிய வாய்மொழி பயிற்சிக்கு வாய்ப்பினை நல்குகின்றன. மாணவர்களிடம் இயல்பாக காணப்படும் அச்சம், கூச்சம், நடுக்கம், படபடப்பு, சொல்லின் கடை எழுத்தையும், சொற்றொடரின் கடைசி சொல்லையும் விட்டுவிடல் ஆகிய முறைகளைப் போக்க நல்ல வாய்ப்புகள் ஏற்படுகின்றன. மாணாக்கரின் மனப்பான்மையை விரிவடையச் செய்து அவர்களின் படைப்பாற்றலை வளர்க்க வாய்ப்பளிக்கின்றது.



## விரிவுரை முறை

கல்வியின் தொடக்க கால முறை விரிவுரை முறையாகும். இது விளக்கம், வர்ணனை, சிறு சொற்பொழிவு என்ற பல வடிவங்களில் வகுப்பறைகளில் பயன்பட்டு வருகின்றன. இம்முறையில் மாணவர் பங்கு குறைவாகவும் ஆசிரியர் பங்கு அதிகமாகவும் காணப்படும். இவற்றின் மூலம் மாணவர்கள் விரைவாக கேட்டல், ஆசிரியர் குறிப்பிடும் முக்கிய பகுதிகளை குறிப்பிடுதல் போன்ற திறன்களை வளர்க்க முடியும். புதிய தலைப்பினையோ, பாடத்தையோ, அறிமுகம் செய்யும்போதும் பாடத்தினை தொகுத்து கூறும் போதும் பயன்படுத்தலாம். மேலும் நிறைய செய்திகளை கூற வேண்டிய இடத்தும் வகுப்பில் பாடம் தொடர்பான வேலைகளை வளர்க்கும் போதும் இம்முறையை பயன்படுத்தலாம். சான்றாக தமிழ் பாடத்தில் உரைநடை, கதை, சிறுகதை, நாவல் கற்பிக்கும் போது இம்முறையை பயன்படுத்தலாம். பல்வேறு பாடங்களையும் பாடப் பகுதிகளையும் தொடர்பு படுத்தி கற்பிக்க ஏற்றது. ஆனால் ஒரே சொற்பொழிவாக இருப்பதால் மாணாக்கர் கவனத்தை ஈர்க்காது நினைவாற்றலை வளர்க்காது.

## உரையாடல் முறை

பாமர் என்னும் பேராசிரியர் “மொழி படிப்பில் கூடியவரை புத்தக உதவியின்றி, எழுதுதலன்றி, சொல்லாக்கம் முதலிய மொழி நூற்களை மேற்கொள்ளாது அயல்மொழிச் சொற்கள் குறிப்பிடாமல் ஒருவர் பேசுவதை மற்றொருவர் கேட்பதும் அதற்கு விடை அளிப்பதுமே உரையாடலாகும்” என்று குறிப்பிடுகின்றார் உரையாடலின் போது ஆசிரியர் பணி மிக முக்கியமானதாகும். ஆசிரியர் உரையாடலை மிக திறமையுடன் தொடங்க வேண்டும். உரையாடலின் பொருள் அதே இடத்தில் தேங்கி நிற்காது நகர்ந்து செல்வதை கண்காணிக்க வேண்டும். சில மாணவரே மீண்டும் மீண்டும் பங்கேற்பதை விலக்கி பலரும் கலந்து கொள்ள செய்ய வேண்டும். மாணவர்களுடன் உரையாடும் ஆசிரியர் இன்முகம் காட்டி அவர்களுடன் பரிவுடன் அன்புடனும் நடந்து கொள்ள வேண்டும். இயல்பாக பேசும் மொழியை கையாள வேண்டும். புதிய கருத்துக்கள் பிறக்கும் போது பாராட்ட வேண்டும். தேவையற்ற கருத்துக்களை தள்ளிவிட்டு தொகுத்து கூறுதலையும் முடித்தலையும் ஏற்க செய்தல் ஆசிரியர் பொறுப்பாகும். சான்று பண்டைக்கால உணவு முறை தற்கால உணவு முறை பற்றி உரையாடல் நடத்தலாம். இம்முறையில் சிந்தனை ஆற்றல் தூண்டப்படும். உடனடி பேச்சு உறுதி பெறுகிறது. கருத்துகள் விரிவடைந்து உற்றுநோக்கும் திறன், கவனிக்கும் ஆற்றல் முதலிய பண்புகள் வளர்கிறது.

## மேற்பார்வை படிப்பு முறை

மேற்பார்வை படிப்பு என்பது ஒரு கற்பிக்கும் முறை என்று சொல்வதை விட படிப்பில் நல்ல பழக்கங்களை மேற்கொள்ளும் ஒரு வழி என்று சொல்லுவதே பொருந்தும். மேல் நாட்டு கல்வி நிபுணர்கள் இதைக் குறித்து பல்வேறு கருத்துக்களை தெரிவிக்கின்றனர். இது கற்பித்தல் முறையா? அல்லது சிறந்த படிப்பு பழக்கத்தை உருவாக்கும் வழியா? என்று ஆராய்தல் வேண்டும். புதிய பாடத்தை கற்கும் திறனை மாணவர்கள் பெற ஆசிரியர்

வழிகாட்டல் அல்லது துணை செய்தல் இம்முறையில் நிகழக்கூடியதாகும். இது பயனுள்ள முறையில் புதுப்பாட ஒப்படைப்புகளை படிக்க கற்க ஆசிரியர் உதவுவதே மேற்பார்வை படிப்பு எனலாம். தனிப்பாட வேளை திட்டமாக ஒவ்வொரு நாளிலும் பாடவேளை முடிந்ததும் ஒரு பாடவேளை மேற்பார்வை படிப்புக்காக ஒதுக்கி கொள்ளலாம். மாணாக்கரின் ஐயங்களை தெளிவுபடுத்தவும், சரியான முறையில் படிப்பை மேற்கொள்ளவும், உதவுகிறது. வகுப்பில் பின்தங்கிய தமிழ் எழுத தெரியாத மாணவிகளுக்கு இப்பாட வேளையில் பயிற்சி வழங்கி ஊக்கப்படுத்தலாம். சிறந்த படிப்பு பழக்கமும், படிக்கும் திறனும் வளர இம்முறை வாய்ப்பளிக்கிறது. மேலும் மாணாக்கருக்கு தன்னம்பிக்கையை வளர்க்கின்றது

### செயல் திட்ட முறை

எட்டுக்கல்வியானது வகுப்பறை தாண்டிய தூழலில் நடைபெறுவது. செயல்திட்டம் என்ற தொடரை முதன் முதலில் கல்வியோடு தொடர்பு படுத்தியவர் ரிச்சர்ட் என்பவர். கில்பேட்ரிக் என்பவர் இதனை கற்பித்தலுக்கு பயன்படும் முறையாக வளர்த்தார். செயல்திட்ட முறையை தனியொரு மாணவர் ஈடுபடும் முறை எனவும் மாணவர் சிலர் சேர்ந்து செயலாற்றும் முறை எனவும் இரு வகைப்படுத்துவர். சான்றாக தமிழ் பயிற்று முறையில் ஐவகை நிலம் பழந்தமிழர் உணவு வகைகள் போன்றவற்றை செயல்திட்ட முறையில் கற்பிக்கலாம். இவற்றின் மூலம் மாணவர்களின் தன் முயற்சி, பொறுப்புணர்ச்சி ஒத்துழைத்தல், விடாமுயற்சி, சகிப்புத்தன்மை, திறந்த மனப்பான்மை, பிறர் கருத்திற்கு மதிப்பளித்தல் போன்ற பல நல்ல பண்புகளை வளர்க்கின்றன.

### செய்யுள் விளக்கும் முறை

செய்யுள் கற்பிக்கும் போது ஆசிரியர் இனிமையுற பாடுவதும் மாணவர்களை பாடச் செய்வதும் பாடத்திற்கு விளக்கம் தரும் துணை கருவிகளை ஆசிரியர்கள் பயன்படுத்துவதும் மாணவர்கள் பாடத்திற்கு தொடர்பான காட்சி படங்களை சேகரிப்பதும், பாடல்களை சேகரிப்பதும் மாணவர் செய்ய வேண்டிய செயலாகும். ஒவ்வொரு வகுப்பிற்கும் ஏற்றவாறு செய்யுள் நூலை தொகுக்கும்படி வழிகாட்டலாம். பிற மொழி கவிஞர்களின் கருத்துகளோடு ஒப்பிட்டு சுவைக்கலாம்.

பள்ளியில் கையெழுத்து படி நடத்தி மாணவர்களின் படைப்பாற்றலைத் தூண்டி வெளிகொணர்ந்து செயல்படுத்தலாம்.

### செய்யுள் கற்பித்தல் நோக்கங்கள்

- பொருள் உணர்தல்
- இலக்கியத்தில் பற்றுக்கொள்ளுதல்
- இலக்கிய சுவையுணர்ந்து இன்புறல்
- கற்பனையாற்றலை வளர்த்தல்
- இலக்கியத்தில் ஈடுபாடு கொள்ளல்
- படைப்பாற்றலை வளர்த்தல்
- மக்கள் பண்பினை வளர்த்தல்
- நாட்டுப் பற்றினை வளர்த்தல்

- நினைவாற்றலை வளர்த்தல்
- பொதுமை நோக்கைப் பாராட்டல்
- படைப்பாளியின் உணர்வை எய்தல்
- உரைநடை இலக்கியங்கள் பல்கி பெருகிய போதிலும் கவிதை இலக்கியங்கள் இன்னும் தம்முடைய இடத்தை இழந்து விடவில்லை.
- கவிதை நம் முன்னோரின் காதல் உணர்வு, ஏக்கம், தவிப்பு, பெருமிதம், மகிழ்வுணர்வு மெய்ப்பாடு, பண்பாடு இவற்றையெல்லாம் காண்பிக்கும் காலம் கடந்த கருவூலமாகும்.

### உரைநடை பயிற்றுவிக்கும் முறை

உரைநடை பாடம் கற்பித்தலில் சொற்களஞ்சிய பெருக்குதலை சிறப்பு நோக்கமாக கொள்ள வேண்டும். பாலர் கல்வி முதல் பல்கலைக்கழக கல்வி வரை பயில்வோரிடம் பல்வேறு வழிகளில் சொற்களஞ்சிய பெருக்கத்தினை ஆசிரியர் கையாள முடியும். உரைநடையில் காணப்படும் புதிய சொற்களுக்கு ஒரு பொருள் தருகின்ற வேறு சொற்களை அறிய செய்யலாம். எடுத்துக்காட்டு பேசினான், செப்பினான், மொழிந்தான் ,உரைத்தான், இயம்பினான், விளம்பினான். நவீனரான்.படிக்கும்போது மிக விரைவாக படித்தல், பிழைகளோடு படித்தல், உச்சரிப்பு தெளிவில்லாது படித்தல் போன்ற பிழைகளை திருத்தல் வேண்டும்.

### தமிழ் மொழி கல்வியின் இன்றைய நிலை

உலக அளவில் ஜப்பான் சீனா மற்றும் பல வளர்ந்த நாடுகள் கல்வி வளர்ச்சியில், அறிவியல் கண்டுபிடிப்புகளில் முன்னிலையில் உள்ளன. இவற்றின் முன்னேற்றத்திற்கு அடிப்படையான காரணம் தாய்மொழி வழி கல்வியாகும். கற்றது கைமண் அளவு கல்லாதது உலகளவு என்ற முது மொழியினை மனத்திற்கு கொண்டு அனைத்து வகையான கல்வியையும் தாய்மொழி வழியில் கொடுத்து மனப்பாட கல்வி, வேற்று மொழி கல்வி தவிர்த்தல் வேண்டும். அவ்வாறு அமையுமேயானால் நாம் உலக அரங்கில் கல்வியில் மட்டுமல்ல அனைத்திலும் முன்னிலையில் நிற்கும் காலம் வெகு தொலைவில் இல்லை.

### தொகுப்புரை

- தொல்காப்பியர் கால கல்விமுறை மற்றும் நன்னூலார் கல்வி முறைகளைப் பற்றி அறிந்து கொள்ள முடிந்தது.
- இடைக்கால கல்வி முறையில் எழுத்து, சொல், தொடர் மொழி என்ற முறைப்படி கற்பித்தல் நடைபெற்றது. மாணாக்கர் அடைந்த தண்டனைக்கு செல்வாக்கு இருந்தது.
- தற்காலத்தில் கல்வி மாணாக்கர் மையக்கல்வியாக கொள்ளப்பட்டு மாணாக்கரே சிறப்பிடமும் முதலிடமும் பெறுகிறார்.
- ஞ்சோ, பெஸ்டெலாஸி, ஹெர்பர்ட், பிரோபெல், ஜான் டூயி போன்ற கல்வியாளர்களின் கருத்துக்கள் அறிந்து கொள்ளப்பட்டன.
- தமிழ் கற்பித்தலில் தற்கால பயிற்று முறைகள் அதன் விளைவுகள் நோக்கம் பற்றி ஆய்வு செய்யப்பட்டுள்ளன.

## முடிவுரை

இன்றைய மனித சமுதாயத்தினை அடையாளம் காண்பதற்கு பெரிதும் பயன்படக்கூடியது மொழியாகும். அவ்வாறான மொழியின் மூலம் ஒரு மனிதனுடைய பண்பாட்டையும் சமுதாயத்தையும் அடையாளப்படுத்த முடியும். 1960 க்கு பிறகு கல்வித்துறையில் தனியார் நிர்வாகத்திற்கு இடம் அளிக்கப்பட்டு சுயநிதி கல்வி நிறுவனங்கள் உருவாக்கப்பட்டன. மத்திய, மாநில கல்வி திட்டத்தில் பயிலும் மாணாக்கர் தாய் மொழியாகிய தமிழ் மொழியை பயிலாமல் ஹிந்தி, சமஸ்கிருதம், ஆங்கிலம் போன்ற மொழிகளை கற்கின்றனர். தமிழ் தெரியாது என்று கூறுவதை இழிவாக கருதாமல் பெருமையாக கருதும் நிலை ஏற்பட்டுள்ளது. தமிழ் மொழி கற்றல் என்பது மாணவர்களுக்கு ஒரு சுகமான அனுபவமாக அமைய வேண்டும். ஆகவே அவர்களுக்கு தமிழ் மொழியில் ஈடுபாடும் ஆர்வமும் ஏற்படுத்தும் கற்பித்தல் முறை வலியுறுத்தப்படுகிறது. தமிழின் ஒவ்வொரு எழுத்து உச்சரிப்பும் அவை கோர்க்கப்பட்ட வார்த்தைகளின் உச்சரிப்பும் ஒரு மனிதனின் உதட்டில் உள்ள நரம்புகளின் அசைவோடு தொடர்புடையது. அவை மனிதனில் உள்ள 72 ஆயிரம் நரம்புகளோடு மற்றும் எல்லா பாகங்களோடும் தொடர்பு கொள்கின்றது. எல்லாவற்றுக்கும் மேலாக கற்றலில் ஒவ்வொரு தமிழ் எழுத்தும் மனித உயிரோடு தொடர்பு கொள்ளும் பாலமாக உருவாக்கப்பட்டுள்ளன. ஆகவே நாம் அனைவரும் தாய் மொழியிலே கல்வி கற்று உயர்வடைவோம்.

## பார்வை நூற்கள்

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- கல்வி நுட்பவியல், பேராசிரியர் முனைவர் மீனாட்சி சுந்தரம், காவியமாதா பப்ளிஷர்ஸ், 7 எஸ் .எஸ் நகர் சின்னாளப்பட்டி திண்டுக்கல்.
- கல்வியில் புதுமைகள்,காவியமாதா பப்ளிஷர்ஸ், 7 எஸ்.எஸ் நகர் சின்னாளப்பட்டி, திண்டுக்கல்.

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## பழந்தமிழரின் உணவுப்பாதுகாப்பு

மா. தே. அருண் மொழி நங்கை

உதவிப்பேராசிரியர், தமிழ்த்துறை, ஹோலிகிராஸ் கல்லூரி (தன்னாட்சி),  
நாகர்கோவில் - 629004.

### முன்னுரை

ஆதி மனிதன் வேட்டை மூலமாகவும் இயற்கையாகவும் விளைந்த உணவுப் பொருட்களை காலச்சூழலுக்கேற்ப உண்டு வந்தனர். அந்த நிலைமை காலப்போக்கில் மாற்றம் அடைந்தது. வேட்டை நிரந்தரமற்றது என்ற சூழலை உணர்ந்து கொண்டனர். ஆகையால் இறைச்சி, மீன் போன்றவை அதிகமாகக் கிடைத்த காலங்களில் அவற்றை வீணாக்காமல் பாதுகாத்து வைத்துக்கொள்ள வேண்டும் என்ற எண்ணம் ஏற்பட்டது. உணவு கிடைக்காத காலங்களில் இச் சிந்தனை அதிகமாகத் தோன்றியது. நிரந்தரமாக வாழப்பழகிய மக்கள் வேளாண்மை செய்ய ஆரம்பித்தனர். வேளாண்மை நடைமுறைக்கு வந்த பிறகு அதிகமாக கிடைத்தவற்றைப் பாதுகாப்புடன் சேமித்து வைத்துக்கொள்ள வேண்டும் என்ற எண்ணம் தோன்றுவது இயல்பானதே. இந்தப் போக்கில் உணவு உற்பத்திக்கு மாறிப்போன சமுதாயச் சூழலில் உணவுப் பாதுகாப்பில் பழந்தமிழர் ஈடுபடலாயினர்.

### உணவில் ஏற்றத்தாழ்வு

"வாடா யாணர் நாடும் ஊரும்" (புற . 240:2) எனும் பாடலடி, இல்லை என்று கூறும் நிலை உருவாகாமலும், புதுவருவாய் உடைய நிலைமையைக் குறிப்பிடுகின்றது. எனவே உணவு உற்பத்தியில் இல்லை என்னும் நிலை நிலவுவது இயல்பான சமுதாய நடைமுறையாக இருந்துள்ளது.

"உண்டாயின் பதம்கொடுத்து, இல்லாயின் உடன்

உண்ணும், இல்லோர் ஒக்கல் தலைவன்" (புற. 95:6-7)

என அதியமான் நெடுமானஞ்சியை ஒளவையார் குறிப்பிடுவது உணவுப்பொருள் குறைவாக இருந்த காலங்களும் குறிஞ்சியில் இருந்ததைக் காட்டுகின்றது. ஒளவையாரின்,

"சிறியகட் பெறினே எமக்கீயு மன்னே

பெரியகட் பெறினே

யாம்பாடத் தான்மகிழ்ந் துண்ணு மன்னே

சிறுசோற் றானும் நனிபல கலத்தன் மன்னே

பெருஞ்சோற் றானும் நனிபல கலத்தன் மன்னே" (புறம். 235:1-5)

எனும் பாடல் கள்ளும் உணவும் குறைவாகவும் மிகுதியாகவும் கிடைக்கின்ற ஏற்றத்தாழ்வு சூழல்களை வெளிப்படுத்துகின்றது.

எருதுகளை விட்டு மிதிக்கச்செய்யும் அளவுக்கு அதிகமாக விளையாததும் இளையவர்கள் கால்களால் மிதித்துத் திரட்டி எடுத்ததுமான சிலவாக விளைந்த வரகின் சிறிய குவியலில் கடன்காரர் (கடவர்) எடுத்துக்கொண்டது போக எஞ்சியுள்ள மீதத்தைப் பாணர் உண்டு சென்றனர் என்னும் நிலையில் முல்லைச் சமுதாயச் சீறார்மன்னன் வரகைக் கடனாகப் பெற்றுள்ளான் (புற. 327). மிகச் சிறிதாக இருந்த உணவையும் பகிர்ந்தளித்த சீறார்த்தலையியைப்

புறநானூற்றின் 331ஆம் பாடல் காட்டுகின்றது. உணவுப் பற்றாக்குறைக் காலங்களை உடைய தாகக் குறிஞ்சி, முல்லைச் சமுதாயங்கள் இருந்துள்ளதை இவை வெளிப் படுத்துகின்றன. இந்நிலையில் உணவுப்பொருட்கள் மிகுதியாகக் கிடைத்த காலங்களில் அவற்றைப் பாதுகாத்து வைத்துக்கொள்ள வேண்டும் என்ற எண்ணம் எல்லாத் திணைச் சமுதாயங்களிலும் நிலவியிருந்தது.

### மீன், இறைச்சி, தானியம் - உலர்த்திப் பாதுகாத்தல்

வேளாண் விளைச்சலும் வேட்டைவழியாக மிகுதியாகக் கிடைத்த மீனும் இறைச்சியும் பிற்காலத் தேவைக்கென உலர்த்தி வைத்துப் பாதுகாக்கப்பட்டுள்ளன. உலரவைக்கப்பட்ட இந்த இறைச்சி, மீன் ஆகியன "புலவமீன் உணங்கல்" (நற். 331:4), "கொழுமீன் உணங்கல் படுபுள் ஓப்பி (அ. 20:2), "பல்மீன் உணங்கல்" (அக. 80:6), "மான் உணங்கல்" (அக. 107:5) என 'உணங்கல்' என்னும் பெயரால் குறிப்பிடப் பட்டுள்ளன. இது 'வாடுன்' (புற. 328:9, பெரு. 100) எனவும் குறிப்பிடப் பட்டுள்ளது.

### மீன் உலர்த்தல்

"மிகுமீன் உணக்கிய புதுமணல் ஆங்கண்" (நற். 63:2) என்னும் பாடலடி மிகுதியாக உள்ள மீனைப் புதிய மணலிலே மீனவர்கள் உலர்த்தியதைக் குறிப்பிடுகின்றது. பரதவர்கள் மீன், இறால் ஆகிய வற்றை மணற்பரப்பில் உலர்த்தியுள்ளனர். கொழுப்புடைய சுறாவினை அறுத்தெடுத்து அத்துண்டுகளை உலரவைத்த நிலையில் அவற்றைக் கவர வந்த பறவைகளை விரட்டிப் பெண்கள் பாதுகாத்துள்ளனர் (நற். 45:6-8). முற்றாத மஞ்சள் நிறத்தில் திரண்ட இறால்மீன் தொகுதி உலர்ந்துவிட்ட நிலையில் அதைப் புன்னைமரத்தின் வளமான நிழலில் பரப்பி வைத்துள்ளனர் (நற். 101:1-5). நெய்தல்நிலக் கானலில் இட்டுக் காயவைத்த மீனைக் கவர வரும் பறவைகளை விரட்டிக் காத்தவர்கள் தம் தந்தையின் திமில் இது, உன் தந்தையின் திமில் இது எனச் சுட்டிக் காட்டி விளையாடியுள்ளனர் (நற். 331:3-7). பரதவப்பெண் தன் தந்தை பிடித்துவந்த கொழுவிய மீனின் துண்டங்களைப் பறவைகள் கவர்ந்து செல்லாதவகையில் பாதுகாத்துள்ளாள் (அக. 20:1-5). பரதவர் அன்றன்று பிடித்துவந்த மிகுதியான மீன்களை மணலில் உலரவைக்கப் பறிகளில் எடுத்துவந்துள்ளனர் (அக. 300:1-4).

### இறைச்சி உலர்த்தல்

உலர்த்திவைத்துக்கொள்ளப்பட்ட 'வாடுன்' எனப்பட்ட இறைச்சி, "முரவுவாய்க் குழிசி முரியடுப்பு ஏற்றி வாராது அட்ட வாடுன் புழுக்கல் வாடாத் தும்பை வயவர் பெருமகன் தெய்வ மடையின் தோக்கிலைக் குவைஇரும் பைதீர் கடும்பொடு பதம்மிகப் பெறுகுவீர்" (பெரு.99-105)

"வாடுன் கொழுங்குறை

கொய்குரல் அரிசியொடு நெய்பெய்து அட்டுத்

துடுப்பொடு சிவணிய களிக்கொள் வெண்ணோறு

உண்டினிது இருந்தபின் ..... தருகுவன் மாதோ(புறம். 328:9-13)

எனும் பாடல்கள் புழுக்கி இடப்பட்டதையும் அரிசியுடன் நெய் பெய்து களியாக இடப்பட்ட சோற்றுடன் வாடுனின் கொழுத்த துண்டுகள் இட்டுச் சமைக்கப்பட்டதையும் காட்டுகின்றன.

"வாடூன் மிசையவும்" (புறம். 386:4) எனும் தொடர் வாடூன் உண்ணப்பட்டதை வெளிப்படுத்துகின்றது.

"கருங்கல் வியலறை கிடப்பி வயிறு தின்று  
இரும்புலி துறந்த ஏற்றுமான் உணங்கல்  
நெறிசெல் வம்பலர் உவந்தனர் ஆங்கண்  
ஒலிகழை நெல்லின் அரிசியொடு ஓராங்கு  
ஆனிலைப் பள்ளி அளைபெய்து அட்ட  
வால்நிணம் உருக்கிய வாஅல் வெண்சோறு  
புகரரைத் தேக்கின் அகலிலை மாந்தும்"(அகம். 107:4-10)

என்னும் பாடல், புலி தின்றது போக எஞ்சிய மானின் இறைச்சியை எடுத்துவந்து உலர்த்தி எடுத்துவைத்துக்கொண்டுள்ளதையும் சமைக்கப்பட்ட அந்த வாடூன், நிணம் ஆகியன இட்டுச் சமைத்த மூங்கில் அரிசிச் சோற்றை தேக்கிலையில் வைத்து வடுகர் உண்டதையும் காட்டுகின்றது. ஆக, விலங்குகள் வேட்டையாடித் தின்றது போக எஞ்சிய விலங்கின் இறைச்சியை எடுத்துவந்து உலர்த்திச் சேமித்து வைத்துக்கொண்டவர்களாகப் பாலையில வடுகர் இருந்துள்ளனர்.

### திணை உலர்த்துதல்

உலர்த்தப்பட்ட திணை 'உணங்கல்' என்னும் சொல்லால் குறிப்பிடப் பட்டுள்ளது (நற். 344:11, குறு. 46:3, ஐங். 469:1, புறம். 319:5). சீறார்மன்னர் சமுதாயத்தில் முற்றத்தில் திணை உலர்த்தப்பட்டுள்ளது (புறம். 319). மான் தோலில் உலர்த்தப்பட்ட திணையைக் கானக்கோழி கவர்ந்து உண்டுள்ளது (புறம். 328). விதைத்திணை கதிராகவே உலர்த்திப் பாதுகாக்கப்பட்டுள்ளது (புறம். 333). மகளிர் உலரவைக்கப்பட்ட உணவுப் பண்டங்களைக் கவர்வரும் கோழிகளைத் தம் குழைகளை எறிந்து விரட்டியுள்ளனர் (பட். 22-24). சீறார்மன்னர் தம் வன்புலச் சமுதாயத்தில் மேல்தோல் நீக்கப்பட்ட வெள்ளை எள் முறத்தில் இட்டு உலர்த்தப்பட்டுள்ளது (புறம். 321:2,3).

'உணக்கும் ஊண் ஆயத்து'(நற். 37:2)

'உணங்கு திணை துழுவும் கைபோல் ஞாமூல்'(நற்.267:4)

'ஐது உணங்கு வல்சி'(அகம். 224: 12)

எனும் இவை உணவுப்பொருட்கள் வெயிலில் உலர்த்திப் பேணப்பட்ட முறையை வெளிப்படுத்துகின்றன.

'பிண்ட நெல்லின் தாய்மனை'(நற். 26:4)

'மழைவளம் தருஉம் மாவண் தித்தன்

பிண்ட நெல்லின் உறந்தை'(அகம். 6: 4,5)

'கொற்றச் செழியன் பிண்ட நெல்லின் அள்ளூர்'(அகம். 46:13,14)

எனும் பாடலடிகளில் வரும் 'பிண்டநெல்' எனும் தொடர் தொகுதியாக வைத்து நெல் பேணப்பட்டதைக் குறிப்பிடுகின்றது.

'ஏர்பரந்த வயல் நீர்பரந்த செறுவின்

நெல்மலிந்த மனைப் பொன்மலிந்த மறுகு' (புறம்.338:1,2)

எனும் பாடலில் வரும் 'நெல் மலிந்த மனை' என்னும் தொடரும் வீடுகளில் நெல் பேணிப் பாதுகாத்து வைக்கப்பட்டதைக் காட்டுகின்றது.

'முகடுற உயர்ந்த நெல்லின் மகிழ்வரப்

பகடுதரு பெருவளம்'(புறம்.391: 3, 4)

என்னும் பாடலடிகள் முகடுமுட்ட அடுக்கிவைக்கப்பட்ட நெல். எருதுகள் தந்த பெருவளமாகப் பேணப்பட்ட நிலையைக் குறிப்பிடுகின்றன.

### பலாப்பழங்களைக் கடாவிடுதல்

அளவிற்கு அதிகமாக விளைந்த பலாப்பலங்களில் உண்டது போக எஞ்சியவற்றை வீணடிக்காமல் அவற்றில் உள்ள கொட்டைகளைச் சேமித்து வைத்துக் கொள்வதற்கு ஏற்ப அப்பழங்களைக் கடாவிட்டுக் கொட்டைகளைத் தனியே பிரித்து எடுத்துக் குறவர்கள் சேமித்து வைத்துக்கொண்டதை மலைபடுகடாம் (337-339) குறிப்பிடுகின்றது.

### நெற்கூடு

நெல்லை வைத்துப் பாதுகாக்கும் குதிர்கள் இருந்ததை, முகடுகள் முட்ட அடுக்கப்பட்ட பழமையான உணவுப்பொருட்கள் நிறைத்து வைக்கப்பட்ட கூடு எனப்பட்ட நெற்களஞ்சியங்கள் இருந்ததை,

'முகடுதுமித்து அடுக்கிய பழம்பல் உணவின்

குமரி மூத்த கூடோங்கு நல்லில்' (பெரு. 246, 247)

'நெல்லுடை நெடுநகர்க் கூட்டுமுதல் புரளும் தண்ணடை'

(புறம். 287: 9,10)

எனும் பாடலடிகளில் வரும் 'கூடு' எனும் சொல் குறிப்பிடுகின்றது.

இந்தக் கூடுகளில் வைத்துப் பேணப்பட்ட நெல் 'பழம்நெல்' எனக் குறிப்பிடப்பட்டுள்ளது. "பழம்பல் நெல்லின் பல்குடிப் பரவை" (அகம். 44:16), "பழஞ்செந் நெல்லின் முகவை கொள்ளாள்" (அகம். 126:11). "பழம்பல் நெல்லின் வேளூர்" (அகம். 166:4), "பழம்பல் நெல்லின் ஊணூர்" (அகம். 220:13) எனும் பாடலடிகளில் இடம்பெற்ற 'பழம் நெல்' எனும் சொல்லாட்சி, நெல் பலநாட்கள் பேணிப் பாதுகாக்கப்பட்டதைக் குறிப்பிடுகின்றது.

காய்த்த நெல்லை அறுத்தெடுத்து அதிலிருந்து பெற்ற அரிசியைச் சோறாக்கிக் கவளமாகச் செய்து யானைக்குக் கொடுத்துவந்தால் ஒரு 'மா' எனும் அளவுகூட இல்லாத நிலத்தில் விளைந்த விளைச்சல்கூடப் பலநாட்கள் யானைகளுக்கு உணவாக வரும் (புறம். 184) எனும் பாடற் கருத்து அறுவடைசெய்யப்பட்ட நெல்லைப் பாதுகாத்துப் பலநாட்கள் பயன்படுத்தும், சேமித்துவைக்கும் முறையைப் பண்டைத் தமிழர் அறிந்திருந்த நிலையைக் காட்டுகின்றது.

### நிறைவுரை

பழந்தமிழர் தங்கள் தேவைக்கு அதிகமாக கிடைத்தவற்றைப் பாதுகாக்க பழகிக்கொண்டனர். வேட்டைச் சமூகமா இருந்த மக்கள் வேட்டையில் கிடைத்தவை மீதமான போது இவற்றைப் பாதுகாக்க வேண்டும் என்று கற்றுக் கொண்டனர். அதன் தொடர்ச்சியாக தினையையும் பாதுகாக்க பழகிக்கொண்டனர். நெற்பயிரிட்டு அவற்றை குதிர்களில் சேமிக்கவும்



செய்தனர்.பலாப்பழம் நீண்ட காலம் இருக்காது என்பதால் அதன் கொட்டைகளைப் பாதுகாத்து வந்தனர். இப்போது பலாப்பழம் பல்வேறு மதிப்புக்கூட்டுதல் வழியாக விற்பனைக்கு வருகிறது. இவ்வாறு பழந்தமிழர் உணவினை எவ்வாறு பாதுகாத்து வந்தனர் என்பதைக் குறித்து இக்கட்டுரையில் எழுதியுள்ளேன்.

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## **Innovative methods in teaching French to non-native speakers**

**P.T. Anbu Hannah Dora**

*Associate Professor and Head, Department of French, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [doraanbu90@gmail.com](mailto:doraanbu90@gmail.com)*

### **Abstract**

In the globalized world, the demand for learning French as a foreign language has increased significantly. This paper explores innovative methods in teaching French to non-native speakers, focusing on modern pedagogical approaches and technological advancements. By integrating immersive experiences, interactive digital tools, and culturally rich content, educators can enhance language acquisition and engagement. This study examines successful techniques, including immersive language environments, gamification, the use of multimedia resources, and strategies tailored to non-native speakers, providing practical insights for educators and language learners. The findings highlight the importance of a dynamic and adaptable approach to language teaching, tailored to the diverse needs of learners.

**Keywords:** French language, Innovative teaching methods, Non-native speakers, Immersive learning, Gamification

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### **Introduction**

Learning French as a foreign language presents unique challenges and opportunities, especially for non-native speakers. Traditional methods often fail to engage learners or address their individual needs. This paper investigates innovative teaching methods that leverage technology, interactive content, and immersive experiences to enhance the effectiveness of French language instruction for non-native speakers. By focusing on tailored approaches, we aim to provide a comprehensive framework for improving language acquisition and learner engagement.

### **Methods**

The research employs a qualitative approach, analyzing case studies and educational practices from various institutions that have successfully implemented innovative French teaching methods. Data is collected through interviews with educators, surveys of students, and observation of teaching practices. Emphasis is placed on techniques specifically designed for non-native speakers.

## **1. Immersive Language Environments**

Immersive environments, such as language camps, exchange programs, and virtual reality simulations, provide learners with real-world contexts to practice French. These experiences foster natural language use, cultural understanding, and improve confidence in speaking.

### **1.1 Language Camps**

Language camps offer a unique opportunity for learners to immerse themselves in a French-speaking environment. Participants engage in daily activities, all conducted in French, which helps to reinforce their language skills in practical settings. The social aspect of camps also encourages conversational practice and peer learning.

### **1.2 Exchange Programs**

Exchange programs allow students to live and study in French-speaking countries. This immersion experience accelerates language acquisition by exposing learners to the language in various contexts, from academic to social. Exchange programs also enhance cultural understanding and adaptability.

### **1.3 Virtual Reality Simulations**

Virtual reality (VR) simulations provide immersive experiences without the need of travel. VR can simulate real-life scenarios where learners can practice their French in a controlled environment. These simulations can include everyday activities, such as shopping or ordering food, and help build confidence in using the language.

## **2. Gamification in Language Learning**

Incorporating game elements into language learning, such as points, badges, and leaderboards, increases motivation and engagement. Language learning apps and platforms like Duolingo and Babbel exemplify successful gamification strategies that make learning fun and competitive.

### **2.1 Points and Badges**

Awarding points and badges for completing lessons or achieving milestones can motivate learners to continue progressing. These elements add a sense of achievement and encourage regular practice.

## **2.2 Leaderboards**

Leaderboards create a competitive environment where learners can compare their progress with peers. This competition can drive learners to put in more effort and stay engaged with their language studies.

## **2.3 Language Learning Apps**

Apps like Duolingo and Babbel use gamification to keep users engaged. These platforms offer interactive exercises, immediate feedback, and progressively challenging content that adapts to the learner's level.

## **3. Multimedia and Interactive Tools**

Utilizing multimedia resources, including videos, audio recordings, and interactive exercises, caters to different learning styles and keeps learners engaged. Platforms like YouTube, educational websites, and language labs offer a wealth of resources that enhance listening, speaking, and comprehension skills.

### **3.1 Videos and Audio Recordings**

Videos and audio recordings expose learners to native speakers and various accents, improving listening skills and pronunciation. These resources can include dialogues, interviews, and cultural content that enriches the learning experience.

### **3.2 Interactive Exercises**

Interactive exercises, such as quizzes and games, provide immediate feedback and help reinforce language concepts. These exercises can be found on educational websites and apps, allowing learners to practice grammar, vocabulary, and comprehension in an engaging way.

### **3.3 Language Labs**

Language labs equipped with advanced technology offer a structured environment for practicing speaking and listening skills. These labs often include software that tracks progress and provides tailored exercises based on the learner's needs.

## **4. Culturally Rich Content**

Integrating cultural content into language lessons helps learners connect with the language on a deeper level. Teaching French through its literature, films, music, and cuisine not only enhances vocabulary and comprehension but also fosters a greater appreciation for the culture.

#### **4.1 Literature**

Introducing learners to French literature, from classic novels to contemporary works, expands their vocabulary and comprehension skills. Analyzing texts also provides insights into French history and cultural norms.

#### **4.2 Films and Music**

Films and music offer authentic language exposure and cultural context. Watching French movies and listening to French songs help learners understand colloquial expressions and cultural references.

#### **4.3 Cuisine**

Exploring French cuisine through recipes and cooking classes introduces learners to culinary vocabulary and cultural traditions. Cooking classes conducted in French can be a fun and practical way to practice language skills.

### **5. Personalized Learning Paths**

Creating personalized learning plans based on individual learner profiles ensures that non-native speakers receive instruction that meets their specific needs and goals. Adaptive learning technologies can track progress and adjust content accordingly, providing a customized learning experience.

#### **5.1 Adaptive Learning Technologies**

Adaptive learning technologies use algorithms to adjust the difficulty and content of lessons based on the learner's performance. This personalization ensures that learners are always challenged but not overwhelmed.

#### **5.2 Individualized Feedback**

Providing individualized feedback helps learners understand their strengths and areas for improvement. Personalized feedback can guide learners on where to focus their efforts for the greatest improvement.

### **6. Collaborative Learning and Peer Interaction**

Encouraging collaborative learning through group projects, language exchange partners, and discussion forums promotes peer interaction and practice. This method helps learners build confidence and improve conversational skills in a supportive environment.

## **6.1 Group Projects**

Group projects require learners to communicate and collaborate in French. These projects can range from presentations to research assignments, providing practical language use opportunities.

## **6.2 Language Exchange Partners**

Pairing learners with native speakers for language exchange sessions allows for conversational practice and cultural exchange. These partnerships can be facilitated through language learning platforms or local community programs.

## **6.3 Discussion Forums**

Online discussion forums provide a platform for learners to practice writing and engage in discussions on various topics. These forums can be part of a language learning website or an educational institution's online platform.

## **7. Use of Technology in Classroom**

Incorporating smart boards, tablets, and language learning software in the classroom can enhance interactive learning. These tools provide immediate feedback, facilitate group activities, and offer access to a vast array of digital resources.

### **7.1 Smart boards**

Smart boards allow teachers to display interactive lessons, videos, and exercises. These boards can also be used for collaborative activities, such as group writing or interactive quizzes.

### **7.2 Tablets**

Tablets offer a portable and versatile tool for language learning. Students can use tablets to access language learning apps, take notes, and participate in interactive exercises during class.

### **7.3 Language Learning Software**

Software programs designed for language learning provide structured lessons, practice exercises, and progress tracking. These programs often include multimedia content and interactive elements to keep learners engaged.

## **Suggestions for Innovative Approaches for Enhancing Language Education**

Educators can adopt these innovative methods by:

### **1. Expand Access to Immersive Environments**

Partnerships with French-speaking communities and institutions can facilitate these experiences, making them more accessible and affordable.

## **2. Integrate Advanced Gamification Techniques**

Incorporating artificial intelligence to create personalized challenges and adaptive learning paths can make the learning process more tailored and effective.

## **3. Utilize Cutting-Edge Multimedia Tools**

Leveraging platforms like YouTube, podcasts, and interactive websites can provide a richer learning experience

## **4. Enrich Culturally Relevant Content**

Introducing a wider variety of French literature, films, music, and culinary experiences can make learning more enjoyable and meaningful

## **5. Enhance Personalized Learning.**

Investing in adaptive learning technologies that use data analytics to monitor progress and adjust content in real-time can provide a more personalized learning experience

## **6. Foster Collaborative Learning Opportunities**

Promoting collaborative learning through more group projects, language exchange partnerships, and online discussion forums can enhance conversational skills and confidence

## **7. Incorporate Emerging Classroom Technologies**

Adopting the latest classroom technologies, such as augmented reality (AR), artificial intelligence (AI), and machine learning (ML), can further revolutionize language teaching

## **Conclusion**

Innovative methods in teaching French to non-native speakers are transforming the landscape of language education. By adopting immersive environments, gamification, multimedia resources, culturally rich content, personalized learning paths; collaborative learning strategies, and advanced classroom technologies, educators can create dynamic and effective language learning experiences. These approaches cater to diverse learning styles and needs, fostering not only language proficiency but also cultural understanding and confidence in using the language

Overall, these innovative methods hold great promise for enhancing the effectiveness of French language instruction for non-native speakers. By embracing these strategies, educators can create a more inclusive, engaging, and successful language learning journey for their students

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## **Role Strain among Working Women and its Relationship with Mental Health in Nagercoil Town**

**T. Santhiya<sup>1</sup> and S. Jeni Sanjana<sup>2</sup>**

<sup>1</sup>*PhD. Research Scholar, Holy Cross College (Autonomous), Nagercoil – 629004.*

<sup>2</sup>*Assistant Professor, Department of Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [santhyathanumoorthy@gmail.com](mailto:santhyathanumoorthy@gmail.com)*

### **Abstract**

Women are critical to economic growth and play a critical role in human resource development. To fully understand women's health experience, we need to look at both women's social roles, e.g. paid worker, wife, mother. They continue to prioritize their family roles above work roles and the roles of mother, spouse and employee are their priority three roles. Larger share of responsibility towards children, domestic task and caregiver's role remains attached them despite joining work, though their workplace dynamics do not seem to be pressurizing. Overall women give maximum time of their day to the work role and minimum to their self-care. There is a significant relationship between multiple roles played by working women and their physical and psychological health.

**Keywords:** Women, Multiple roles, Paid workers, Spouse and Mother.

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### **Introduction**

Women are playing a very important role in the economic and social development of the nations all over the world. In this context, women have been treated as the virtue-holders of society, living a life of roles and doing their duty as daughters, spouse and mother. As the number of employed women has increased over the past several decades, women are at par with their male counterparts. The problems stress is inevitable and unavoidable in the sector. The psychological health of working women is also better than that of females in the general population, however their physical health is affected slightly. Majority of the working women develop chronic illnesses and many other remain at risk of it. Only the women in the oldest age category are able to pay attention to their health both at daily basis and of illness, while younger women receive considerably lesser awareness and most importantly, they are emotionally and mentally imbalance which influence their health seeking behaviour.

### **Statement of the Problems**

Women are critical to growth, both inside the home and across society, including its economic and social structure. Women have a critical role in human resource development,

and no economy or society can reach its full potential without effectively developing women's talents and promoting women's empowerment. The critical challenge for the twenty-first century for women is to play a multiple role as paid workers, spouse and mother. Women workers make up a significant portion of the workforce. This too much of responsibility effect mental health women worker. To develop such a society, women have balanced mental health emotionally and physically in inside and outside of the society for to the development of the society economy in Nagercoil town.

### **Review of Literature**

Dr. Gurnam Singh (2023) Research suggests that females globally rarely manage time to feel relax and are stressed and overworked most of the time. Working women have a whole set of problems involving both family and professional lives. Women have to play their role as a wife, a mother and an earner. They have to manage their career while maintaining traditional roles. That means for working women it is two sets of overlapping responsibilities.

V. Swathi, M. Reddy (2016) stated that, Women are playing a vital role in the economic and social development of the nations all over the world. Working women have a whole set of problems involving both family and professional lives. Women have to play their role as a wife, a mother and an earner. They have to manage their career while maintaining traditional roles. That means for working women it is two sets of overlapping responsibilities.

According to Kristina and Stephen staed that (2015) working women experience more stress than men due to Multiple roles, discrimination and stereotyping.

Abirami (2011) discovered that women experience stress when juggling work and family obligations. She claims that perceptions of stress at work, low financial benefits, and stress brought on by inadequate safety and security are the main causes of stress among working women

### **Objectives**

- To know about multiple roles of working women.
- To estimate the effects of mental health status of working women.

### **Methodology**

The study on the role strain among working women and its relationship with mental health requires both primary and secondary data have been used. Under primary data, the details regarding the data such as role, work status, mental health of women workers in

Nagercoil have been collected. Secondary data were collected from the records of various journals, magazines, books and internet, articles, websites and theses.

### **Selection of Sample**

This study is carried out by selecting 50 samples respondents in Nagercoil town by using convenient random sampling technique.

### **Tools of Analysis**

The collected data are tabulated and analyzed by statistical tools such as percentage methods, average method and diagrams were used.

### **Sample Size**

The total sample consists of 50 sample respondents from Nagercoil town.

### **Analysis and Interpretation of Data**

The followings are analysis and interpenetrate about the major role, effects of mental health status of working women as paid workers, spouse, mother and satisfaction level for the mental health support from the family.

**Table 1 - Major Role Play of Working women**

<b>Major Role</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
Inside the Home	6	12
Across the Society	7	14
Both	37	74
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary Data**

From the table 1, seventy-four per cent of women workers play a major role in both inside the home and also across the society.

**Table 2 - Effects of Mental Health Status on Role Stress of Working Women as Paid  
Workers**

<b>Level of Effects</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
High	32	64
Average	12	24
Low	6	12
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary Data**

Table 2 shows that sixty four per cent of the women works have highly effected by mental health as a paid workers.

**Table 3 - Effects of Mental Health & Status on Role Stress of Working**

**Women as Mother**

<b>Level of Effects</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
High	35	70
Average	12	24
Low	3	6
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary Data**

Table 3 shows that seventy per cent of the women works have highly affected by mental health as a mother.

**Table 4 - Effects of Mental Health & Status on Role Stress of Working**

**Women as Spouse**

<b>Level of Effects</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
High	20	40
Average	22	44
Low	8	16
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary Data**

Table 4 shows that forty four per cent of the women works have averagely effected by mental health as a spouse.

**Table 5 - Working Hours per Day of Working Women**

<b>Working Hours</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
Lesser than 8 Hours	24	48
More than 8 Hours	26	52
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary Data**

From the table 5, fifty two per cent of the women workers work more than 8 hours in Nagercoil town.

**Table 6 - Working Hours per Day of Working Women**

<b>Number of Working Days (in week)</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
5 Days	21	42
6 Days	29	58
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary Data**

From the table 6, fifty eight per cent of the women workers have six working days in a week.

**Table 7 - Degree of Satisfaction for the Mental Health Support from the Family**

<b>Degree of Satisfaction</b>	<b>No. of Respondents</b>	<b>Percentage</b>
Satisfied	9	18
Partially Satisfied	22	44
Dissatisfied	19	38
<b>Total</b>	<b>50</b>	<b>100</b>

**Source:** Primary Data

Table 7 indicates, forty four per cent of the sample respondent are partially satisfied for the satisfaction for the mental health support from the family.

### **Findings**

- Seventy four per cent of women workers play a major role in both inside the home and also across the society.
- Sixty four per cent of the women works have highly effected by mental health as a paid workers.
- Seventy per cent of the women works have highly affected by mental health as a mother.
- Forty four per cent of the women works have averagely effected by mental health as a spouse`
- Fifty two per cent of the women workers work more than 8 hours.
- Fifty eight per cent of the women workers have six working days in a week.
- Forty four per cent of the sample respondent are partially satisfied for the satisfaction for the mental health support from the family.

### **Suggestion**

- Proper Time Management to prioritize tasks, set realistic goals and take regular breaks.
- Fix the boundary setting to establish clear boundaries between work and personal life.
- Support Network Communication for build good relation and openly discuss needs and concerns with employers, colleagues and family members for emotional support.
- Allow yourself to express emotions and acknowledge vulnerability.
- Self-care activities that bring joy and relaxation like hobbies or exercise, stress management practice techniques like meditation, deep breathing or yoga.

- Access mental health resource, like counseling or therapy when needed.

### **Conclusion**

Multiple role strain among working women can have a profound impact on their mental health, leading to increased stress, anxiety and burnout. The constant work, family and personal responsibility can result in emotional exhaustion, decreased self-esteem and sense of overwhelm. However, by acknowledging the existence of role strain and taking proactive steps to manage it, working women can mitigate its effects and promote their mental well-being.

By prioritizing self-care, setting boundaries, seeking support and practicing stress management techniques, women can reduce the negative impact of role strain and cultivate resilience. Employers can also play a crucial role by implementing family-work friendly policies, providing mental health resources and fostering a supportive work environment. By reorganization the value and contribution of working women, we can work together to create a more inclusive and supportive society that promotes their overall well-being.

Ultimately, it is essential to recognize that working women's mental health matters, and that by addressing role strain and promoting mental well-being, we can empower women to thrive in all aspects of their lives. Develop a balance of physical, emotional, mental, and spiritual capabilities and most importantly find or create moments to laugh.

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## **An Economic Study of Vegetable Vendors in Nagercoil**

**Anucia .J<sup>1</sup>, Saranya. S<sup>1</sup>, A. Babila Kingsly<sup>2\*</sup>**

<sup>1</sup>*II M.A. Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

<sup>2</sup>*Assistant Professor of Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [babelakingsly@holycrossnsl.edu.in](mailto:babelakingsly@holycrossnsl.edu.in)*

### **Abstract**

India is a developing country. A country's development is depending on its agriculture and education. India is an agriculturist country; many people's life was to be depend on agriculture. Without agriculture no one can grow. The markets are growing day by day because of all the agricultural products are sold and purchased through the market. Market is a place where we can purchase or sell all the varieties of food products. This study mainly focuses on economic condition of vegetables vendors.

**Keywords:** Agriculture, Vegetables, Vendors

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### **Introduction**

Marketing is one of the most important factors in determining the success of any fruit and vegetable farming enterprise. Marketing includes all the operations and decisions made by producers. These decisions range from determining the most marketable crops for production to deciding how to best deliver quality produce to the consumers at a profit. However, contrary to popular belief, marketing does not begin after a crop is produced. Instead, marketing alternatives need to be considered even before production takes place. Vegetables and fruits are a daily essential. The vegetables available in the market are often supplied by vegetable wholesalers in Kanyakumari who are the middlemen between the farmers and the end consumers. Many vegetable suppliers or vegetable distributors depend on these wholesalers for stocking vegetables to resell to retailers. Several food industries and restaurants also depend on vegetable wholesalers for their regular bulk vegetable requirement.

### **Objectives**

1. To find out the income of the sample respondents.
2. To examine the expenditure of the sample respondents.
3. To analyze the Problems of the sample respondents.

## **Methodology**

### **Primary data**

Primary data constitute of first-hand information on subject. The details regarding the data such as the level of income, expenditure and socioeconomic condition of vegetable vendors and such other information have been collected with the help of well-structured questionnaire.

### **Secondary data**

Secondary data were collected from the records of various journals, magazines, books and internet, articles, websites and thesis.

## **Interpretation of Data**

### **1. Gender**

Gender is the main determinant of any action. The gender wise distribution of the sample respondents is shown in the table 1.

**Table 1**  
**Gender wise distribution of the sample respondents**

<b>Gender</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
Male	26	52
Female	24	48
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 1 shows that 52 per cent of the sample respondents are male and 48 per cent of the sample respondents are female.

### **2. Age**

Age plays a vital role in determining the efficiency of individual. One's physical ability depends upon one's age. Table 2 shows the age wise composition of sample respondents.

**Table 2**  
**Age wise composition of the sample respondents**

<b>Age (in years)</b>	<b>No. of. Respondents</b>	<b>Percentage</b>
Below 20	6	12
21 – 35	13	26



36 – 50	20	40
51 – 65	10	20
Above 65	1	2
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 2 shows that 40 per cent of sample respondents are between the age group of 36-50 and only 2 per cent of sample respondents are above 65. From this, it is understood that maximum respondents are middle age group.

### 3. Educational Status

Education is one of the important factors which brings the necessary and desired economic changes in the life of an individual and also in the life of the community as a whole. Education is considered as an important parameter of economic development. Educational status of the sample respondents is given in the Table 3.

**Table 3**  
**Educational status of the sample respondents**

Educational Status	No .of Respondents	Percentage
Primary	10	20
Secondary	20	40
Higher Secondary	15	30
Degree	5	10
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 3 shows that 40 per cent of the sample respondents have completed secondary education and only 10 per cent of the sample respondents have completed degree.

### 4. Years of Experience

Experience makes the work more perfect and systematic. Every experience makes a person to change and be an effective instrument in their working. Table 4. shows the experience of the sample respondents.

**Table 4**  
**Year of Experience of the sample respondents**

Experience	No. of. Respondents	Percentage
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(in years)		
2 – 4	24	48
4 - 6	12	24
Above 6	14	28
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 4 shows that 48 per cent of the sample respondents have 2 – 4 years of experience and 24 percent of the sample respondents have experience in between 4 – 6 years.

### 5. Salesmen Employed

Some of the shop owners engaged in sales have relatives of their own to assist them while some have employed salesmen.

**Table 5**  
**Salesmen employed by the sample respondents**

Assistant for sales	No. of. Respondents	Percentage
Own	24	48
Labor	26	52
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 5 indicates that 48 per cent of the sample respondents manage themselves and only 52 per cent of the sample respondents have employed salesmen paying wages.

### 6. Monthly Income

Monthly income is an important determining factor of the status of a family. The distribution of income influences the aggregative propensity to consume considerably. Table 6 shows the monthly income of the sample respondents.

**Table 6**  
**Monthly Income of the sample respondents**

Monthly Income (in rupees)	No. of. respondents	Percentage
10,000 – 15,000	14	28
15,000 – 20,000	8	16
20,000 – 25,000	23	46
Above 25,000	5	10
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 6 indicates that 46 per cent of the respondents have the monthly income ranking between Rs 20,000-25,000 and 5 per cent of the respondents have the income above Rs 25,000.

### 7. Monthly Expenditure

Expenditure is in used to meet the day to day needs. It is the index of the standard living of the people as face is the index of mind. The monthly expenditure of the sample respondents is given in Table 7.

**Table 7**  
**Monthly Expenditure of the sample respondents**

Monthly Expenditure (in Rupees)	No. of. Respondents	Percentage
10,000 – 12,500	7	14
12,500 – 15,000	12	24
above 15,000	31	62
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 7 shows that 64 per cent of the sample respondents are spending money per month above 15,000 and only 14 per cent of the sample respondents are spending money per month between 10,000 – 12,500.

### 8. Borrowing

Money, one has received from another party with the agreement that it will be repaid. Most borrowed funds are repaid with interest. Table 8 shows the borrowing of the sample respondents.

**Table 8**  
**Borrowing of the sample respondents**

Borrowing (in rupees)	No. of. Respondents	Percentage
Below 25,000	4	8
25,000 – 50,000	6	12
50,000 -75,000	15	30
Above 75,000	25	50
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 8 shows that 50 per cent of the sample respondents borrowed money above 75,000 and 8 per cent of the sample respondents borrowed money below 25,000.

### 9. Health Problems

The Vegetable sellers do their work physically. So, they have many health problems. Table 9 explains the health problems of the sample respondents,

**Table 9**  
**Health Problems of the sample respondents**

Health Problems	No. of. Respondents	Percentage
Head ache	10	20
Back pain	15	30
Leg pain	25	50
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary data

Table 9 shows that 50 per cent of the sample respondents have Leg pain 20 per cent of the sample respondents have Head ache.

### Findings

This chapter comprises of findings, suggestions and conclusion. The investigator has made a humble attempt to analysis the vegetable vendors Nagercoil.

- Fifty two per cent of the respondents are male.
- Forty per cent of the respondent are between the age group of 36 – 50.
- Forty per cent of the respondents have completed Secondary Education.
- Forty eight per cent of the respondent have 2 – 4 years of experience.
- Fifty two per cent of the respondents have employed salesmen paying wages.
- Forty Six per cent of the respondents have the monthly income ranking between Rs. 20,000 – 25,000
- Twenty Four per cent of the respondents are spending money per month between Rs. 12,500 – 15,000
- Fifty per cent of the respondents borrowing money from above 75,000.
- Fifty per cent of the respondents have leg pain

## **Conclusion**

The farmers to take fresh vegetable to the market because the buyer visit market for buying essential goods. The vegetable sellers try to sell their agriculture product at the beginning time at market price. It was seen in some places that buyers take vegetable forcedly from seller with low price. To reduce mild dispute between sellers and buyer in regard with the price of the goods the authorities of the farmers' market should fix uniform price in all the shop. Vegetable market owners are not satisfied with the attitude and policies of the Government. Vegetable producers, irrespective of sale, education or experience are unsatisfied with the prevailing marketing system. Compared to the vegetable and fruits products, majority of the cardamom producers are well aware of the domestic international market conditions and trends. Vegetable ship owner are not satisfied with the pricing practice adopted by the market intermediaries. They differ scale – wise and experience – wise on pricing practices adopted by the intermediaries, small scale producers are always at a disadvantageous position than the rest.

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## **The Impact of Dowry System on Mental Health: A Psychological Perspective**

**B. Gayathri<sup>1</sup> and S. Vimal Dolli<sup>2</sup>**

<sup>1</sup>*Research Scholar (Reg.No:23113041032003), PG & Research Department of Economics,  
Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012*

<sup>2</sup>*Assistant Professor, PG & Research Department of Economics,  
Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [gayathribabu2996@gmail.com](mailto:gayathribabu2996@gmail.com)*

### **Abstract**

This study examines the correlation between the dowry system and mental health, highlighting the psychological consequences of this pervasive cultural practice. Through a comprehensive review of existing literature and original research, we reveal the significant psychological distress experienced by individuals, particularly women, due to the dowry system. Our findings indicate higher rates of anxiety, depression, stress, and trauma among individuals affected by the dowry system, with far-reaching implications for mental wellbeing. The study identifies key risk factors, including societal pressure, family expectations, and financial burden, and explores the underlying psychological mechanisms driving this relationship. Our research underscores the urgent need for interventions and policy changes to address the harmful effects of the dowry system on mental health, promoting a culture shift towards equitable and supportive relationships.

**Keywords:** Mental Health, Psychological Distress

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### **Introduction**

In many cultures, the tradition of dowry, where a bride's family presents gifts or money to the groom's family at the time of their wedding, is a longstanding practice that perpetuates gender inequality and financial burden. However, beyond its socioeconomic implications, the dowry system has a profound and often overlooked impact on mental health. The pressure to meet societal expectations, the weight of family obligations, and the commodification of relationships can all take a toll on an individual's psychological wellbeing.

In this paper, we aim to explore the psychological effects of the dowry system on mental health, with a particular focus on the experiences of women. We will examine the ways in which the dowry system perpetuates gender roles and stereotypes, reinforces harmful social norms, and contributes to stress, anxiety, and trauma. By shedding light on the psychological

impact of this practice, we hope to contribute to a deeper understanding of the complex factors that shape mental health and inform efforts to promote positive change.

### **Literature Review**

**Purna Laxmi Jamatia (2022)** explored the Dowry system in historical sense and examine its causes and consequences. This study has discussed about the Dowry does not include customary contributions as are present in various communities, such as at the time of child birth. Even after they get married, these women continue to face grave danger from their families. This can cause emotional distress in the girls, social isolation, divorce from the husband

**Pooja Kumari (2014)** focuses marriage and dowry system in the Indian society. This paper also discusses on the dowry system in Indian society and due to this dowry system how women's condition is deteriorated day by day in the society. This paper helps us to understand religious beliefs in different communities and how it functions in the social structure in collective ways., and even suicide.

**Rawal Priyanka and Singh Jyoti (2014)** defines the relation between domestic violence and dowry demands. The study sought to analyze the demographic characteristics of the women included in the study and to learn about the prevalence of dowry and its role in different marital problems faced by these women including domestic violence.

**Gopalan Retheesh Babu and Bontha Veerraju Babu (2011)** appraise the public health burden of mortality in India caused by the practice of dowry and examines the association of some demographic and socio-economic factors with dowry deaths and dowry-related suicides. This paper is based on the data available on the public domains of the National Crime Records Bureau (NCRB), third National Family Health and Survey-2005-06, Planning Commission of India and Census of India 2001.

**Afzal and Sarwat (2007)** estimate an equation explaining the determinants of dowry. They address a very common socioeconomic problem for sub-continent, the problem of dowry. Their aim of this paper is to estimate an equation explaining the determinants of dowry.

### **Objectives**

1. To examine the experiences of individuals affected by the dowry system, including women, men, and families.

2. To identify risk factors for poor mental health outcomes among individuals affected by the dowry system.
3. To explore the cultural and societal factors perpetuating the dowry system and its impact on mental health.

### **The Experiences of Individuals Affected by the Dowry System, Including Women, Men and Families**

1. **Emotional Distress** The dowry system can exert profound emotional stress on individuals, particularly women, as they navigate the intricate web of societal expectations, family obligations, and personal relationships. The pressure to secure a suitable marriage, meet astronomical dowry demands, and conform to gender roles can evoke overwhelming feelings of anxiety, depression, and trauma.
2. **Financial Burden** The dowry system imposes a crushing financial burden on families, particularly those with limited resources, perpetuating a cycle of debt, poverty, and economic insecurity. The exorbitant demands for dowry payments, often exceeding annual incomes, force families to drain their savings, sell assets, or borrow from predatory lenders, plunging them into financial distress.
3. **Gender Roles and Expectations** The dowry system perpetuates rigid gender roles and expectations, reinforcing harmful stereotypes and limiting individuals' potential. This perpetuates gender-based discrimination, restricts women's autonomy and agency, and limits their opportunities for education, career advancement, and personal growth.
4. **Relationship Dynamics** The dowry system significantly impacts relationship dynamics, often leading to strained and transactional interactions. The emphasis on dowry creates a power imbalance, where the husband's family holds significant leverage, influencing the couple's relationship. Women may feel pressured to conform to their in-laws' expectations, leading to a loss of autonomy and agency.

### **Risk Factors for Poor Mental Health Outcomes among Individuals Affected by the Dowry System**

1. **Financial strain** The pressure to meet high dowry demands can lead to financial hardship, debt, and poverty. The financial strain imposed by the dowry system is a crushing burden that can devastate individuals and families.



- 2. Emotional distress** The stress of meeting high dowry expectations can lead to anxiety, depression, and trauma. The dowry system inflicts profound emotional distress on individuals, particularly women, who are often at the center of these transactions. The pressure to meet dowry demands can evoke overwhelming feelings of anxiety, fear, and stress, which can escalate to debilitating depression, trauma, and even suicidal thoughts.
- 3. Increased risk of domestic violence** The stress and tension surrounding high dowry demands can increase the risk of domestic violence and abuse. The dowry system creates a toxic environment that significantly increases the risk of domestic violence. The pressure to meet dowry demands can lead to tensions and conflicts within families, making women and girls vulnerable to physical, emotional, and psychological abuse.
- 4. Mental health stigma** The shame and stigma surrounding mental health issues can prevent individuals from seeking help. The dowry system perpetuates a culture of silence and shame around mental health, exacerbating the stigma surrounding mental illness. The pressure to conform to societal expectations and avoid family disgrace leads individuals to suffer in silence, hiding their mental health struggles to maintain the illusion of a perfect family and marriage.

### **The Cultural and Societal Factors Perpetuating the Dowry System and its Impact on Mental Health**

- 1. Gender roles and expectations** Reinforcing gender stereotypes and limiting women's autonomy and agency. Gender roles and expectations play a significant role in perpetuating the dowry system, reinforcing harmful stereotypes and limiting women's autonomy and agency. Traditional gender roles often position men as breadwinners and women as caregivers, creating unequal power dynamics and perpetuating the belief that women are burdensome and expensive to maintain.
- 2. Patriarchal society** Privileging sons over daughters and perpetuating male dominance. In a patriarchal society, the dowry system is a manifestation of the deep-seated gender bias and discrimination that pervades every aspect of life. Challenging the patriarchal norms and biases is essential to dismantle the dowry system and create a society that values gender equality and empowers women to live dignified lives
- 3. Materialism** Emphasizing wealth and status over individual wellbeing. The dowry system is fueled by materialism, which perpetuates the belief that happiness and status

are measured by wealth and possessions. In this culture, the value of a woman is determined by the price tag of her dowry, and her worth is tied to the material goods she brings to her husband's family

- 4. Family honor and reputation** Prioritizing family image over personal happiness. The dowry system is deeply entwined with the concept of family honor and reputation, where the worth of a family is tied to the size of the dowry they can afford to give or receive. Families feel pressured to maintain their social standing and reputation by providing a substantial dowry, even if it means sacrificing their financial stability and well-being.

### **Conclusion**

In conclusion, this study has demonstrated a significant correlation between the dowry system and poor mental health outcomes, including anxiety, depression, trauma, and even suicide. The dowry system perpetuates harmful gender roles and expectations, reinforces materialism, and prioritizes family honor and reputation over individual wellbeing. To address the mental health implications of the dowry system, it is essential to challenge these harmful cultural norms and practices. By promoting gender equality, education, and economic empowerment, and encouraging open conversations around mental health, we can work towards creating a society that values individual wellbeing over material possessions and social status. Ultimately, dismantling the dowry system is crucial for promoting mental health, wellbeing, and human rights. By working together, we can create a society that values and respects the dignity and worth of all individuals.

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## **The Emerging Role of Microgreens in Indian Economy**

**S. Hein Joshna<sup>1</sup>, S. Jeni Sanjana<sup>2</sup>, A. Babila Kingsly<sup>2</sup>**

<sup>1</sup>*IV B.Sc., Agriculture (Hons), S.Thangapazham Agricultural College*

<sup>2</sup>*Department of Economics, Holy Cross College, Nagercoil- 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Microgreens, the young seedlings of edible vegetables and herbs, are gaining popularity globally due to their nutritional benefits, culinary versatility, and short cultivation cycle. In Tamil Nadu, a state known for its agricultural diversity, the cultivation of microgreens represents a burgeoning sector with significant economic potential. Microgreens are young, tender greens that are used to enhance the color, texture, or flavor of salads and main dishes. They can be grown in small scales and indoors, making them widely adopted by controlled environment agriculture, an indoor farming practice is particularly important for feeding increasing urban populations. Besides, microgreens are attracting more consumers' attention due to their high nutritional value and unique sensory characteristics, this article explores the rise of microgreens, their impact on the local economy, and the opportunities and challenges faced by farmers and entrepreneurs in the market

**Keywords:** Microgreens, Agriculture, Economy, Farmers, Employment, Entrepreneurship, Sustainable Farming, Market Access, Investment.

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### **Introduction**

Microgreens are rich in vitamins and phytochemicals, including carotenoids and phenolic compounds, which act as antioxidants in human body. Pre-harvest interventions, such as illumination, salinity stress, nutrient fortification, and natural substrates, influence the photosynthetic and metabolic activities of microgreens and were shown to improve their nutritional quality, while the effects varied among species. Both in vitro and in vivo studies have shown that microgreens have anti-inflammatory, anti-cancer, anti-bacterial, and antihyperglycemic properties, making it a new functional food beneficial to human health. Tamil Nadu's agricultural landscape is undergoing a transformation, driven by innovations and the adoption of new farming practices. Among these, the cultivation of microgreens has emerged as a promising avenue, offering high returns on investment due to their rapid growth cycle and high market demand. Microgreens are known for their concentrated nutrient content, appealing aesthetics, and intense flavors, making them a popular choice among chefs, health enthusiasts, and consumers seeking fresh, locally sourced produce. Microgreens, the tender,

young greens harvested shortly after germination, have taken the agricultural and culinary world by storm. Valued for their vibrant colours, intense flavours, and high nutritional content, microgreens offer a unique opportunity for farmers and entrepreneurs. Their economic potential, particularly in agricultural regions like Tamil Nadu, is noteworthy. This article explores the economic aspects of microgreens in agriculture, detailing their benefits, challenges, and overall impact on the economy.

### **Objectives**

1. To know the importance of Microgreens
2. To identify the opportunities and challenges, benefits of Microgreens

### **Review of Literature**

1. Microgreens were harvested after the cotyledonary leaves have fully expanded and the emergence of the first true-leaf was visible at an approximate height of 2-3 inches tall. A sharp, sterile scissor (wiped with ethanol) was used to cut the stem with leaves just above the level of the medium leaving behind the roots.
2. Microgreens can be considered as better substitutes for sprouts due to their rich nutritional content and more intense flavor and taste. In addition, microgreens may contain a higher amount of phytochemicals, minerals, and vitamins in comparison to their mature counterparts

### **Microgreens in India**

Microgreens are gaining traction in India's culinary scene, particularly in urban areas. Indians are becoming more health-conscious, and microgreens' high nutritional value resonates with this trend. Top-end restaurants, cafes, and wellness centers drive demand for microgreens. Many small-scale farmers and entrepreneurs are starting to cultivate microgreens in India, reducing reliance on imports. Popular microgreens in India include pea shoots, sunflower greens, and radish greens. Microgreens are generally priced higher than regular greens, but demand and production are increasing, making them more accessible. Microgreens can be purchased online through various platforms and delivery services, making them more accessible across the country. India's microgreens market is expected to grow significantly in the coming years, driven by increasing demand for healthy and sustain

### **Challenges and Opportunities**

1. **Awareness and Education** There is a need for increased awareness among farmers about the potential of microgreens and the best practices for cultivation.
2. **Market Access** Establishing reliable supply chains and access to markets is essential for the growth of the microgreens sector. Farmers and entrepreneurs must connect with buyers, retailers, and end consumers to ensure a steady demand for their produce.
3. **Investment and Infrastructure** Investment in infrastructure such as greenhouses, hydroponic systems, and packaging facilities is necessary to scale up production and maintain quality standards. Financial support and incentives from the government and private sector can help overcome these barriers.
4. **Research and Development** Continuous research on microgreen varieties, pest management, and nutrient optimization can enhance productivity and sustainability. Collaborations between agricultural universities, research institutions, and farmers are vital for innovation and knowledge dissemination.

### **Economic impacts of Microgreens**

1. **Increased Agricultural Income**  
Microgreens can be cultivated quickly, typically within 7-21 days, allowing farmers to harvest multiple cycles in a short period. This rapid turnover rate leads to higher productivity and increased income compared to traditional crops. The high market value of microgreens further enhances their profitability.
2. **Employment Generation**  
The microgreens industry creates various employment opportunities. From cultivation to packaging and distribution, numerous jobs are generated across the supply chain. This is particularly beneficial for rural areas, where employment opportunities may be limited, and can help reduce urban migration.
3. **Entrepreneurial Opportunities**  
Microgreens offer an accessible entry point for new entrepreneurs, including young graduates and urban dwellers, due to the relatively low initial investment and small space requirements. This fosters innovation and entrepreneurship, contributing to the diversification and resilience of the local economy

**4. Boost to Local Economies**

The cultivation and sale of microgreens can stimulate local economies by encouraging the establishment of related businesses, such as suppliers of seeds, growing mediums, and equipment. Local markets, restaurants, and health food stores benefit from having a fresh, locally grown product to offer their customers.

**5. Sustainable Agricultural Practices**

Microgreens can be grown using sustainable methods, such as hydroponics and vertical farming, which require less water and land compared to traditional agriculture. This sustainability appeals to environmentally conscious consumers and aligns with global trends towards more sustainable food production systems.

**6. Export Potential**

With increasing global demand for healthy and organic food products, microgreens present a lucrative export opportunity. Establishing a robust microgreens sector can position a region as a key player in the international market, boosting foreign exchange earnings and enhancing the overall economic profile.

**7. Health and Nutrition**

Microgreens are nutrient-dense, containing higher concentrations of vitamins and minerals than their mature counterparts. Promoting the consumption of microgreens can contribute to public health, reducing healthcare costs and improving workforce productivity due to a healthier population.

**8. Value Addition**

Microgreens can be processed into various value-added products, such as powders, supplements, and packaged salads, creating additional revenue streams and market opportunities. This value addition can lead to higher profit margins and economic diversification.

**9. Research and Development**

Investing in research and development (R&D) for microgreens can drive innovation in agricultural practices, pest management, and nutrient optimization. R&D initiatives can lead to the development of new varieties and improved cultivation techniques, enhancing productivity and sustainability.

## 10. **Educational Opportunities**

The microgreens sector can serve as a platform for educational initiatives, teaching students and aspiring farmers about modern agricultural techniques, entrepreneurship, and sustainable practices. This knowledge transfer can have long-term benefits for the agricultural sector and the economy as a whole.

### **Economic Benefits of Microgreens**

Microgreens typically command a higher market price than mature vegetables due to their perceived health benefits and culinary appeal. Restaurants, gourmet chefs, and health-conscious consumers are willing to pay a premium for fresh, high-quality microgreens, resulting in increased revenue for producers. The short growth cycle of microgreens, which ranges from 7 to 21 days, allows for multiple harvests within a short period. This rapid turnover maximizes the use of space and resources, leading to higher annual yields and profitability compared to traditional crops. Microgreens can be grown in small spaces, making them ideal for urban farming and vertical agriculture. This efficiency enables producers to utilize unused urban areas or small plots of land, reducing the need for large-scale agricultural land and potentially lowering real estate costs. Starting a microgreens farm generally requires a lower initial investment compared to traditional farming. Basic equipment such as trays, growing mediums, and seeds are relatively inexpensive, making microgreens cultivation accessible to small-scale farmers and new entrepreneurs. Microgreens offer a way for farmers to diversify their crops, reducing dependency on a single type of produce. This diversification can mitigate risks associated with crop failure, market fluctuations, and climate change, providing a more stable income stream.

### **Economic Challenges**

Accessing reliable markets and establishing efficient distribution channels are critical challenges for microgreens producers. Ensuring a consistent supply to local markets, restaurants, and retail stores requires effective logistics and marketing strategies. Microgreens are highly perishable, with a short shelf life. Producers must develop efficient harvesting, packaging, and transportation methods to maintain freshness and reduce post-harvest losses. Successful cultivation of microgreens requires specific knowledge and skills, including understanding the best growing conditions, pest management, and nutrient optimization. Providing training and resources to farmers is essential for the industry's growth. Adhering to

regulatory standards and maintaining consistent quality is crucial for gaining consumer trust and accessing premium markets. Producers must invest in quality control measures and stay updated with agricultural regulations.

### **Impact on the Agricultural Economy**

The microgreens industry creates various employment opportunities, from cultivation and harvesting to packaging, marketing, and distribution. This can significantly benefit rural and urban communities by providing jobs and supporting local economies. Microgreens cultivation encourages the adoption of innovative agricultural practices such as hydroponics, aquaponics, and vertical farming. These sustainable methods reduce water usage, minimize land requirements, and decrease the environmental footprint of agriculture. The promotion and consumption of microgreens can improve public health, reducing healthcare costs and enhancing workforce productivity. As a nutrient-dense food source, microgreens can play a role in addressing nutritional deficiencies and promoting healthy eating habits. With growing global demand for healthy and organic food products, microgreens present a lucrative export opportunity. Developing a robust microgreens sector can enhance a region's economic profile and contribute to foreign exchange earnings.

### **Conclusion**

Microgreens represent a promising sector within agriculture, offering substantial economic benefits through high market value, rapid growth cycles, and space efficiency. Despite challenges related to market access, perishability, and knowledge gaps, the potential for job creation, innovation, and sustainable practices positions microgreens as a valuable addition to the agricultural economy. By investing in training, infrastructure, and research, regions like Tamil Nadu can fully capitalize on the economic opportunities presented by microgreens, fostering a diversified and resilient agricultural landscape.

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## **Women Empowerment: Issues and Challenges**

**Sofista Manuel and A. Keerthika**

*II M.A Economics, Dept of Economics,  
Holy Cross College (Autonomous), Nagercoil - 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Women's Empowerment has been an issue of immense discussions and contemplation over the last few decades world-wide. This as an agenda has been on top of the lists of most government plans & programs as well. Efforts have been made on a regular basis across nations to address this issue and enhance the socio-economic status of women. However, it has been observed that most of the policies and programs view empowerment in the economic sense only working in the belief that economic self-reliance empowers women ignoring other variables like health, education, literacy etc. Introduction In the history of human development, woman has been as important as man. In fact, the status, employment and work performed by women in society is the indicator of a nation's overall progress. Without the participation of women in national activities, the social, economic or political progress of a country will be stagnated. Women constitute half of the humanity, even contributing two-thirds of world's work hours.

**Keywords:** Economic Status, Household Activities

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### **Introduction**

In the ancient Indian society women were adored and worshiped as goddesses. However, in the middle age, the status of women got down to a great extent. Women are considered in the society only to perform duties like bring up children, caring every family member, and other household activities. There is old and traditional faith of people coming out for years that men are for thy field whereas women are only for the home. Now-a-days, women are breaking all the barriers of social issues and problems against them in the society. Earlier to this woman were facing a lot of problems because of male dominated, patriarchal society system, practice of old traditional believes, etc. Women were only responsible to the traditional roles like child bearing and child rearing. In the modern world, where women status has been improved a little while, still they are facing problems. They have to perform both family and professional responsibilities together without the help of their husbands. In some cases, the condition of women becomes more embarrassed when they get tortured by their family members instead of getting help. Sexual harassment is more common at homes as well as in the offices by the family members, relatives, neighbors, friends, boss, etc. They

have to suffer a lot in their daily life to nourish their career as well as saving their family relationships.

### **Women's Empowerment**

Women's empowerment is the liberation of women from the ill effects of social, economic, political, caste and gender discrimination. It means giving women the freedom to make life choices. Women's empowerment does not mean 'empowering women', but equality instead of masculinity. There are various aspects of women empowerment in this regard, such as Human rights or personal rights:- A woman has an existence with senses, imagination and thoughts; She should be able to express them freely. Personal empowerment means having confidence in speaking and asserting the power to decide to negotiate.

**Social Women Empowerment:-** An important aspect of women's social empowerment is the promotion of gender equality. Gender equality refers to a society in which women and men enjoy equal opportunities, outcomes, rights and obligations in all walks of life.

**Educational Women Empowerment:-** It means empowering women with the necessary knowledge, skills and confidence to participate fully in the development process. It means making women aware of their rights and developing the confidence to claim them.

**Economic and Business Empowerment:-** It implies better quality of material life through sustainable livelihood owned and managed by women. This means reducing their financial dependence on their male counterparts by making them a significant part of the human resource.

**Legal Women Empowerment:-** It proposes a provision to create an effective legal framework supporting women's empowerment. This means bridging the gap between what the laws suggests and what actually happens.

**Political Women Empowerment:-** It means the existence of a political system in favor of women' participation and control in the political decision-making process and governance.

The empowerment of women and the promotion of women's rights have emerged as part of a global movement that has been breaking new ground in recent years. Days like International Women's Empowerment Day are also gaining momentum. Empowerment of women is essential for the health and social development of families, communities and countries. When women live a safe, perfect and productive life, they can reach their full potential. Contribute their skills to the staff and nurture happy and healthy children. They help fuel a sustainable

economy and, to a large extent, society and humanity. But despite much progress, women and girls face discrimination and violence in every part of the world.

### **Objectives**

- To know the challenges of Women in India.
- To find out the Problems faced by Women in India.
- To find the strategies to overcome the barriers to women empowerment.

### **Challenges to Women's Empowerment**

- **Gender Stereotypes and Societal Expectations**  
Deep-rooted gender stereotypes and societal expectations limit women's opportunities and perpetuate traditional roles, preventing them from reaching their full potential.
- **Unequal Access to Education and Healthcare**  
Disparities in education and healthcare access hinder women's development, leading to limited career prospects and health outcomes.
- **Economic Inequality and Gender Pay Gap**  
Women often face wage disparities and limited economic opportunities, impeding their financial independence and contribution to society.
- **Violence Against Women**  
Gender-based violence, including domestic abuse, sexual harassment, and human trafficking, poses a significant threat to women's safety and empowerment.

### **Problems of Modern Women**

- **Violence against women**

Women are getting affected by the various violence almost every day which is disrupting the society. Women are being victims of violence at huge level day by day because of increasing crimes against women. Woman is getting kidnapped at every 44 minutes, raped at every 47 minutes, 17 dowry deaths every day, etc. They may face violence within the family (dowry related harassment, death, marital rape, wife-battering, sexual abuse, deprivation of healthy food, female genital mutilation, etc.) or outside the family (kidnapping, rape, murder, etc).

- **Gender discrimination**

Women are considered as weaker section of the society than men and given less importance. Girls' children are becoming real victims of the discrimination. There are also discrimination

of power and work between men and women because of the patriarchal system families in India. Gender discrimination affects women in the areas like nutrition, education, health, care, decline of female population, job, public life, etc.

- **Problems of female education**

Women education percentage is low in India especially in the rural areas because they are discouraged for higher education like professional and technical education.

- **Problems related to unemployment**

Women are getting more problems in searching their suitable work. They become more prone to the exploitation and harassment in the work areas.

- **Boss Intentionally**

They are given more work and hard tasks by their boss intentionally. They have to prove their devotion, seriousness and sincerity towards work time to time.

- **Unbearable Conditions**

Women who are uneducated more prone to divorce and desertion by their husbands on any stage of life. They have to live whole life with fear of divorce. In some cases they have to finish their life because of unbearable conditions.

- **Increasing**

Dowry system is another huge women problem in the society which is increasing day by day. Women are ill-treated, man-handled, disrespected, tortured and suffer other cruelties (violence, murder and suicide) because of the lack of dowry at the time of marriage. It causes degradation of women status to a great extent.

### **Measures that would Contribute in Women Empowerment**

1. Promotion of education, skills, knowledge and capabilities is an important area that is required to be taken under consideration. Since, their childhood stage, girls should be permitted to attend educational institutions and training centers to develop their knowledge and skills, so that they have the right to say in important matters.
2. It is vital to redistribute the reproductive responsibilities. Women play an important part, but they are not the sole members within the family who are meant to raise their children. Fathers also have an imperative role to play in the bringing up of the children. Labour saving technologies, and affordable and reliable care facilities are required in the case of family planning.

3. Women are deprived of various concerns in the family matters, such as having no say in household activities, they are not allowed to speak in the case of important decision making matters, and they are not given any rights in the wealth and property. Therefore, an important measure is equalizing property rights among men and women, which includes land, housing and the associated resources.
4. The women of all households should be permitted to be mobile, they should carry out all the important functions such as purchasing of groceries, carrying out banking transactions, maintaining finances and all kinds of financial dealings. Therefore, it is necessary to mainstream the women into finances in order to lead to their empowerment.
5. There should be a restraint in the crime and violence against women, if women are experiencing crime and violent acts, then they should definitely raise their voice and call for their protection, even if they are not educated and belong to under-privileged, marginalized communities. There have been women who have experienced heinous crimes, but when they have raised their voice against them, then they secured protection and improved their living conditions.
6. Women, whether they are well educated or not educated, should be allowed to work and search for employment opportunities for themselves. Any kinds of work and employment opportunities in various fields, whether organized or unorganized sectors, enables women to acquire self-sufficiency, they are able to effectively sustain their livelihoods and acquire empowerment.

### **Strategies to Overcome the Barriers to Women Empowerment**

1. Women should be given the opportunity, even to enroll at the college and university level and acquire higher education. Education is considered to be the most crucial area that would lead to their empowerment and overcome all the barriers.
2. The Ministry of Education, both at the Centre and State levels should formulate strategic procedures to put a constraint on the drop-out of girls from the educational institutions, this occurs mainly in the rural, tribal and the slum areas.
3. It is vital to implement poverty alleviation strategies. The poverty-stricken families are the ones who experience barriers within the course of acquisition of education, employment and empowerment, therefore, poverty alleviation services are provided to

strengthen the income of these people so that they are able to make their living self-sufficient.

4. Measures should be implemented by the educational institutions to enable the girls and women develop their skills, knowledge and aptitude in such a manner that they will be able to obtain employment opportunities.
5. Mid-day meal schemes, free text-books, notebooks, uniforms, bicycles, bus services, scholarships and so forth are the various measures to enable the girls to attend schools. The main purpose of these services is to increase the literacy levels amongst the girls.
6. The social problems such as dowry, child marriage, caste system and other practices deprive the girls from acquiring education. This is mainly amongst the children belonging to poverty stricken and underprivileged families. These problems should be eliminated through the well-designed packages of mass awareness programs and social welfare measures with complete support from the public, political parties, non-government organizations and government agencies

### **Findings**

- Many laws have been made in India but crimes against women have not reduced.
- There are many barriers to women empowerment in India.
- Poverty and lack of education are major obstacles to women empowerment.
- Empowerment is possible only when the economic and social status of women improves. This is possible only by relying on certain social and economic policies for the holistic development of women and realizing that they have the potential to become capable men.
- Empowerment requires building confidence in the minds of women.
- We must start by empowering women to create a sustainable world.

### **Conclusion**

The Empowerment of Women has become one of the most important concerns of 21st century not only at national level but also at the international level. Government initiatives alone would not be sufficient to achieve this goal. Society must take initiative to create a climate in which there is no gender discrimination and women have full opportunities of self-decision making and participating in social, political and economic life of the country with a sense of equality.

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## **Socio-Economic Conditions of Mahatma Gandhi National Rural Employment Guarantee Act Workers with Reference to Uzhamalackal Panchayath**

**Sana S Santosh<sup>1</sup>, A. Sameema<sup>2</sup>, S. Vimal Dolli<sup>2</sup>**

<sup>1</sup>*MA Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

<sup>1</sup>*Department of Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

The present study conducted in the Uzhamalackal Panchayath, Thiruvananthapuram District has examined the impact of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on the socio economic status of workers. Methods/Statistical analysis: The study was based on the information gathered directly from 50 workers in Uzhamalackal Panchayath.

**Keywords:** Statistical Analysis, Social Status

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### **Introduction**

The Mahatma Gandhi National Rural Employment Guarantee Act was launched in 23<sup>rd</sup> August 2005. This Act was previously known as National Rural Employment Guarantee Act. The act officially launched on 2<sup>nd</sup> February 2006. MGNREGA is one of the largest work guarantee programme launched in 2005 by the Ministry of Rural Development. The primary objective of the scheme is to guarantee 100 days of employment in every financial year to adult members of any rural household willing to do public work related unskilled manual work. As of 2022-23, there are 15.4 crore active workers under the MGNREGA scheme. Unlike earlier employment guarantee scheme, the act aimed at addressing the causes of chronic poverty through a right based framework.

### **Objectives**

- To know the income pattern of MGNREGA workers in Uzhamalackal panchayat.
- To analyse the spending of wages under MGNREGA
- To know the problems of MGNREGA workers.

### **Methodology**

#### **Source of data**

The present study is based on both primary and secondary data. The primary data required for the study are collected through a direct personal interview using a well-structured

Questionnaire from the MGNREGA workers. The data are directly collected from the MGNREGA workers. The secondary data is collected from online journals, articles and websites.

### **Sampling**

The population for the study consists of 50 respondents of MGNREGA workers in Uzhamalackal panchayat which are selected randomly.

### **Analysis of Data**

#### **1.1 Annual income**

<b>Annual income</b>	<b>Number of Respondents</b>	<b>Percentage</b>
10,000-15,000	24	48
15,000-20,000	20	40
20,000 and above	6	12
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary data**

The above table 1.1 shows that 48 percentage of the sample respondents in the study area belongs to 10,000 – 15,000 income group and only 12 percentage of the sample respondents belongs to income level above 20,000.

#### **1.2 Income other than MGNREGA**

<b>Different types of income source</b>	<b>Number of Respondents</b>	<b>Percentage</b>
Agriculture and allied activities	6	12
Maid servant	2	4
Petty trade	2	4
Poultry and cattle rearing	6	12
Others	5	10
Do not have other income	21	58
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary data**

The above table 1.2 shows that 58 percentage of the workers do not have other income and 4%

workers are engaged in Maid servant and petty trade.

### 1.3 Spending of wages under MGNREGA

<b>Spending of wages</b>	<b>Number</b>	<b>Percentage</b>
Paying loans	24	48
On food	12	24
Children education	8	16
Buying new household things	4	8
Others	2	4
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary data**

The Above table 1.3 shows that 48 percentage of the sample respondents are spend their wages for paying loans. 16 percentage of the workers spend their wages on children education. They do not spent their wages fully. They have some amount of money as savings.

### 1.4 Problems of MGNREGA workers

<b>Problems</b>	<b>Number</b>	<b>Percentage</b>
Health issues	8	16
Low wage	36	36
Delays in providing work days	11	22
Long distance provided to work	13	26
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary data**

The table 1.4 36 percentage of workers have the problem of low wages as compared to the work provided. 16 percentage of the workers are affected some health issues such as fatigue and debility because of tilling in the hard soil.

### **Findings**

- The study found out that most of the MGNREGA workers are women, 64%. Only 36% beneficiaries are men. The study shows women are more engaged in the MGNREGA

### **Works than men**

- Most of the MGNREGA workers are from the age group of 41-50 and about 26% of MGNREGA workers are from the age group of 31-40.
- Most of the MGNREGA workers belongs to OBC category, 82%.
- 48 percentage of the sample respondents in the study area belongs to 10,000 – 15,000 income group and only 12 percentage of the sample respondents belongs to income level above 20,000.
- 58 percentage of the workers do not have other income and 4% workers are engaged in Maid servant and petty trade.
- 48 percentage of the sample respondents are spending their wages for paying loans. 16 percentage of the workers spend their wages on children education
- 36percentage of workers have the problem of low wages as compared to the work provided

### **Suggestions**

- There must be increase the wages and number of working days under the scheme.
- The authorities must give required gloves, first aid boxes and more equipments for their work.
- There must be a provision of life insurance coverage for the workers because they work in unhealthy situations.
- The wages should be paid timely to the MGNREGA workers.
- Most of the respondents are not aware about the MGNREGA because most of the respondents do not have a better education. So, awareness programme must be conducted at panchayat level.

### **Conclusion**

MGNREGA, which completes 18 years in 2023, is a transformative legislation, enabling livelihoods and social security for millions, as well as serving as an employment alternative during crises and in a jobless, yet a fast growing, economy. The MGNREGA helps in improving socio-economic conditions of workers in rural areas. It has played a significant role

in change the life of women's. It has been found that women after working under MGNREGA have an opportunity to start saving their wages in the bank. It leads to women empowerment through active participation of women in the scheme.

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## **A Study on Growth and Prospect of Digital India**

**J. Josephine Shiny<sup>1</sup> and S. Jeni Sanjana<sup>2</sup>**

<sup>1</sup>*Research Scholar, Department of Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

<sup>2</sup>*Assistant Professor, Department of Economics, Holy Cross College (Autonomous), Nagercoil – 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

The Digital India drive is a dream project of the Indian Government which was launched on 1 July 2015 by Prime Minister Narendra Modi to remodel India into a knowledgeable economy and digitally empowered society, along with good governance for citizens with an objective of providing participative, transparent and responsive government. Digital India imagines, universal digital literacy and approachability for all digital resources for citizens by ensuring that the resources and services are accessible in regional languages and providing digital scaffold to participatory governance ensuring convenience, like making all government certificates and documents available on the Cloud with portability. The objective of this paper is to know the impact, challenges of digital India on all aspects of governance and improvement in the quality of life of citizens. The research methodology is descriptive cum analytical in nature and the data for this study is collected through secondary sources such as websites, research journals, newspapers, magazines etc. The study gives an optimistic thought of providing more employment prospects for the youth which will boost the nation's economy if it comes into reality.

**Keywords:** Digital, Cloud Computing, Governance, Dream project

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### **Introduction**

Now-a-days world has transformed from knowledge centric to techno centric. And all information which one thinks is available in one click. A good governing body also requires a good communication platform to communicate with the stakeholders efficiently. The efficient way to communicate with the citizens of the world's largest democracy with a population of 1.2 billion is only possible by communicating with everyone on a digital platform. The Digital India drive is a dream project of the Indian Government to remodel India into a knowledgeable economy and digitally empowered society, with good governance for citizens by bringing synchronization and co-ordination in public accountability. So, Digital India is a step by the Modi government to inspire and connect Indian Economy to such a knowledge savvy world to techno knowledge savvy world. The program launched on 1 July 2015 by Prime Minister Narendra Modi to make Government services available to people digitally and enjoy the benefit of the newest information and technological innovations.

### **Objectives of the study**

- To understand the concept of DigitalIndia.
- To find out the challenges in implementing this project.
- To find out the impacts of implementingthis project.
- To analyze the future prospects of theproject.

### **Research Methodology**

To make research a success, one has to define and plan the whole program properly and effectively. The research methodology is descriptive cum analyticalin nature.

### **Data Collection Method**

This present study is entirely based on secondary data source which has been collected from government official websites, journals, newspapers and related studies.

### **Limitations of the Study**

Digital India is a dream project of the Modi government where some of the projects are ongoing andsome of them are yet to start. Necessary design, redesign, reengineering activities is needed to for successful implementation of this project. As it is a newdream project much more data are not available andwith the limited data this descriptive and analytical research has been made.

**VISION AREAS** The 3 major targets/Aims of the programme are

### **To create a digital infrastructure as a utility to every Indian citizen**

This includes providing high-speed internet, mobile phone and bank account enabling participation in digital & financial space, shareable private space on a public cloud, and creating a safe and secure cyber space. The government is planning to provide high speed internet connectivity to 2, 50,000gram panchayats, which will be a core utility for digital inclusion.

### **Digital empowerment of citizens**

This programme aims to empower citizens through digital literacy and universal access to digital resources e.g. Mygov website for crowd sourcing ideas and will focus on finding ways to encourage people to opt for cashless financial transactions.

### **Governance and services on demand**

The initiative also aims at seamless integration across government departments/jurisdictions, and ensuring availability of services in real time from online and

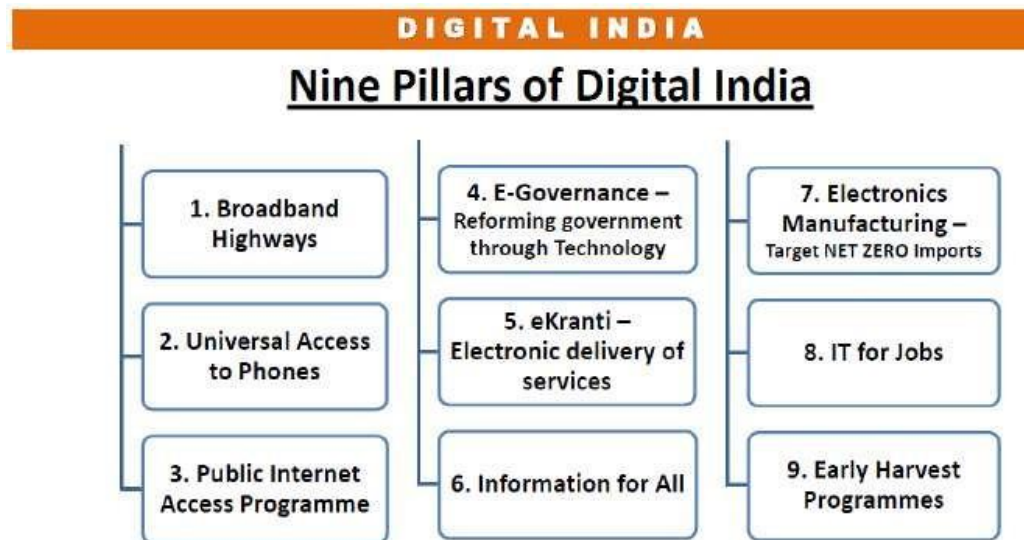
mobile platforms. It will also result in real time service delivery from online platform.

### **Projects and Products of Digital India**

- Digital locker system to minimize usage of physical documents and enable their e-sharing via registered repositories.
- MyGov.in as an online platform to engage citizens in governance through a "Discuss, Do and Disseminate" approach.
- Swachh Bharat Mission Mobile app to achieve the goals set by this mission.
- e-Sign framework to allow citizens to digitally sign documents online using Aadhaar.
- e-Hospital system for important healthcare services such as online registration, fee payment, fixing doctors' appointments, online diagnostics and checking blood availability online.
- National Scholarship Portal for beneficiaries from submission of application to verification, sanction and disbursement.
- Digitize India Platform for large-scale digitization of records in the country to facilitate efficient delivery of services to the citizens.
- Bharat Net programme as a high-speed digital highway to connect all 250,000 gram panchayats of country -- the world's largest rural broadband project using optical fibre.
- BSNL's Next Generation Network to replace 30-year old telephone exchanges to manage all types of services like voice, data, multimedia and other types of communication services.
- BSNL's large scale deployment of wi-fi hotspots throughout the country.
- 'Broadband Highways' as one of the pillars of Digital India to address the connectivity issue while enabling and providing technologies to facilitate delivery of services to citizens.
- Outsourcing Policy to create such centres in different north-eastern states and in smaller towns across the country.
- Electronics Development Fund to promote innovation, research and product development to create a resource pool within the country as also a self-sustaining ecosystem of venture funds.
- National Centre for Flexible Electronics to promote research and innovation in the emerging area of flexible electronics.



- Centre of Excellence on Internet on Things (IoT) as a joint initiative of the government agencies and private institutions such as Nasscom.



### **Broadband highways**

The government with the vision of digital India has allocated 5 billion to build high speed broadband highways connecting all the villages, government department, university etc. For faster implementation and growth of this project, participation of private players is very important to cover all the geographical area of this country.

### **E-governance**

The national e-governance plan has been formulated by the department of electronic and information technology, and department of administrative reforms and public grievances. This project works in both centralized and decentralized way. There are many different initiatives from central Government as well as state government under this project to ensure government services are available to citizen's electronics.

### **E-kranti**

The government has allocated 5 billion for the e-kranti project with an objective of providing electronic delivery of services to the citizens which include: e-health, e-education and technology for farmers, technology for planning, technology for security, technology for financial inclusion and technology for justice.

### **Universal Mobile Access**

Government is specially preparing to connect unconnected areas and speedy use of technologies like network technologies like 3G, 4G and 5G etc. General public will access the

online government services with the help of handheld devices so that nation will be well connected, efficient and more productive.

### **Public Internet access**

Superior technologies that support cost containment, collaboration, and security, social connect and in-built intelligence that deliver remote access to any information or service available across the domain. This change will open new doors of e-services to every citizen.

### **Information for all**

Everything is connected through virtual networks for which fast work flow and no delays will be there due to wait in queues. Websites and mobile apps will convey data and practical participation and even through social media at large.

### **Electronics manufacturing**

The empowerment of manufacturing through the internet of things will enable intelligent workshops that demonstrate data driven operational excellence and decentralised production control systems within and beyond the physical factory walls.

### **IT for jobs**

The government is preparing to provide training and teaching skills to the youth for employment opportunities in the IT sector. BPO industries will be established for the fastest growing segment of the IT enabled services industry which offers e-services 24/7 in every field and gives more jobs potentials.

### **Early Harvest**

This programme will generate short timeline projects where every manual service is altered by e- service. E-services like educational books to e-books, public Wi-Fi, sports to access online game.

### **Impending Challenges**

The digital India initiative is the biggest ambitious project of the government. There are many challenges that could come in the way of successful completion of the project. These are as follows:

#### **High cost of implementation**

The dream project Digital India requires new infrastructure for successful implementation which involves high cost as some are ongoing projects and some are yet to start.

### **Time overrun**

Some projects will take more time to harvest and the delayed project may lead to delay in other dependent projects and meeting the budget limit will be difficult.

### **Poor private participation**

The private participation in the government projects in India is poor because of long and complex regulatory processes.

### **Lack of coordination among departments**

In order to implement any new project, support and coordination from top to bottom is highly essential. It involves participation of several department and demanding commitment and efforts. Hence, strong leadership and timely support of all the involved entities will play a critical role.

### **Uniform and fast adoption of internet**

Despite lowest data tariffs in the world, adoption of internet in India will be difficult due to illiteracy, affordability and availability of mobile devices.

### **Impacts of Digital India**

There are some impacts of digital India which are as follows

#### **Impact on Technology**

The digital India project provides a huge opportunity to use the latest technology to redefine India the paradigms of service industry. A digitally connected India can help in improving social and economic condition of people living in different geographical area

#### **Impact on Economy**

It can play a key role in macro economic factors such as GDP growth, employment generation, labour productivity, growth in number of businesses and revenue leakages for the government.

#### **Impact on Social sector**

Social sectors such as education, healthcare, and banking are unable to reach out to the citizens due to obstructions and limitations such as middleman, illiteracy, poverty, lack of funds, living locality and investments. Modern ICT makes it easier for people to obtain access to services and resources. The penetration of mobile devices may be highly useful as a complementary channel to public service delivery apart from creation of entirely new services.

### **Impact on Environment**

The major changes in the technology space have not only brought changes to the economic system but are contributing to the environment changes. The next generation technologies are helping in lowering the carbon footprint by reducing fuel consumption, waste management, greener management, greener workplaces and thus leading to a greener ecosystem.

### **Impact on Agricultural Sector**

The governance will shift from e-governance to m governance i.e. is mobile governance. Farmers can access all kind of information through their mobile phones as when required which will boost this sector also.

### **Conclusion**

With the imminent of “Digital India” campaign, India will have a heavy and powerful digital infrastructure. The outcome of Digital India is to provide Wi-Fi to people, creating job, universal phone connection, high speed internet, Digital Inclusion, e- Services, e Governance, Digitally motivated people, National Scholarships Portal, Digital Lockers System, e-education and e-health making India to be pioneer in IT use solution. More employment prospects will open for the youth that will boost the nation’s economy. And some of the aforementioned projects are under various stages of implementation which may require some transformational process reengineering, refinements and adjustment for successful implementation to achieve the desired objectives. The success of this dream project lies not only in the hands of government but it requires all round support from the all citizens and other stake holders of the nation. Although, digital India programme is facing some barriers, yet it has a great impact on India to make the best future of every citizen. We Indians and others should work together to shape the knowledge economy. Let us all look forward and join hands for the successful implementation of this project for the brighter and prosperous India

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## **A Study on Socio Economic Conditions of Sanitary Workers in Nagercoil Corporation of Kanyakumari District**

**Sweetlin Jaffy. S<sup>1</sup>, Taruna. R<sup>1</sup>, Vinitha Charles<sup>2</sup>**

<sup>1</sup>*II M.A.Economics. Holy Cross College (Autonomous), Nagercoil - 629004.*

<sup>2</sup>*Assistant Professor, Department of Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Sanitation work includes emptying toilets, pits and septic tanks; entering manholes and sewers to fix or unblock them; transporting faecal waste; working treatment plants; as well as cleaning public toilets or defecation around homes and businesses. Sanitation workers are some of the most vulnerable workers. This paper aims to shed light on the critical contributions of sanitary workers, while addressing the challenges they encounter in their daily tasks. Through a comprehensive review of existing literature and empirical data gathered from field studies, we explore the health risks, safety concerns, and socio-economic issues affecting this workforce. By raising awareness and advocating for systemic changes, this paper seeks to contribute to the betterment of the lives of sanitary workers and underscores the importance of their role in sustaining community health.

**Keywords:** Sanitary workers, Sanitation, Hygiene, Cleanliness, Waste, Public health, Environmental aesthetics, Garbage

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### **Introduction**

Sanitary workers are essential in maintaining safe sanitation in places all over the world, but they do face many health risks in doing so, including from exposure to a wide range of biological and chemical agents. Additionally, they may be at a risk of injuring from heavy labour, poor and prolonged postures and positions and confined spaces, as well as physico-social stress. The risks are exacerbated under conditions of poverty, illness, poor nutrition, poor housing, child labour, migration, social stigma and societal neglect. In many developing countries, sanitation workers are more vulnerable due to unregulated or unenforced environment and labour protections and lack of occupational health and safety. But without sanitary workers. The Sustainable Development Goal 6 target cannot be definitely achieved. It is important to safeguard the dignity and health of the sanitation workers.

A sanitary worker is a person responsible for cleaning, maintaining, operating or emptying the equipment or technology at any step of the sanitation chain. This is the definition used in the narrower sense within the WASH sector. More broadly speaking, sanitation workers

may also be involved in cleaning streets, parks, public spaces, sewers, storm water drains, public toilets, hospitals etc.

### **Women Sanitary Workers**

Out of the total sanitary workers, women contribute about fifty per cent to the sanitation sector. The repercussions of being a member of sanitation workers community fall hardest on women: in addition to being socially marginalized, they are at increased risk of gender based violence, both within and outside their own families. The wages earned by these sanitary workers from manual scavenging barely cover two meals a day, so families are at a higher risk of hunger and malnutrition. Meanwhile, the children of these sanitary workers are mostly excluded from schools, exposing girls to child marriages, and blunting their development potential.

Female sanitation workers are one of the most vulnerable groups in the society. A research found a strong correlation between caste, lack of education, and lack of professional agency for women sanitary workers across the cities. Often hired as contractual and outsourced workers, women suffer further vulnerability due to low compensation with no benefit whatsoever. These women sanitary worker lack any accountability toward their physical and mental health. Awareness among the women sanitation workers about laws, politics or schemes that are meant to protect them and their rights is very low.

Several health checkups have been conducted for women sanitation workers from time to time across the country and it was observed that the majority suffered from joint pains, especially elder women. Conditions such as hemorrhoids, contact dermatitis, poor appetite, low or high blood pressure are common among workers.

### **Methodology**

A suitable methodology is very much necessary for the scientific analysis and objective interpretation of an economic problem. The methodology chapter of this study on socio-economic conditions of sanitary workers in Nagercoil corporation of Kanyakumari district. Covers the statement of the problem, objectives, sources of data, tools of analysis and selection of samples

### **Statement of the Problem**

The sanitary workers in the Nagercoil corporation face several problems in their day to day life-both personally and economically. Most of them do not even have a proper and

satisfactory mode of living. They leave their children under the care of someone and go for work to earn a small amount. At times they do not even get proper salary. These workers may also have to stay late in the night and do their work, which is really troublesome. They also get health issues like allergy. Skin diseases, heart problems, bone weakness, over tiredness, respiratory diseases etc. This study on socio economic conditions of sanitary workers in Nagercoil corporation highlights these issues.

### **Objectives**

- To find out various aspects of the lifestyle of the sample respondents.
- To focus on and find solutions and give suggestions for the problems faced by the sample respondents.

### **Sources of Data**

For the completion of this study, we have collected both primary & secondary data. A suitable questionnaire was framed to collect the primary data from the Nagercoil corporation. The secondary data were obtained from the materials published in journals, magazines, reports and books. The collected data had been analyzed and consolidated.

### **Selection of Samples**

For this study, the primary data are collected from the respondents in Nagercoil corporation. This study is carried out on the basis of convenient random sampling method. Data have been collected from fifty sanitary workers in Nagercoil corporation. The suitable questionnaire was framed to collect the primary data.

### **Data Analysis**

#### **Gender Wise Classification**

Gender defines if a human is a male or a female in relation to the social and cultural roles that are considered appropriate for men and women. Some people experience a mismatch between their gender identity and their biological sex. Table 1.1 represents the gender wise composition of the sample respondents.

**Table 1.1**

**Gender wise classification of sample respondents**

<b>Gender</b>	<b>No. of respondents</b>	<b>Percentage</b>
Male	7	14



Female	43	86
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary Data

Table 1.1 explains that 14 per cent of the sample respondents are males and females show a higher ratio with 86 percent.

### **Type of Family**

Family maybe nuclear or a joint one. These days most of them prefer to live in a nuclear family. Joint families have reduced due to family problems and interest to live independently.

**Table 1.2**  
**Type of family of the sample respondents**

Type of Family	No.of respondents	Percentage
Nuclear family	39	78
joint family	11	22
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary Data

Table 1.2 shows that 78 percent of the sample respondents are living a in nuclear family and 22 percent of them are living in joint families.

### **Monthly Income**

Monthly income is the amount paid to an employee within a month before taxes or other deductions. The specific amount appears on both jobs offer letters and paychecks. Potential additions to monthly income include overtime, bonuses and commission. The table 1.3 shows the monthly income of the sample respondents.

**Table 1.3**  
**Monthly income of the sample respondents**

Income (Rs)	No. of respondents	Percentage
5000-10,000	29	58
10,000-15,000	15	30
Above 15,000	6	12

<b>Total</b>	<b>50</b>	<b>100</b>
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Source: Primary Data

The table 1.3 shows that 58 percent of the sample respondent's monthly income ranging from Rs. 5000-10,000 and 30 percent of the respondent's monthly income ranging from Rs. 10,000-15,000.

### **DEBT**

Debt is something usually money, borrowed by one party from another. A debt arrangement gives the borrowing party permission to borrow money under the condition that it is to be paid back at a later date, usually with interest. The table 1.4 shows the debt of the sample respondents.

**Table 1.4**  
**Debt of the sample respondents**

Debt	No. of respondents	Percentage
No debt	11	22
In debt	39	78
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary Data

The table 1.4 shows that 22 percent of the sample respondents are living happily without debt and 78 percent of the respondents are in debt.

### **Working Experience**

Experience is used to refer to the past events, knowledge and feelings that makeup someone's life or character. The work experience of the sample respondents are given in table 1.5.

**Table 1.5**  
**Work experience of the sample respondents**

Work Experience	No. of respondents	Percentage
Less than 1 Year	2	4
1-3 Years	10	20
4-6 Years	6	12
7-10 Years	14	28

Above 10Years	18	36
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary Data

The table 1.5 reveals that 4 percent of the sample respondents have a work experience of less than a year, and 36 percent of them have an experience of more than 10 years.

### **Health Problems**

Good health is very much important for a healthy life. Health problems arise unexpectedly due to non-acceptable environment conditions, the work a person does or some other reasons. It may be a fast curable one or an everlasting one. The health problems of the sample respondents are shown in table

**Table 1.6**  
**Health problems of the sample respondents**

<b>Health Problems</b>	<b>No. of respondents</b>	<b>Percentage</b>
Yes	29	58
No	21	42
<b>Total</b>	<b>50</b>	<b>100</b>

Source: Primary Source

The table 1.6 shows that only 20 percent of the sample respondents are affected by health issues and 80 percent of them don't have any health problems.

### **Findings**

- 86 per cent of the sample respondents are females
- 36 per cent of them have more than 10 years of experiences.
- 30 per cent of the sample respondent's income range between Rs.10,000-15,000
- 78 per cent of the respondent's expenditure is between Rs. 11,000-15,000
- 20 per cent of the respondents are affected health problems because of their work.

### **Suggestions**

- Sanitary workers can register and create an union for themselves.
- Free and regular medical checkups should be conducted for the sanitary workers, so that their health issues can be reduced.

- Government must take initiatives and form an union to promote the welfare of the sanitary workers.
- Extra allowances can be provided for the sanitary workers based on their family situations.

### **Conclusion**

Owing to our study, we conclude that the life of sanitary workers is little pitiable due to their low income and working situations. Sanitary workers are not treated as like other people, but still they are forced to work in a situation that cannot be accepted to earn their living. In many developing countries, they are informal workers with no legal protection or rights. With a lack of visibility, they can be stigmatized, marginalized and ignored. The sanitation workers are very much essential for public health and global well-being.

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## **Globalization and its Impact on the Indian Economy**

**M. Seetha Lakshmi<sup>1</sup>, P. Sowmiya<sup>1</sup>, Benshika.J<sup>2</sup>**

<sup>1</sup>*I.M.A Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

<sup>2</sup>*II M.AEconomics, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Globalization has transformed the world economy, leading to increased interconnectedness and integration of markets across borders. This paper examines the impact of globalization on the Indian economy, focusing on various economic, social, and political dimensions. It explores how globalization has influenced trade patterns, foreign investment, technological advancements, labour markets, income inequality, cultural exchange, and government policies in India. The paper also discusses the challenges and opportunities posed by globalization and suggests strategies for maximizing its benefits while mitigating its adverse effects on different sectors of the Indian economy.

**Keywords:** Globalization, Economic Growth, Development, Impact

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### **Introduction**

Globalization is a process of global economic, political and cultural integration/It has made the World become a small village; the borders have been broken down between countries. “The history of Globalization goes back to the second half of the twentieth century, the development of transport and Communication technology led to situation where national borders appeared to be too limiting for economic Activity”. Globalization is playing an increasingly Important role in the developing countries. It can be seen that, globalization has certain advantages such as Economic processes, technological developments, political influences, health systems, social and natural Environment factors. It has a lot of benefit on our daily life. Globalization has created a new opportunities For developing countries. Such as, technology transfer hold out promise, greater opportunities to access Developed countries markets, growth and improved productivity and living standards. However, it is not True that all effects of this phenomenon are positive. Because, globalization has also brought up new Challenges such as, environmental deteriorations, instability in commercial and financial markets, increase Inequity across and within nations. It involves the exchange of goods, services, ideas, technology, and people across borders, leading to a global integration of markets and cultures. The historical background of globalization can be traced back centuries,

but it gained significant momentum in the late 20<sup>th</sup> century with advancements in transportation, communication, and technology.

### **Objectives**

- To stimulate economic growth by leveraging global markets for exports, attracting foreign investment, and fostering competition, innovation, and efficiency within domestic industries.
- To reduce poverty by creating Employment opportunities.

### **Economic Impact**

#### **Positive Impact**

#### **Export Growth**

India has become a major player in global trade, exporting a wide range of goods and services. Access to international Markets has boosted the of industries like IT, Pharmaceuticals, and textiles

#### **Technological Advancement**

Globalization has facilitated the transfer of technology and knowledge, leading to improvements in productivity and innovation across various industries

#### **Job Creation**

Integration into the global economy has created employment opportunities, particularly in sectors like IT, business process outsourcing (BPO), and manufacturing of industries like IT, pharmaceuticals, and textiles

#### **Negative Impact**

#### **Income Inequality**

While globalization has contributed to overall economic growth, it has also widened the gap between the rich and the poor in India. The benefits of globalization have not been equally distributed, leading to increased income inequality.

#### **Displacement of Traditional Industries**

The liberalization of trade has led to the decline of traditional industries, such as agriculture and small-scale manufacturing, as they struggle to compete with cheaper imports

## **Social Impact**

### **Urbanization**

Economic globalization has spurred urbanization in India, as people move from rural areas to cities in search of better employment opportunities. This has led to the growth of urban centers and the emergence of new lifestyles and social dynamics.

### **Education and Skills**

Globalization has increased access to education and skills training in India, particularly in sectors like IT and services. This has empowered individuals to participate in the global economy and has contributed to social mobility and upward economic mobility.

### **Labor Market Dynamics**

Globalization has transformed the Indian labor market, leading to changes in employment patterns, working conditions, and labor rights. The rise of informal and precarious employment, particularly in sectors like services and manufacturing, has posed challenges to social protection and workers' rights.

## **Political Impact**

### **Policy Reforms**

Globalization has driven significant policy reforms in India, particularly in the areas of trade, investment, and liberalization. Governments have implemented measures to open up the economy, reduce trade barriers, and attract foreign investment, in line with global economic trends and international agreements.

Integration into Global Institutions India's participation in global institutions such as the World Trade Organization (WTO), International Monetary Fund (IMF), and World Bank has increased as a result of globalization. This has influenced India's economic policies and decision-making processes, as well as its role in global governance

## **Challenges**

### **Job Displacement**

While globalization has created new job opportunities in sectors such as IT and services, it has also led to the displacement of workers in traditional industries such as agriculture and small-scale manufacturing. This has resulted in unemployment and underemployment, particularly among low-skilled workers.

### **Social and Cultural Erosion**

Globalization has led to the spread of Western cultural influences and consumerism in India, leading to concerns about the erosion of traditional values and cultural identities. This can have social and psychological impacts on individuals and communities.

### **Opportunities**

#### **Human Capital Development**

Globalization has increased access to education, skills training, and employment opportunities for individuals in India. This has empowered the workforce with the skills and knowledge needed to thrive in the global economy.

#### **Technological Advancement**

Globalization has facilitated the transfer of technology and knowledge, leading to improvements in productivity, innovation, and competitiveness across industries. This has positioned India as a global hub for IT and digital services.

#### **Export Growth**

Access to international markets has boosted India's exports, particularly in sectors such as IT, pharmaceuticals, textiles, and automotive. This has contributed to economic diversification and competitiveness on the global stage.

### **Policy Recommendations**

- Strengthening infrastructure and institutional capacity
- Promoting innovation and entrepreneurship
- Enhancing social safety nets and skill development programs
- Formulating proactive trade and investment policies.

### **Conclusion**

Globalization has had a transformative impact on the Indian economy, driving economic growth, trade expansion, and technological advancements. However, it has also posed challenges in terms of income inequality, job displacement, and environmental sustainability. Addressing these challenges while harnessing the benefits of globalization is crucial for India's continued economic development and inclusive growth. This paper provides a comprehensive analysis of the multifaceted impact of globalization on the Indian economy, offering insights into the opportunities and challenges that arise from increased economic integration and global



connectivity. It underscores the importance of proactive policy measures to harness the benefits of globalization while addressing its associated risks and vulnerabilities.

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## **An Economic Study of Tourism Industry in Kanniyakumari District**

**T. J. Iswarya, B. Sharmi, K. Gopika**

*I MA Economics, Holy Cross College (Autonomous)Nagercoil – 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Tourism is one of the very ancient industries known to mankind. Its contributions to economic prosperity have been illustrious and phenomenal. The international reputation of a country and its culture and civilization too could be influenced beyond measure by tourism. No wonder, it is treated for all practical purposes as a smokeless industry. Generally speaking, tourism is a complex industry, which comprises a dynamic sector and a static sector. The dynamic sector covers economic activities and community services of every description. Those who are closely associated with this sector are tour operators, travel agents, transport undertakers and ancillary services. The static sector on the other hand consists of the demand for accommodation, food and refreshment. In other words, tourism creates a demand or market for different industries.

**Keywords:** Tourism, Culture, Community, Accommodation

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### **Introduction**

Tourism is more difficult to define and there are many different forms of tourism. Tourism is about a temporary or short-term movement away from the place where a person normally lives and works. The tourist intends to return home at the end of the visit. The length of the visit may be from just one night up to one year. Most tourist trips are taken as holidays lasting one or two weeks but many business trips last only one night and ‘gap year’ students might be travelling for several months. Tourism usually, but not always, involves staying away from home. People travelling outside of their home area are called day visitors who are taking part in excursions

Tourism is not only related to leisure although most tourism activity takes place during leisure time. People become tourists for other reasons including business, visiting friends and relatives, education purposes and health purposes. Tourism is also about the activities which people do while at the destination they are visiting. These activities might include sunbathing, visiting a theme park, taking part in a religious ceremony, skiing or attending a business conference.

People travel to take part in leisure activities outside of the area in which they live, and they also become tourists by spending time away from home. There are many thousands of

organisations which exist to provide people with the opportunity to take part in leisure activities, to travel for leisure or other purposes, and to be tourists. These organisations form the leisure and tourism industries.

### **Objectives**

- To examine the opinion of the tourists regarding environment and hotel accommodations and
- To offer suggestions for the development of tourism in Kanyakumari district.

### **Need for the study**

We are living in an era of E-Commerce, E-Democracy, E-Governance and E-Administration. Among all these E-governance enjoys a place of predominant significance. E-governance requires a very fast flow of information and knowledge. The Tourism Industry could be brought under E-governance when every minute aspect of it is subjected to an empirical study. For example, a computerized study of the tourist spots and the facilities available there in, tourist arrivals, the spending patterns of tourists, tourism supported industries, employment generation and the like, will make it easy for people all over the world to obtain tourism related information from the department of tourism. Further, tourists can interact with the government at different levels and get their grievances redressed.

### **Significance of the Study**

Tourism is an important economic activity. It earns a country the much needed foreign exchange while providing opportunities of employment. It can also correct adverse trade imbalances and regional imbalances. Besides these, it is an important medium of socio-economic development, capable of promoting lasting goodwill and friendship among the nations around the globe. It also helps in the regional development of a country. Further it also facilitates the growth of universal peace. Thus, it is clear that tourism is a fast-growing industry which has been endowed with vast and inexhaustible potentials to enhance the growth of the country as well. Over and above these, its impact on the environment of an economy is also rather enormous.

### **Importance of Tourism**

Tourism is not only an economic activity of importance in as much as it earns a country the foreign exchange and provides employment; it can correct adverse trade balance and regional imbalances, as it is both a labor-intensive and capital-intensive activity. It is an

important medium of social cultural development, capable of promoting lasting goodwill and friendship among the nations of the world. It also helps in the regional development of the country and acts as a means of social education and better understanding among peoples of different regions in the country. In the long run, the most important contribution of tourism is in the area of developing understanding among varied cultures and life styles.

Thus, it is clear that tourism is a fast-growing industry which has vast and inexhaustible potentials to enhance national income, foreign exchange reserves and opportunities of employment to the growing 17 million of the country as well.

Tourist Information Centre in Kanyakumari district. They were stratified into two strata, namely, domestic and foreign tourists. The first stratum covers 132 samples. The remaining 118 samples come under the second stratum. The data collected from the sample tourists have been analyzed and studied.

Tourism is one of the most powerful and time-honored industries which is inextricably linked with the all-round growth of an economy. This characteristic feature of the tourism industry has been found to be quite true from the remarkable role played by it in accelerating the pace of growth of the Indian economy over the years. The present study has been undertaken to show how the developmental role of the tourism industry starts from the grass root level.

The study, as it is evident from the title and the foregoing discussions was confined to Kanyakumari district. Its objectives as it could be seen from the first chapter were seven in number. A summary of the discussions held on the basis of these objectives and the conclusions arrived at constitutes the content of this chapter.

In keeping with the first objective an elaborate study was undertaken in about the major tourist centers in Kanyakumari district. No pain was spared in giving a vivid portrayal of the environmental significance tourist attractions such as forests, Waterfalls, landscapes, monuments of ancient civilization like Kumari Amman Temple, Bhagavathi Amman Temple, Vivekananda Memorial, Gandhi Memorial, Suchindram Temple, Udayagiri Port, Padmanabhapuram Palace, Mathor Thotti Palam etc. This chapter shows how the natural cultural, and social environments of regions constitute a major lure for both national and international tourism.

The objective of the study was to bring out in detail the expenditure portfolio and its basic determinants with respect to sample tourists in Kanyakumari district. The patterns of

expenditure of domestic and international tourists were subjected to a detailed statistical study. While dealing with the expenditure pattern of the tourists, care was taken to show how money was spent on food, accommodation, health, shopping, transport, food, entertainment, handicrafts, textiles and so on by the tourists of national and foreign origins.

The investigator in the course of the survey undertaken tried to find out the opinions of tourists regarding the natural environment of Kanyakumari district and the facilities of hotel accommodation available therein because it was the fifth objective of the present project.

Towards the close of the chapter a statistical study regarding percentage distribution of tourists who feel irritated amongst both domestic and foreign nationals, with regard to unclean public places, poor roads, lack of sign boards, want of discipline among drivers, beggary, cheating in shops, impure drinking water, guidance and, lack of entertainment was made.

The investigator could infer from the data about the opinions of environment and hotel accommodation that most of the foreign tourists have nothing but dissatisfaction regarding the second set of factors investigated also, except the natural cultural and social environment around the places of tourist attraction. The employment generation potentials of the tourism industry have been studied. As this is the objective of the present investigation, the investigator has collected a huge mass of primary data to show how tourism has been responsible for the growth of micro and macro employers all over the district. From the analysis of such data, it becomes evident that these two categories of employers are centered on the hotel industry, the handicrafts industry, tourist promotion industry, transport industry and telecommunication services. These employers who have registered a mushroom growth over the years have been responsible for generating employment opportunities for both men and women. At the close of the present study the investigator contends that in a small district like Kanniyakumari, tourism industry has in fact shaped along the lines of production-oriented industries, in opening new vistas of employment opportunities to all categories of skilled and under skilled and educated and uneducated men and women.

### **Findings**

1. Tourism industry is absolutely essential for the socio-economic growth of any country.
2. In Kanyakumari district tourism industry has grown by leaps and bounds over the years due to the locale's unique environmental and scenic beauty with which it has been endowed, as well as the historic role it has played in the life of the nation, through its

association with lives of saints, savants, poets, freedom fighters and above all symbolic connection with the Divine.

3. The record of growth and the impact of the tourism industry on the economic background of Kanniyakumari district and its social natural and political environment has been quite impressive.
4. Though Kanniyakumari district has a poor track record as far as the industrial growth is concerned, some amends have been made to it by the ever-growing tourism industry.
5. The hotels and lodges necessary to lure tourists have not yet registered satisfactory rates of growth over the years.
6. There has been a dearth of worth-buying and attractive manufactures from the sphere of handicrafts industry

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## **Impact of Climate Changes in India**

**N. Jenisha, G. Brightlin**

*I MA Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

India's high population density, large spatial and temporal variability in rainfall, and high poverty rates make it particularly vulnerable to the impacts of climate change. This chapter provides a baseline of knowledge on evidence and impacts. More frequent episodes of extreme rainfall, longer dry spells, higher sea levels, and heat waves are expected. This will have unpredictable impacts on agriculture and public health. This study mainly focuses on Impact of Climate Change in Indian Economy.

**Keywords:** Temperature, Health and Population

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### **Introduction**

The periodic modification of Earth's Climate brought about due to the changes in the atmosphere as well as the interactions between the atmosphere and various other geological, chemical, biological and geographical factors within the Earth's system is called Climate Change. Agriculture is crucial for ensuring food, nutrition and livelihood securities for India. Indian agriculture had made a significant progress in the past, but currently it is facing many challenges. Stagnating net sown area, plateauing yield levels, deterioration of soil quality, reduction in per capita land availability and the adverse effect of climate change are the major challenges for Indian agriculture. On the other hand, the increased rate of population is pressurizing the agricultural sector for enhanced food production. The task is very challenging because about 60% of the net cultivated area is rainfed and exposed to biotic and abiotic stresses arising from climatic variability and climate change.

### **Objectives**

To know the impact of agriculture production in India.

1. To affect the climate change in human health.

### **Methodology**

This study based on Secondary data were collected from the records of various journals, magazines, books and internet, articles, websites and thesis.

## **Impact of Agriculture production**

Climate change refers to changes in the earth's environmental conditions like temperature, rainfall patterns, storms, heatwaves, etc. It is caused by many natural and artificial factors, such as volcanic activity, variations in solar activity, deforestation, burning of fossil fuels, mining, and many others. The growing industrial demand in India has created more emphasis on crop production. As a result, more forests are converted into farming lands, resulting in an abnormal change in temperatures and weather patterns. A major **impact of climate change on biodiversity** is that it leads to the extinction of many species of plants and animals.

The shift in climate patterns is a global phenomenon that has badly affected the crop yield in India. It has also influenced the types of crops that can be cultivated in certain regions by affecting the soil, water and pest prevalence in those regions. In this article, we will discuss the impact of climate change on agriculture in India.

Agriculture is one of the largest and most important sectors in the Indian economy. The contribution of agriculture to India's GDP is about 19.9 per cent in 2020–21. Moreover, this sector employs 42.6 per cent of the Indian population. However, it is a major source of hazardous greenhouse gases (methane and nitrous oxide), which contribute to the greenhouse effect and climate change.



### **1. Agriculture and Food Security**

Monsoon patterns are becoming increasingly erratic, leading to periods of drought and flooding. This unpredictability affects crop yields and the livelihoods of millions of farmers. Higher temperatures and changing precipitation patterns can reduce the productivity of staple crops like wheat, rice, and maize, leading to food insecurity.



## **2. Water Resources**

The Himalayan glaciers, which feed major river systems like the Ganges, Brahmaputra, and Indus, are melting at an accelerated rate. This can lead to reduced water availability in the long term. Increased temperatures and altered rainfall patterns can exacerbate groundwater depletion, a critical issue for India's agriculture and drinking water supply.

## **3. Health Impacts**

Rising temperatures are increasing the frequency and intensity of heatwaves, posing severe health risks, especially to vulnerable populations. Changes in climate can expand the range of diseases like malaria and dengue, affecting public health systems.

## **4. Economic Impact**

Reduced agricultural productivity can lead to economic losses, higher food prices, and increased poverty, particularly in rural areas. Extreme weather events like floods, cyclones, and storms can cause extensive damage to infrastructure, disrupting economic activities and requiring significant expenditure on repairs and recovery.

## **5. Biodiversity and Ecosystems**

Climate change can lead to habitat loss and shifts in species distribution, threatening biodiversity in India's diverse ecosystems. Rising sea temperatures and ocean acidification can affect marine ecosystems and fisheries, impacting coastal communities.

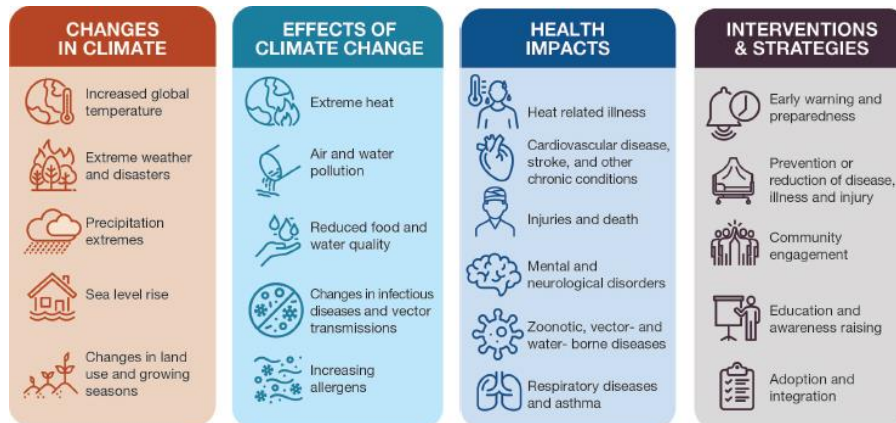
## **6. Coastal Areas**

Coastal regions, including major cities like Mumbai and Kolkata, are at risk from rising sea levels, leading to increased flooding, erosion, and displacement of communities. Increased intensity and frequency of cyclones can devastate coastal infrastructure and livelihoods.

## **Climate Changes in Human Health**

Climate change impacts human health in both direct and indirect ways. Extreme heat waves, rising sea level, changes in precipitation resulting in flooding and droughts, and intense hurricanes can directly cause injury, illness, and even death. The effects of climate change can also indirectly affect health through alterations to the environment. For example, worsening air pollution levels can have negative impacts on respiratory and cardiovascular conditions. Changes in temperature and rainfall can alter the survival, distribution, and behavior of insects and other species that can lead to changes in infectious diseases. Increases in precipitation, storm surge, and sea temperature can lead to more water-related illnesses. Climate change can

also affect food safety, exposing people to contaminated foods that can result in foodborne illnesses. In addition, climate change can affect mental health and well-being.



Exposure to climate-related hazards can include biological, chemical, or physical stressors and can differ in time, locations, populations, and severity. These are referred to as exposure pathways. These threats can occur simultaneously, resulting in compounding health impacts. Climate change threats may also accumulate over time, leading to longer-term changes in resilience and health.

### Conclusion

More than 80% of Indian farmers are marginal and small with poor coping capacity. Furthermore, the Indian farmers are heterogeneous and unorganized. Climate change and variability are likely to aggravate the problem of future food security by putting pressure on agriculture affecting its sustainability. The impact of climate change in India is extensive, affecting almost all aspects of life. It necessitates urgent and sustained efforts in adaptation, mitigation, and resilience building to safeguard the country's future. Collaboration among government, private sector, and civil society is essential to address these challenges effectively.

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## **A Study on Socio – Economic Status of Women Beedi Workers in Radhapuram Taluk, Tirunelveli District**

**M. Elakiya Gayathri, D. Dhanu Shakani, S. Indra**

*I M.A Economics, Dept of Economics, Holy Cross College (Autonomous), Nagercoil - 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012.*

### **Abstract**

The study investigates the socio-economic conditions of women beedi workers in Radhapuram, a rural region in India. Beedi rolling, a lucrative industry in the area, employs thousands of women, yet their working conditions, health and livelihoods remain precarious. The research reveals alarmingly low levels of literacy, income, and social security among these women.

**Keywords:** Women workers, Social Status

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### **Introduction**

Indian tobacco cultivation began in the late 17th century and beedies were first created when tobacco workers took leftover tobacco and worked it in leaves. The commercial Indian beedi industry saw rapid growth during the 1930 probably an expansion of tobacco cultivation at the time but also helped by Gandhi's support of Indian industry and Indian products. Muslim leaders calling cigarettes foreign products here were also endorsed at the time. Driven Factory based beedi production declined as a result of increase during the 1940 and 1950 and beedi making became a cottage industry with a home-based woman work force predominantly employed only in the beedi working

### **Beedi Industry in Tamilnadu**

The beedi industry in Tamilnadu is 95 years old, though it came to be established here, much later than the rest of India. One of the traditional and 8 times honored industries in which any amount of industrialization can bring hardly a meager amount of changes in the field of production is the beedi industry. It is a kind of labor intensive one and the method of production is still kind of traditional, monotonous. Right from the inception of beedi production in India it has been carried out in the same way. Though mechanization has come in the way of production of cigarettes, it has not rocked the production of beedi. It is being carried out as a part time job by the entire family members in many families in Tamil Nadu. Beedi making is a big industry in Tamilnadu and the number of workers employed at present in this industry is over six lakhs and the volume of beedi production in a single day runs to several crores. The

value of production in terms of money is nearly 15 crores.

### **Beedi Industry in Tirunelveli District**

The beedi industry has a history of 95 years in this District. Majority are women and children. The system of production by employees, that is home based workers via contracting and subcontracting, has been the prevalent one Tirunelveli in Tirunelveli District, Melapalayam, Vallioor, Ambasamudram, Radhapuram, Sankarankoil, Thenkasi are the oldest centers of beedi industry. One of the important organized industries especially in rural areas is the beedi making industry. More than 80 percent of the beedi making centers are rural in nature. Therefore, beedi making is considered to be a rural based industry. Cheap female labor is largely available in these rural areas. The new entrepreneurs with brands such as Kajahbeedi from Kerala, Mangalore Ganesh beedi from Karnataka, a host of smaller brands such as Khilladibeedi from Gujarat, and King beedi from Tamilnadu have established their branches at Tirunelveli and Melapalayam, withoutlets in the form of shops gradually spreading out to cover the entire district.

### **Women in Beedi Industry**

There are varying estimates of female involvement in beedi working. One source estimated that women constitute 76 percent of the total employment in beedi manufacturers. The All India Beedi, Cigar and Tobacco Workers Federation peg the figure at 90 percent to 95 percent. In some regions of India, 10 beedi making is largely regarded as “Women work”, with the exception of young boys. In other areas, men roll beads if and when other work is not available or they are unable to engage in manual labor. The beedi industry is male dominated, where the manufacturer, the contractor and the consumers are male and only the beedi workers are female. This often makes women subject to economic exploitation. Some middle men reportedly supply low quality leaf and reject bundles of beedies on grounds of poor standards, but then eventually take them without paying. Female beedi workers also report verbal and physical abuse based on gender and caste differences. In areas where the beedi cottage industry is pervasive, some women engage in beedi rotting as a full-time occupation and are able to roll 800 – 1200 beedies by working 8 to 12 hours in a day. Other women work part time while caring for children and attending to household duties and roll 300 to 500 needs a day. In many cases, several women from the same household will pool their efforts working to fill quotas. Nichter observes that beedi rolling is often preferred to other manual labor, particularly in

communities were going “outside” the home to work in the fields of others is considered lower status than working at home.

### **Problems Faced by Women Beedi Works**

- Non – representation of women in planning.
- Middlemen/ women who exploit them.
- Non implementations of Minimum Wages Act.
- Sense of insecurity
- Piece work / contract rate.
- No provision for childcare and maternity benefits.
- Problem of choice of techniques
- Non-cooperation by men.
- Lack of coherent ideology.

### **Objectives**

- To analyze the Income level of the sample respondents.
- To know the saving pattern of the sample respondents.
- To analyze the Problems of the sample respondents.

### **Data Collection**

- **Primary data** Primary data are those which are fresh and for the first time and thus happen to be original in character. primary data were collected by questionnaire from the workers.
- **Secondary Data** Secondary data means that data has been already available. They referred to the data which has already been collected and analyzed by someone. The secondary datais collected from various records kept in company profiles, websites, journals etc.

### **Sampling Size**

The sampling size used for the study is 100.

### **Data Analysis**

#### **1.1 Monthly income**

<b>Amount of Income</b>	<b>No of Respondents</b>	<b>Percentage</b>
Below ₹2,000	33	33
₹2,000 to ₹4,000	25	25
₹4,000 to ₹6,000	19	19

Above ₹6,000	23	23
<b>Total</b>	<b>100</b>	<b>100</b>

**Source: Primary data**

Above table 1.1 shows that 33 percentage of the sample respondents monthly income are below Rs.2,000. 19 percentage of the sample respondents monthly income are Rs.4,000 to 6,000. 23 respondents.

### 1.2 Educational Qualification

Particulars	No of Respondents	Percentage
Illiteracy	41	41
SSLC	25	25
HSC	20	20
Graduate	14	14
<b>Total</b>	<b>100</b>	<b>100</b>

**Source: Primary data**

Above table 1.2 shows that 41 percentage of the sample respondents are illiteracy. 14 percentage of the sample respondents are Graduates. It is concluded that majority of the respondents are illiteracy.

### 1.3 Members in the family

Particulars	No of Respondents	Percentage
1-4	39	39
4-6	27	27
Above 6	34	34
<b>TOTAL</b>	<b>100</b>	<b>100</b>

**Source: Primary data**

Above table 1.3 shows that 39 percentage of the sample respondents having 1 – 4 members. 27 percentage of the sample respondents having 4 – 6 members.

### 1.4 Monthly saving amount of the respondents

Amount of Saving	No of Respondents	Percentage
Below ₹1,000	30	30
₹1,000 - ₹ 1,500	28	28

₹1,500 - ₹2,000	15	15
Above ₹2,000	27	27
<b>Total</b>	<b>100</b>	<b>100</b>

**Source: Primary data**

Above table 1.4 shows that 30 percentage of the sample respondents are saving at below Rs.1,000.15 percentage of the sample respondents are savings Rs. 1,500 to 2,000.

#### 1.5 Pattern of saving amount

<b>Saving Pattern</b>	<b>No of Respondents</b>	<b>Percentage</b>
Post office	39	39
Bank account	25	25
Private chit fund	20	20
Others	16	16
<b>Total</b>	<b>100</b>	<b>100</b>

**Source: Primary data**

Above table 1.5 shows that 39 percentage of the sample respondents are depositing in post office. 16 percentage of the sample respondents are others. Others denote family members, friends etc.

#### 1.6 Problems Faced by Beedi Workers

<b>Problems</b>	<b>No of Respondents</b>	<b>Percentage</b>
Eye irritation	15	15
Back pain	30	30
Vessing	15	15
Cough	10	10
Finger pain	20	20
Others	10	10
<b>Total</b>	<b>100</b>	<b>100</b>

**Source: Primary data**

Above table 1.6 shows that 30 percentage of the sample respondents are affected by back pain. 10 percentage of the sample respondents are affected by cough.



### **Findings**

- Majority (37%) of the respondent's income level is ₹10,000 to ₹15,000.
- Majority (33%) of the respondent's monthly income are below ₹ 2,000.
- Majority (41%) of the respondents are illiteracy.
- Majority (39%) of the respondents are having 1 – 4 members in the family.
- Majority (30%) of the respondents are saving below ₹ 1,000.
- Majority (39%) of the respondent's saving pattern is post office.
- Majority (30%) of the respondents are affected by back pain.

### **Suggestions**

- The government has to take necessary steps to improve the standard of living of beedi workers.
- The government has to implement new policies like pension, insurance and welfare schemes.
- The companies have to introduce welfare schemes, pensions and door delivery of materials and recollect the beedies.
- Beedi rollers should wear a mouse while rolling beads.
- The companies can introduce medical camps periodically for their workers.

### **Conclusion**

Beedies are injurious to health. But it generates employment opportunities for poor families. It provides an income to the poor people. It is useful for them in many ways. Generally, beedies are generating national income to the country.

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## **An Economic Study of Agriculture Workers in Karairuppu in Tirunelveli District**

**S.K.Abisha, V.Swathiga and A.Abisha,**

*I MA Economics, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Agriculture is an important sector in India. It is indispensable for the sustenance and growth of the Indian economy. On an average about 70% of the households and 10% of the urban population is dependent on agriculture as their source of livelihood. Today, India is a major supplier of several agricultural commodities like tea, coffee, rice, spices, oil meals, fresh fruits, fresh vegetables, meat and its preparations and marine products. In terms of quantity of production, India is the top producer in the world in milk, and second largest in wheat and rice. Agricultural production is prone to several risks which affect both producers and consumers. In order to enhance investment and achieve a sustained increase in production coherent and integrated long-term strategies and policies are required to reduce risk aversion and build flexibility among Indian rural producers.

**Keywords:** Karaiyiruppu Village, Social status, Formers

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### **Introduction**

Agriculture is the back bone of India economy. It is the largest sector of economic activity. It provides not only food and raw materials but also employment to a very large proportion of the population. Agriculture the dominant sector provide the capital required for its own development and make available surpluses for national economic development. In the early stage of economic development, the exports of primary produce earn valuable foreign exchange which can be used to import capital goods for the development of leading to increase in demand for food and other consumer goods many of them have an agricultural base.

The agriculture sector forms only about 18 percent of India's GDP despite employing almost 65 percent of the total work face. Agriculture in India is largely dependent on nature but climate and global warming issues make farming unpredictable.

## **Agriculture In Tamilnadu**

Agriculture contains to be the most predominant sector in Tamil Nadu. Consolidation of the green revolution continued in the eighties and nineties it further in a sustainable manner to meet the food requirement of the growing population. Tamil Nadu agriculture is the greatest overriding sector in the economy of the state nearly 70% of the state's population is involved in agricultural activities as this one of the major means of livelihood in Tamil Nadu. Tamil Nadu has occupied an area of 1.3 lakh sq .km with an overall area of nearly 63 lakhs hectare for plantation. The primary duty of the government of Tamil Nadu is to activate stability in the agricultural sector and also rise the sustainability in the agricultural production of the state. This is done to reach the demands put forth by the growing population in the food segment in addition to the raw materials department in the agro-based industries. This will take a toll on the unemployment in the rural areas in Tamil Nadu.

## **Method of Data Collection**

The present study is based on both primary and secondary data. For the used to collect required information from sample respondents. The secondary data are to be collected from journals, books, magazine and internet.

## **Objectives**

- To analyze the income and expenditure of the sample respondents.
- To examine the debt of the sample respondents.
- To find out the health problems of the sample respondents.

## **Sampling Design**

The sample size was selected from Karaiyiruppu Village. Satisfied random sampling method was adopted for the study. For the purpose of the study the respondent are equally selected from Karaiyiruppu Village, as non-proportional basis. The size of the sample is 50 respondents.

## Data Analysis

### 1.1 Income

<b>Amount of Income</b>	<b>No. of respondents</b>	<b>Percentage</b>
Below 10,000	8	16
11,000 – 15,000	12	24
16,000 – 20,000	18	36
21,000 – 25,000	12	24
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary data**

Above table 1.1 shows that 36 percent of the people get 16,000 – 20,000 and 16 percent of the people get below 10,000. The respondents having more experience are earn the Income more.

### 1.2 Level of Expenditure

<b>Expenditure</b>	<b>No. of respondents</b>	<b>Percentage</b>
Below 10,000	20	40
11,000-15,000	10	20
16,000-20,000	12	24
21,000-25,000	8	16
<b>Total</b>	<b>50</b>	<b>100</b>

Expenditure condition reveals the social status of the people and social status determines the economic status. The expenditure is shown in the following table1.2

**Source: Primary data**

Above table 1.2 Shows that 16 percent of the people spent 21,000-25,000 and 40 percent of the people spent below 10,000.

**Debt**

**Source: primary data**

Amount of Debt	No. of respondents	Percentage
6,000 – 10,000	14	28
11,000 – 15,000	21	42
16,000 – 20,000	15	30
<b>Total</b>	<b>50</b>	<b>100</b>

Above table 1.3 shows that 42 percent of the sample respondents have 11,000 – 15,000 debt and 28 percent of the sample respondents have 6,000 – 10,000 debt.

**Health Problems**

Diseases	No. of respondents	Percentage
Skin Problem	18	36
Breathing Problem	12	24
Allergy Problem	12	24
Insect bite	8	16
<b>Total</b>	<b>50</b>	<b>100</b>

**Source: Primary data**

Above table 1.4 reveals that 24 percent of the respondents are affected by breathing problem and Allergy Problem. 16 percent of the respondents are affected by insect bites. So, there are some risk in the agricultural field which affect the health conditions of the respondent

**Findings**

- Seventy Six percent of the people get additional income.

- Eighty percent of the respondents are not used loan.
- Hundred percent of people are used traditional pattern of canal irrigation.
- Twenty Four percent of the respondents are affected by breathing
- Problem and Allergy Problem.

### **Suggestions**

- They should keep up with the least farming techniques and technologies.
- They should attend workshop, seminar, and training programs to improve their skills knowledge.
- They should consider diversifying the crops they grow to reduce risk and improve overall yield.
- They should implement sustainable farming practices to protect the environment and ensure long-term productivity.

### **Conclusion**

It is essential to note that the distribution of agricultural workers has likely changed since my last knowledge update. Factors like urbanization, technological advancements, and shifts in the global economy can impact the agricultural workforce. For the most current and detailed statistics, you should refer to reports from organizations like the United Nations Food and Agriculture Organization or the World Bank. In September 2021, Tamil Nadu, a state in southern India, has a significant number of agricultural workers due to its reliance on agriculture as one of the primary economic activities. Here are some approximate figures related to agricultural workers in Tirunelveli. Agriculture is an important sector in Tirunelveli, and a substantial portion of the state in population is engaged in agricultural activities directly or indirectly. However, the percentage of the workforce engaged in agriculture has been decreasing over the years due to diversification into other sectors like manufacturing and services.

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## **Trade's Hidden Hurdles: Unraveling the Complexities of SPS and TBT Measures**

**Harishankar. K**

*Assistant Professor (Agricultural Economics), Department of Agricultural Economics,  
Vanavarayar Institute of Agriculture, Pollachi, Tamil Nadu – 642103.*

*Email: [harishankar1020@gmail.com](mailto:harishankar1020@gmail.com)*

### **Abstract**

Non-tariff barriers (NTBs), encompassing sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT), have assumed a prominent role in international trade discourse. While essential for safeguarding human, animal, and plant health, they also risk becoming veiled protectionist tools, impeding trade and economic progress. This comprehensive research article investigates the multifaceted influence of SPS and TBT measures on global trade, dissects the underlying complexities associated with their application, and proffers holistic strategies for dismantling these non-tariff impediments. The study underscores the significance of harmonization, transparency, and capacity enhancement to ensure the legitimate utilization of SPS and TBT measures while promoting international trade.

**Keywords:** Harmonization, Resolution Mechanism

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### **Introduction**

In the contemporary interconnected global economy, international trade serves as a pivotal driver of economic growth and prosperity across nations (Coe and Yeung, 2015). As globalization burgeons, trade negotiations and agreements have predominantly centered on the reduction of traditional trade barriers, notably tariffs (Bagwell and Staiger, 2013). However, non-tariff barriers (NTBs) have emerged as formidable challenges that have the potential to obstruct the movement of goods, services, and investments across international borders. Among these NTBs, two categories - sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT) - have assumed increasing prominence due to their capacity to disrupt the dynamics of global trade (Kang and Ramizo, 2017).

SPS measures primarily aim to protect the health and safety of humans, animals, and plants, encompassing regulations pertaining to food safety, animal health, plant health, and disease control (Khetarpal, 2016). On the other hand, TBT measures encompass a range of product standards and technical regulations that products must adhere to for market eligibility. While both SPS and TBT

measures are founded on essential public policy objectives, they may inadvertently be manipulated as protectionist instruments, thereby posing significant challenges to international trade (Ruckteschler, 2022).

This research article embarks on a comprehensive exploration of the intricate landscape of SPS and TBT measures. It scrutinizes their influence on the global trade milieu, unravels the underlying complexities and challenges tied to their implementation, and prescribes a compendium of strategic initiatives to mitigate these non-tariff barriers. Striking a balance that allows nations to uphold public welfare while fostering international trade for the collective benefit of the global community is of paramount importance.

## **The Impact of SPS and TBT Measures on Global Trade**

### **Economic Implications**

SPS and TBT measures wield substantial economic clout, impacting not only businesses but also consumers and governments. These measures introduce an element of unpredictability and intricacy into international trade, engendering a spectrum of economic ramifications:

**Increased Compliance Costs** Exporters are mandated to adhere to an array of standards and regulations to access foreign markets. Navigating these diverse and often stringent requirements incurs elevated compliance costs, which are particularly onerous for small and medium-sized enterprises (SMEs). These costs encompass expenditures associated with testing, certification, and compliance documentation (Seyoum, 2017).

**Export Delays** SPS and TBT measures can engender delays at border crossings as products undergo scrutiny and validation. These delays disrupt supply chains, augment inventory holding costs, and diminish the reliability of just-in-time production systems (Kogan, 2005).

**Eroded Competitiveness** The cumulative effect of compliance costs and delays can erode the competitiveness of businesses in international markets. Inefficiencies within trade procedures can pose challenges for companies aiming to compete on a global scale (Leonidou, 2004).

**Consumer Price Effects** Ultimately, the expenses borne by businesses to surmount SPS and TBT measures are frequently passed on to consumers in the form of higher prices for imported goods. This phenomenon can contribute to an augmented cost of living for consumers (Deodhar, 2001).

### **Disguised Protectionism**

One of the most pressing concerns associated with SPS and TBT measures is their susceptibility to manipulation as tools of concealed protectionism. Nations may impose ostensibly stringent standards and certification procedures not solely to protect public health and safety, but also to insulate domestic industries from foreign competition (Hufbauer, 2013). This manifestation of protectionism can unleash several detrimental effects:

**Market Access Constraints** Rigorous and potentially unwarranted standards can pose significant barriers to entry for foreign products, constraining their market access (Hoekman, and Mavroidis, 1996). This restriction can distort trade patterns and inflict harm upon exporters from other countries.

**Trade Distortions** Concealed protectionism can distort the dynamics of global trade, precipitating suboptimal resource allocation. Inefficient domestic industries may be shielded from international competition, thereby curbing incentives for innovation and the enhancement of productivity (Mariotti, 2022).

**Impediments to Economic Growth** By constricting competition and innovation, concealed protectionism can impede economic growth within both the protectionist nation and its trade partners.

### **Challenges Surrounding SPS and TBT Measures**

#### **Lack of Harmonization**

An inherent challenge in addressing SPS and TBT measures lies in the absence of harmonization among nations. Divergent regulations, standards, and certification procedures coalesce to engender substantial trade barriers and compliance quandaries for exporters (Cadot *et al.*, 2012). Although international organizations like the World Trade Organization (WTO) have established frameworks to tackle these issues, attaining harmonization proves to be a formidable endeavor due to:

**Diverse Regulatory Goals** Nations may harbor distinct public health and safety objectives, culminating in divergent standards and regulations.

**Technical Hurdles** The attainment of harmonization necessitates an intricate comprehension of the technical and scientific dimensions intertwined with health and safety, rendering it a daunting challenge.

**Political Considerations** The sphere of harmonization can be influenced by political considerations, rendering consensus on shared standards a complex task.

**Resource Deficiencies** Developing nations, in particular, may grapple with resource and technical expertise constraints, rendering alignment of their regulations with international standards a herculean undertaking (Head, 2022).

### **Transparency and Information Sharing**

Transparency and information sharing constitute pivotal components in tackling SPS and TBT issues. Several nations encounter a paucity of transparency in their regulatory processes, constructing an environment wherein exporters wrestle with anticipation and compliance. Notable challenges in this arena encompass:

**Opaque Decision-Making** In select instances, the decision-making processes underpinning the imposition of SPS and TBT measures lack transparency, rendering it intricate for affected parties to discern the rationale and necessity of these measures.

**Notification Gaps** Certain nations inadequately notify trading partners of proposed SPS and TBT measures in a timely manner, thereby engendering last-minute compliance predicaments for exporters.

**Data Accessibility** The availability and accessibility of data and scientific information underpinning these measures can exhibit substantial variations, further complicating transparency endeavors (Stone and Casalini, 2020 & Prinja *et al.*, 2018).

### **Capacity Building**

Developing nations frequently confront significant capacity constraints concerning the implementation and compliance with SPS and TBT measures. These constraints manifest on multifarious fronts:

**Technical Expertise** A myriad of developing nations lacks the technical prowess requisite for the effective evaluation and implementation of intricate SPS and TBT measures.

**Infrastructural Shortcomings** Inadequate infrastructure, paucity of laboratories, and testing facilities can impede compliance with standards and regulations.

**Human Capital Deficits** An inadequacy of skilled personnel in domains such as food safety, animal health, and plant health can impede capacity building efforts.

**Resource Impediments** Developing nations may grapple with the allocation of financial and human resources requisite for enhancing their capacity to comply with SPS and TBT measures (Fukuda-Parr and Lopes, 2013).

### **Strategies to Address SPS and TBT Issues**

#### **International Cooperation and Standardization**

The redressal of SPS and TBT issues demands a foundation of international cooperation and standardization. Vital strategies in this context encompass:

**Augmented Multilateral Engagement** Nations should reaffirm their commitment to multilateral accords such as the WTO's Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) and the Agreement on Technical Barriers to Trade (TBT Agreement), fostering cooperation and harmonization (Kohl *et al.*, 2016).

**Adoption of International Standards** Encouraging nations to align their domestic regulations with established international standards, including those formulated by the Codex Alimentarius Commission and pertinent international standards bodies, can foster augmented harmonization (Pekdemir, 2018).

**Peer Review Mechanisms** The establishment of peer review mechanisms permitting nations to assess the compliance of their counterparts with international standards can promote transparency and the adoption of best practices (Paulo and Reisen, 2010).

#### **Transparency Mechanisms**

Enhancing transparency mechanisms emerges as a sine qua non for ameliorating the predictability of SPS and TBT measures. Pertinent strategies comprise:

**Online Databases** Nations should maintain up-to-date online databases housing information regarding SPS and TBT measures, encompassing draft regulations, for facile access by stakeholders, including businesses and other governments (Pauwelyn *et al.*, 2016).

**Notification Systems** The development of robust notification systems mandating timely and comprehensive notifications to trading partners regarding proposed SPS and TBT measures can amplify transparency (Wolfe, 2020).

**Consultation Procedures** The institution of consultation procedures enabling stakeholders to contribute input on proposed measures can ensure the reasonableness of regulations, anchoring them in scientific foundations while accommodating the interests of all stakeholders.

### **Capacity Building and Technical Assistance**

Capacity building and technical assistance initiatives warrant prioritization to empower developing nations to meet international standards. Vital strategies encompass:

**Training Programs** Conception and implementation of training programs intensifying the technical expertise of individuals involved in the implementation of SPS and TBT measures prove invaluable.

**Infrastructure Augmentation** Investment in laboratory facilities, the bolstering of testing infrastructure, and the augmentation of inspection capabilities can aid developing nations in meeting the requirements of international standards.

**Knowledge Transfer** The facilitation of knowledge transfer through partnerships and collaborations between developed and developing nations can accelerate capacity building endeavors.

**Resource Mobilization** Support rendered to developing nations in resource mobilization for SPS and TBT compliance constitutes an essential facet of their seamless integration into the global trading landscape (Braganza *et al.*, 2009).

### **Dispute Resolution Mechanisms**

Efficient dispute resolution mechanisms furnish a quintessential apparatus for addressing instances of non-compliance or the misuse of SPS and TBT measures. Salient strategies encompass:

**Strengthened WTO Dispute Settlement** The reinforcement and streamlining of dispute settlement procedures within the WTO can ensure the fair and expeditious resolution of disputes related to SPS and TBT measures (Mavroidis, 2022).

**Alternative Dispute Resolution** Exploration of alternative dispute resolution mechanisms, including mediation and arbitration, can proffer more flexible and expeditious resolutions to disputes intertwined with SPS and TBT (Mercurio, 2004).

## **Conclusion**

In summation, non-tariff barriers, prominently featuring SPS and TBT measures, have materialized as pivotal challenges in international trade. While safeguarding human, animal, and plant health stands as a legitimate and imperative objective, it is equally vital to strike an equilibrium that permits the seamless flow of goods and services across international borders. Addressing SPS and TBT issues necessitates concerted endeavors at both the national and international echelons. To efficaciously dismantle these non-tariff barriers, the global community must prioritize harmonization, transparency, and capacity enhancement. By endorsing these principles and fostering international collaboration, nations can ensure the legitimate utilization of SPS and TBT measures while facilitating international trade, thereby serving the mutual benefit of all stakeholders. However, it is incumbent upon us to acknowledge that the path forward shall not be bereft of challenges. Varying national interests, the intricacies of technology, and resource constraints shall continue to present formidable impediments. Nonetheless, the exigency of addressing SPS and TBT issues is unmistakable, especially in the backdrop of an increasingly intertwined global economy. Through collaborative endeavors, nations can chart a course towards a more open and equitable global trading milieu, thereby catalyzing economic growth and enhancing the well-being of both developed and developing nations.

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## **Managing Work Life Integration: A Detailable Examination of its Impact on Bank Employees' Job Satisfaction**

**Annie Riya Michael. C<sup>1</sup>, M. Gnana Muhila<sup>2</sup>**

*<sup>1</sup>(Reg.No:22113041012001) Research Scholar, Department of Commerce,  
Holy Cross College (Autonomous) Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar university, Abishekapatti, Tirunelveli – 627012.*

*<sup>2</sup>Research Supervisor in Commerce, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar university, Abishekapatti, Tirunelveli-627012.*

*Email: [annie\\_riya\\_michael@holycrossnsl.edu.in](mailto:annie_riya_michael@holycrossnsl.edu.in), [gnanamuhilangl@holycrossnsl.edu.in](mailto:gnanamuhilangl@holycrossnsl.edu.in)*

### **Abstract**

**Propose:** This study aims to examine how managing work-life integration affects job satisfaction among bank employees. By focusing on this relationship, the research seeks to identify key factors that contribute to balanced work-life integration and how these factors influence job satisfaction. The goal is to provide insights and recommendations for improving job satisfaction in the banking sector.

**Design/Methodology/Approach:** This study uses a Proportionate Stratified Random Sampling technique and an empirical survey method. A structured questionnaire was administered to 150 bank employees in Kanniyakumari, with data analyzed using SPSS. The findings show a significant positive correlation between work-life integration and job satisfaction, leading to recommendations for improving workplace policies and promoting a supportive culture.

**Research Limitations/Implications:** This study's focus on 150 bank employees in Kanniyakumari may limit its generalizability. A larger, more diverse sample could provide more robust results. Despite these limitations, the study reveals a strong positive link between work-life integration and job satisfaction, offering insights for improving workplace policies and culture.

**Findings:** The study finds a significant positive correlation between work-life integration and job satisfaction among bank employees. It underscores the importance of balancing professional and personal life, revealing that effective work-life integration enhances job satisfaction.

**Keywords:** Work-life integration, Job satisfaction, Work-life balance and bank employees

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### **Introduction**

Work-life integration is changing the way the banking industry balances financial duties and personal fulfilment. This approach recognizes the need of banking professionals efficiently managing

their work duties as well as their personal interests and well-being in an industry noted for its fast-paced atmosphere and strict timetables. Banks increasingly understand the importance of building a workplace culture that promotes not only efficiency but also total employee well-being. Implementing flexible scheduling, remote work choices, and support for maintaining a healthy work-life balance are all part of this. Work-life integration in banks requires a combination of technical improvements, developing workplace standards, and a culture transformation that prioritizes people's holistic needs. The ultimate goal is to establish an atmosphere in which banking professionals may succeed while also prioritizing personal obligations, family time, and individual well-being, resulting in a more engaged, contented, and productive workforce in the banking sector.

### **Work Life Integration in India**

Work-life integration, a contemporary philosophy, seeks to harmonize professional responsibilities and personal aspirations by transcending traditional work-life boundaries. This approach recognizes that fulfillment extends beyond professional success, emphasizing the importance of personal interests, family time, and overall well-being. It aims to create an environment where individuals seamlessly blend their work and personal lives, fostering a more rewarding and holistic lifestyle. Specifically within the banking sector, this integration is pivotal, acknowledging the need for employees to balance career demands with personal pursuits. Enabling banking professionals to synchronize work commitments with personal well-being fosters an environment that encourages flexibility and empowers employees to excel in their roles while maintaining a healthy life-work balance. This transformative approach is essential for cultivating a content, motivated, and productive workforce in the banking industry.

### **Statement of the Problem**

Because of the demanding nature of the banking profession, bank personnel frequently have difficulties in efficiently integrating their work responsibilities with personal life hobbies. This disparity between work commitments and personal well-being may result in increased stress, burnout, and a reduced quality of life. While work-life integration measures such as flexible scheduling and remote work possibilities have gained popularity, their effectiveness in increasing

job satisfaction among bank employees remains unknown. The present gap in knowing how various characteristics of work-life integration influence job satisfaction in the banking sector needs a comprehensive investigation. Furthermore, the impact of organizational policies, cultural norms, and support systems on employees' capacity to manage work-life integration and its subsequent effect on job satisfaction requires extensive research. The purpose of this study is to investigate the complex relationship between work-life integration practices and job satisfaction among bank workers, with the goal of identifying critical aspects that influence their overall satisfaction within the changing banking environment.

Many studies are now being undertaken in the field of Work Life Integration. This study intends to investigate the relationship between work-life integration and job satisfaction. It will explore how such factors influence work-life integration in bank employees' decisions. As a result, this research focuses on answering the following research question.

RQ: How does work-life integration influence job satisfaction?

By answering this question, this study will contribute more to existing Work Life Integration and job satisfaction.

### **Theoretical Framework**

The border theory is a new theory to Work life balance issues. Clark (2000) argues that even though the work and family system differ from each other, they are interconnected and individuals often manage to integrate them to certain degree. People shape their environments, and in turn, they are shaped by them; “it is this very contradiction of determining and being determined by our work and home environments that makes work/family balance one of the most challenging concepts in the study of work and the study of families” (Clark, 2000)

### **Review of Literature**

Job satisfaction is one of the most commonly studied factors in the domains of organizational behavior and applied psychology. (Lawler and Porter, 1967; Locke and Latham, 1990; Spector, 1997). QWL is related to workers' feelings about their occupations as well as their well-being and attitude toward their jobs (Beaudoin and Edgar, 2003). QWL leads to employee motivation,

dependability, and flexibility in the workplace, and these elements are recognized as critical components for organizational competitiveness as well. Furthermore, QWL helps to reduce absenteeism, staff turnover rates, and overall employee work satisfaction (Adhikar and Gautam 2010). Employees who are happy at their jobs According to the findings of a study that investigated the relationship of job satisfaction with the QWL components of bank employees in India, an uncondusive work environment had a negative relationship with job satisfaction. WLB and job satisfaction are linked (Jackson and Fransman, 2018).Based on previous research, we hypothesize.

*H1: Work-life integration is positively related to job satisfaction*

### **Methodology**

This study included both primary and secondary data. The study focused on Bank employee of Kanniyakumari. The questionnaire method was used to acquire primary data. Secondary data were acquired from websites and magazines.

<b>Study Area</b>	<b>Number of banks</b>	<b>Distribution of Questionnaire</b>	<b>Completed Response</b>
Kanyakumari	Public: 4 Private: 8	150 (per bank 13 questionnaire)	120 (per bank 10 questionnaire)

Bank employees' details were gathered from Kanyakumari banks. Total number of banks in Kanyakumari is 12. Under Proportionate Stratified Random Sampling technique, 150 questionnaires were distributed as 10 questionnaires per bank. From 150 questionnaires, 120 responses were solicited and found as valid (10 questionnaires found to be valid). Hence, the sample size is 15.

### **Data Analysis**

SPSS was used to analyze the data. For analysis, data were grouped and tallied. Gender, age, education qualification, industry, annual salary, and year of experience were all measured using percentage analysis. The indicators' validity was checked using reliability analysis. Regression analysis was used to determine the relationship between dependent and independent variables. Correlation analysis is also used to determine the link between variables.

## Demographic Profile of the Respondents

Demographic profile of the respondents was captured in table 1.

<b>Category</b>	<b>Profile</b>	<b>Total number</b>	<b>Percentage</b>
Gender	Male	89	57
	Female	67	43
	<b>Total</b>	<b>150</b>	<b>100</b>
Age	25-30	22	15
	31-35	35	23.3
	36-40	38	25
	41-45	37	24.7
	46 and Above	18	12
	<b>Total</b>	<b>150</b>	<b>100</b>
Education Qualification	School Education	17	10
	ITI or Diploma	28	19
	Undergraduate	49	33
	Postgraduate	37	25

	Others	19	13
	<b>Total</b>	<b>150</b>	<b>100</b>
Industry	Branch Manager	12	8
	Assistant Manager	49	32.7
	Cashier	54	36
	Others	35	23.3
	<b>Total</b>	<b>150</b>	<b>100</b>

### Measures

The questionnaire used in this study consists of 9 items adapted from previous studies. Adapting questionnaire from previous studies was to ensure its validity and reliability. All constructs were measured on a Likert-type five-point scale (anchored as ‘1’ = strongly disagree; and ‘5’= strongly agree).

The reliability coefficients of all the constructs are over the acceptable level of 0.6 and less than the threshold level of 0.9 (Hair et al., 2019). This provides evidence for the reliability and validity.

### Testing Hypothesis H1

Regression model summary of H1 is captured in Table 2.

**Table 2**

R	R square	Adjusted R Square	Std. Error of the Estimate	F	Sig.	H1 Result
.896	.809	.792	.32530	82.171	.000	Accepted
			<b>Coefficients</b>			
<b>Unstandardized Coefficients</b>		<b>Standardized coefficients</b>				
<b>B</b>	<b>Std. Error</b>	<b>Beta</b>	<b>T</b>		<b>Sig.</b>	

<b>.826</b>	<b>.115</b>		<b>7.164</b>		<b>.000</b>	
<b>-.520</b>	<b>.115</b>	<b>-.675</b>	<b>-4.538</b>		<b>.000</b>	

**Source:** Primary Data

The correlation coefficient R is 0.896. This suggests that the association between Work-Life Balance Variables and Job Satisfaction is 89.6% positive and strong. Increases in the Work-Life Balance variable will be accompanied by increases in Job Satisfaction. The R Square (coefficient of determination) in the table summary model is 0.809. This suggests that the Work-Life Balance variable determines 80.9% of Job Satisfaction, whereas the remaining (100% - 80.9% = 19.1%) is determined by other variables.

**Table 2. ANOVA**

Model		Sum of Square	Df	Mean Square	F	Sig.
1	Regression	60744	6	10,124	95.566	0.000
	Residual	15,149	143	.106		
	Total	75,893	149			

The F test is performed to see if the indicators on the Work-life balance variable have a significant effect on the dependent variable at the same time. The level of trust chosen is 0.05. If the F value of the calculation results is greater than the F value in the table, the alternative hypothesis, which claims that all independent factors simultaneously have a significant effect on the dependent variable, is true. We can observe from the table above that the sig value is  $0.000 < 0.05$ , implying that the indicators of the work-life balance variable have a simultaneous and substantial influence.

<b>Unstandardized Coefficients</b>		<b>Standardized coefficients</b>		
B	Std. Error	Beta	T	Sig



.826	.115		7.164	<b>.000</b>
.544	.107	1.369	11.169	<b>.000</b>

As shown in Table 2, the regression model (R square = 0.809; beta = -0.675) is significant at 0.000. Hence, findings of this study point out that there is a positive association between Work Life Integration and Job satisfaction. This results support H1.

### **Findings**

- 57 per cent (89) of the respondents were male and 43 per cent (67) of the respondents were female.
- 25 per cent (38) of the respondents were belong to 36-40 years age group. 12 per cent (18) of the respondents were belong to 46 and above age group.
- 33 per cent (49) of the respondents completed their undergraduate course. 10 per cent (17) of the respondents completed School education.
- 36 per cent (54) of the respondents are Cashiers. 8 per cent (12) of respondents are Branch Manager.
- 33 per cent (49) of the respondents come under the monthly income of 10,000 -20,000. 29 per cent (19) of respondents obtained annual income of Above Rs. 40,000.
- 38 per cent (56) of the respondents having 11- 20 years of experience. 23 per cent (15) of respondents have more than 30 years' experience.
- Since, the regression model (R square = 0.809) is significant at 0.000, thus there is a positive association between work life balance and job satisfaction.

### **Suggestion**

- Examine the bank's current work-life integration rules and consider implementing flexible work hours, remote work choices, or reduced workweeks to suit workers' personal demands while maintaining productivity.

- Encourage open communication channels to better understand employees' work-life balance demands. Employee assistance programmes, counselling services, or courses focused at resolving work-life issues can all help.
- Offer training programs to managers and supervisors on promoting work-life integration among their teams. Encourage a supportive culture that acknowledges and values employees' personal lives.
- Encourage employees to keep a good balance of work and personal life. Encourage employees to avoid after-hours emails or phone conversations by emphasising the significance of unplugging to recharge.

### **Conclusion**

The comprehensive study on the impact of work-life integration on job satisfaction among bank workers reveals a striking link between a balanced lifestyle and professional contentment. The findings highlight a substantial positive relationship between effective work-life integration and increased job satisfaction, emphasizing the crucial importance of banking institutions championing initiatives that allow this synergy. Embracing adaptable work arrangements, embracing initiatives that promote employee well-being, and cultivating a culture that values personal time all emerge as critical in strengthening job satisfaction in the banking sector. This study serves as evidence, advising banks to prioritise and foster an atmosphere in which the seamless integration of work and personal life thrives, ultimately growing a workforce that is not just satisfied but also productive and engaged.

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## **Role of India Post Payments Bank in Postal Services**

**A. I. Jaheera Thasleema<sup>1</sup>, C. K. Sunitha<sup>2</sup>**

<sup>1</sup>*Research scholar in Commerce, Reg. No.21113041012003, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

<sup>2</sup>*Assistant Professor and Research Supervisor in Commerce, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Government of India owns all the equity in the India Post Payments Bank (IPPB), which was established under the Department of Post in the Ministry of Communication. On January 30, 2017, Ranchi (Jharkhand) and Raipur (Chattisgarh) hosted the introduction of IPPB, which was intended to spread throughout India by the FY 2018–2019. Through a network of 650 IPPB branches and controlling offices that operate on a hub and spoke model, IPPB has increased its influence over post offices throughout India. The purpose of this study is to examine the role of Indian Post Payment Bank in postal services. Additionally, an effort was made to assess India Post Payments Bank's potential in the future.

**Keywords:** IPPB, India Post, Door step banking, Services

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### **Introduction**

In India, the postal service is run by the Government and is known as India Post. It is the largest postal system in the world and is commonly referred to as "the post office" within India. To explore the best method for leveraging the current postal services to offer standard banking services to post office clients, the Government of India established a working group led by T.S.R. Subramanian. A focus of the working group's report, which was turned in on December 4th, was the requirement for adding new services including banking, insurance, and E-commerce. Based on the working group's recommendation, India Post started issuing ATM cum-debit cards to owners of savings bank accounts. The Indian Government then considered passing legislation to create a postal payment bank. The Reserve Bank of India (RBI) published Guidelines for licensing of Payment Banks on November 27, 2014, based on this explicit policy guidance. On January 30, 2015, the Department of

Posts submitted an application for a licence as a payment bank, and was given an in-principle permission to establish India Post Payments bank On September 7, 2015.

Through dependable postmen, IPPB brought banking services to every door step of Indian's. Together, IPPB and the Department of Posts developed the necessary digital infrastructure and delivered postal and banking financial services to all Indian homes at their doorsteps in a safe setting. As a result, the IPPB expanded the range of financial services offered by post offices to include official banking services. With the aid of the largest post office network in the world and a sizeable number of postmen serving as doorstep banking service providers, the Department of Posts used this platform to offer financial banking services at home to every person across the nation.

### **Statement of the Problem**

A new type of bank called India Post Payments Bank is being marketed with the specific aim of bringing banking to the vast majority of the unbanked and under banked sectors of the population. In order to offer the targeted population, the designated financial services at a reasonable price, the Payments Bank promoted by India Post is anticipated to utilise both the physical network of post offices and digital platforms like mobile, internet banking, debit cards, point of sale devices, etc. Hence, an exploratory study has been identified and the researcher has formulated the research problem as “Role of Indian Post Payment Bank in Postal Services”.

### **Objectives of the Study**

Following are the objectives of selecting the topic

1. To study the role of India post Payments Bank in postal services.
2. To know the prospective challenges and problems in operation of India Post Payments Bank.
3. To suggest the future prospects of India Post Payments Bank.

### **Research Methodology**

The research design of the study is basically descriptive. The study is based on secondary data. Secondary data was collected from Annual Administrative Report, Annual Report and websites of the India post. Supporting literature from relevant sources, journals, research reports, websites etc. also form the sources of secondary data.

## **Review of Literature**

The researcher attempted to understand the problems and prospectus in India Post Payment Bank. She suggested the IPPB to offer credit facilities by tying up in partnership with commercial banks (Dr. K. Meena Kumari 2017). The researcher aims to study the role of Indian post offices in financial inclusion. She concluded that The Department of Post's IPPB system could become the nation's most user-friendly banking network (Afsana Sultana 2020). In terms of current technological and economic trends, India Post Payment Bank is more practical and adaptive. IPPB's success may be largely dependent on innovation and creative problem-solving (Dr. N. Prakash and Suganya Sampat 2021).

### **Features of India Post Payments Bank (IPPB)**

- The IPPB provides regular, digital, and basic saving accounts.
- Due to a partnership with Punjab National Bank, there is no cost for withdrawals made from IPPB ATMs or PNB ATMs.
- In order to encourage savings, the bank will provide 4% interest on all accounts.
- It also provides lower-cost Forex services.
- Unlike most banks, there would be no requirement to keep a minimum quarterly average balance
- No fees are assessed for insufficient account balances.
- Additionally, the IPPB provides QR card service that enable the users to access their bank accounts and conduct transactions without having to recall their account numbers. All transactions involving the QR card can be verified using biometric information.
- A free debit card is provided by India Post Payments Bank with a second-year maintenance cost of Rs. 100.
- The IPPB will serve people without traditional bank branches by utilising a network of post offices and a labour of over 3,000,000 postmen.

- Through its partnerships with other banks and businesses, IPPB offers third-party goods like loans and insurance.
- The IPPB seeks to connect with its clients through their mobile phones in the absence of conventional bank branches. Because of this, it has a potential to thrive among those who are tech-savvy and at ease with technology.
- Any person who is at least 18 years old will be encouraged by the IPPB to register a digital savings account using their PAN and Aadhar cards. Such accounts are subject to a 12-month deadline for completing the KYC procedures.

### **India Post Payments Bank Services**

Indian Post Payments Bank offers services to all citizens, but its main priorities are low-income households, social sector beneficiaries, the unorganised sector, migrant workers, MSMEs - Micro Small and Medium Enterprises - and Panchayats in rural areas. It also provide services to the underbanked and unbanked segments in both urban and rural areas. Through doorstep banking services, powered by an effective Postman or GDS network, IPPB provides banking services in rural, semi-urban, and urban Customers can use the doorstep banking services at their communication address, whether it is a home or a store or enterprise. **The following are the services provided by IPPB.**

#### **Customer On-boarding**

The Postman will open a requested type of account by visiting the registered address. People can open any of the following accounts using this service:

- Basic savings account
- Regular savings account
- Salary account
- Current account (This type of account can be opened in addition to any one of the above three accounts)

#### **Merchant On-boarding**

- People can open a current account and avail merchant services through a Postman at doorstep.

- Once on-board, one can enjoy digital payment acceptance solutions and manage day-to-day business activities efficiently.

### **Account Services**

- Cash deposit and withdrawals
- Instant money transfers
- Easy money transfer to your own as well as to other IPPB accounts
- Bill payments
- Account modification
- Domestic Money Transfer services for IPPB and Non-IPPB customers

### **Third Party Products**

- Third-party insurance – Group term insurance
- Payments of DoP products like PPF, SSA, Rd and LARD
- Issuance of Digital Life Certificate

### **Other Account-Related Services**

- Update PAN and nominee details.
- Beneficiary management.
- Request for account statement and related reports.
- Add or delete standing instructions.
- QR card re-issuance.
- Aadhaar linking.
- Share Complaints or Feedback with the Postman.
- Upgrade Account and Update personal details through post office doorstep banking services.
- Avail the facility of sweep-in and sweep-out at the doorstep.

Through a combination of physical and digital venues, IPPB provide services. IPPB services are delivered through the following channels:

- Banking by doorstep, mobile, and the internet.



- Prepaid instruments, including Point of Sales (POS) and mobile wallets.
- ATMs and micro-ATMs.
- Counter operation.

### **India Post Payment Bank Challenges**

- It is challenging for IPPB to make a profit since, according to RBI regulations, all payments banks must invest 75% of their total demand deposits in treasury bills and government-linked assets.
- The lack of technology infrastructure in the nation's most rural and isolated regions is another issue. The Government is optimistic, though, that it will be able to get through them and that the IPPB will be a successful venture.
- The introduction of the IPPB has caused a fundamental change in the Indian banking system, allowing rural India to take advantage of countless opportunities in the banking industry. The massive Government initiative does, however, face several challenges that must be overcome and which do not seem to be just infantile problems.
- It is anticipated that it will offer services by utilising mobile technology and other types of digital technology. Mobile banking has not taken off, despite the widespread growth of mobile services and mobile phone use in rural regions, for a number of reasons, including customer preference for cash, security concerns, illiteracy, and a lack of awareness about technological products and services. It could be difficult to educate and persuade consumers to use their mobile devices to access financial services.
- Infrastructure is a significant issue for the India Post Payments Bank (IPPB). The majority being in rural, isolated places. In communities with poor access to electricity and the internet, the idea of turning the postman into a mobile bank appears challenging. This is a problem that would require immediate response given that 90% of post offices are located in rural areas.
- Even though an IT modernization initiative has been running since 2012, not all post offices are fully automated. Similar to Core Banking Solution connectivity is limited to a small number

of post offices. To automate the front and back ends of post office operations and so lower the cost of service, it is essential to ensure that IT modernization projects are properly completed. Additionally, Project Arrow, which aims to enhance the working environment in post offices, is now fully implemented.

- Although there are a lot of people who are unbanked, financial institutions and companies like Scheduled Commercial Banks and mobile service providers are becoming more competitive. In rural areas with a death of conventional bank offices, the number of mobile customers is rising, especially. Even though it has not taken off, mobile banking would significantly increase if payment and remittance options were made available through smart phones at low cost.

#### **Future Prospects of India Post Payments Bank**

1. A significant part of everyday people's financial transactions is anticipated to be played by India Post Payments Bank. The rural population will have the chance to save their hard-earned money if IPPB is expanded to the country's farthest reaches.
2. The residents of the village and other interior areas will undoubtedly gain if IPPB opens operating centres in such locations since the major banks do not create their branches in distant sections of the country but post offices are found there everywhere.
3. Many educated young people's employability can be mobilised by IPPB.
4. Customers frequently interact with postal workers, and they have confidence in them. They need to receive training on how to manage banking activities including various delivery channels, like online banking, mobile banking, and so on.
5. Although Payments Bank is unable to grant credit directly, it can provide credit facilities through partnerships or affiliations with commercial banks.
6. IPPB should successfully raise awareness among people about their services.

#### **Conclusion**

The Department of Post newly founded Payments Bank could become the nation's most user-friendly banking system. The postal delivery system combined with digital platforms including

mobile, internet banking, prepaid cards, debit cards, ATMs, and point-of-sale devices will make Payments Bank the face of the transformation of post offices. India Post Payments Bank, one of the country's largest financial inclusion networks that serve both urban and rural areas, is preparing to lead the next banking revolution.

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## **Evaluation of User Experience of Google Pay (Upi Payment App)**

**T. Sahaya Abeesa<sup>1</sup>, J. Divya Merry Malar<sup>2</sup>**

<sup>1</sup>*Reg.No:241220806033, Research Scholar of Commerce, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

<sup>2</sup>*Department of Commerce, Holy Cross College (Autonomous), Nagercoil – 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [abeesa.t95@gmail.com](mailto:abeesa.t95@gmail.com)*

### **Abstract**

Google Pay, a prominent Unified Payments Interface (UPI) application in India. This research paper presents an evaluation of the user experience (UX) associated with Google Pay. The study employs a quantitative survey and interview methods to assess various dimensions of User experience, including usability, accessibility, performance, security, and user satisfaction. Key metrics such as ease of navigation, transaction success rate, response time, and perceived security are analysed to provide a holistic understanding of user interactions and satisfaction levels. Findings indicate that while Google Pay generally receives high ratings for usability and convenience, challenges related to transaction failures and customer support emerge as significant areas for improvement. This research contributes to the growing body of literature on digital payment systems, offering insights and recommendations for enhancing user-centric design in UPI applications.

**Keywords:** User experience, UPI application, security

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### **Introduction**

Google Pay is a digital wallet platform and online payment system developed by Google to power-in-app and tap-to-pay purchases on mobile devices, enabling users to make payments with Android phones, tablets or watches. Google pay adopts the features of both android pay and google wallet through online payment services. Google pay uses Near Field Communication (NFC) to transmit card information facilitating funds transfer to the retailer. It replaces the credit or debit card chip and pin or magnetic stripe transaction. It is similar to contactless payments already used in many countries, with the addition of two factor authentication. The service lets and android devices wirelessly communicate with point of sale systems using a near field communication (NFC) antenna,

host-based card emulation (HCE), and android's security. Google Pay takes advantage of physical authentications such as fingerprint ID.

### **Statement of the problem**

From the traditional times banking plays an important role within the development of nation also because the individual. For the stable financial condition, banking helps to a better extent. Nowadays the life sort of the peoples getting too busy and thus significance of Google Pay is increasing day by day. Despite its widespread use and significant impact on the digital economy, there remains a critical need to evaluate the user experience of Google Pay.

### **Objectives of the study**

- To identify the reasons for using Google pay (UPI payment app).
- To study the facilities provided by Google pay (UPI payment app).
- To study the consumer satisfaction of Google pay (UPI payment app).

### **Methodology**

The Primary sources were collected from 50 sample respondents through well-structured questionnaire. The main sources of Secondary data are websites. The study employed a simple random sampling method to ensure a representative sample of Google Pay users at Aralvaimozhi Town, Kanyakumari District. 50 users participated in this study.

### **Tools for Analysis**

The presented data were treated with appropriate statistical techniques like percentage method, Garrett's ranking method and Liker's five-point scaling.

### **Data Analysis and Interpretation**

#### **Reasons for using Google Pay**

**TABLE 1**  
**Reasons for using Google Pay**

S.No	Reasons	No of respondents	Percentage
1.	Bill Payment	16	32
2.	Mobile /DTH Recharge	19	38
3.	Fund Transfer	12	24

4.	Ticket Booking	3	06
	Total	50	100

Source: Primary Data

The above table shows that 16 (32%) respondents use the google pay for bill payment and 19 (38%) respondents use the google pay for mobile recharge. 12(24%) respondents use the google pay for fund transfer and 3(6%) respondents use the google pay for ticket booking.

### **Facilities Provided by Google Pay**

TABLE 2  
Facilities Provided by Google Pay

S.No	Facilities provided	Garretts score	Rank	Percentage
1.	Technical infrastructure	3064	II	15.78
2.	Wide mobile network coverage	2310	VII	11.89
3.	ATM outlets	2799	IV	14.41
4.	High speed internet access	2540	V	13.08
5.	Bio-metrics fingerprint scanner	2525	VI	13.6
6.	Transaction history	3049	III	15.72
7.	Checking account balance	3133	I	16.13

Source: Computed data

Table shows that first majority of the respondents prefer facility for the checking account balance and scored I<sup>st</sup> rank, second majority of the choosing respondents prefer the Technical infrastructure for digital payment and scored II<sup>rd</sup> rank, third choosing of the facility transaction history and scored III<sup>rd</sup> rank, fourth choosing of the facility ATM outlets and scored IV<sup>th</sup> rank, fifth choosing of the respondents the facility in high speed internet access and scored V<sup>th</sup> rank, sixth choosing for respondents of the facility for bio-metrics finger print scanner and scored VI<sup>th</sup> rank, seventh choosing the facility of the wide mobile network coverage and scored VII<sup>th</sup> rank.

**Level of User’s Satisfaction**

**TABLE 3**  
**Level of User’s Satisfaction**

S.No	Factors	Highly Satisfied	Satisfied	Neutral	Dis satisfied	Highly dis satisfied	Total	Mean Score	Rank
1.	Convenient	120(24)	52(13)	21(7)	8(4)	2(2)	203	40.6	I
2.	User Friendly	15(3)	24(6)	36(12)	20(10)	19(19)	114	22.8	IV
3.	Speed	25(5)	32(8)	51(17)	26(13)	7(7)	141	28.2	III
4.	Security	60(120)	72(18)	33(11)	8(4)	5(5)	178	25.6	II
5.	Language	30(6)	20(5)	9(3)	38(19)	17(17)	114	22.8	IV

Source: Computed Data

The Table shows that among the factors “CONVENIENT” ranked first with a mean score of 40.6, it is followed by “SECURITY “which ranked second with a mean score of 35.6 and ‘SPEED” ranked third with a mean score of 28.2, “USER FRIENDLY” with a mean score of 22.8 and “COMMUNICATION LANGUAGE” with a mean score of 22.8 got the fourth ranks respectively.

**Findings**

- Majority of the Google pay user’s using the Google pay for the reasons prefer mobile / DTH recharge 38 percentage of respondents.
- Majority of the respondents prefer facility for the checking account balance and scored I<sup>st</sup> rank.
- Among the factors “CONVENIENT” majority of the respondents are highly satisfied ranked first with a mean score of 40.6.

**Suggestions**

- Google pay users should have to use the appliance securely.
- They should select the proper app for his other usage.

- The app must be redesign supported the feedback getting from the users.

### **Conclusion**

Google Pay is taking giant steps at revolutionizing the payments market in India. Consumers/users will miss a hoard of features and easy money transfer transactions if they don't use the app. In India, which has a poor merchant payment acceptance infrastructure UPI, enables even the smallest merchant to start accepting digital payments without the need for any POS machine. UPI has done away with the need to know the complicated payment details of the transacting parties, which makes payments easy and seamless for transacting parties. Compared to all other payment systems it would not be misplaced to say that UPI is the most advanced payment system in the world. With its standard set of APIs, UPI has allowed different banks to communicate with each other and has enabled interpretability between disparate bank payment systems. cards etc. take days to complete the transaction and settlement process, UPI allows payment to be completed in seconds. UPI can be a great enabler for financial inclusion in India and allow a huge set of population to be a part of digital economy.

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## **Influence of Perceived Relational Support on Entrepreneurial Intention**

**Anusha Mini.S<sup>1</sup>, S. Sahayaselvi<sup>2</sup>**

<sup>1</sup>*Research Scholar, Reg. No: 22213041012001, Department of Commerce,  
Holy Cross College (Autonomous), Nagercoil – 629004.*

<sup>2</sup>*Research Supervisor Department of Commerce, Holy Cross College (Autonomous), Nagercoil – 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.  
Email: [sahayaselvi@holycrossngl.edu.in](mailto:sahayaselvi@holycrossngl.edu.in), [anushamini03@gmail.com](mailto:anushamini03@gmail.com).*

### **Abstract**

This study explores the relationship between perceived relational support and entrepreneurial intention. Perceived relational support refers to the extent to which individuals perceive they receive encouragement, advice, and assistance from their social networks, including family, friends, mentors, and peers. Entrepreneurial intention reflects individuals' readiness and inclination to engage in entrepreneurial activities. To collect data, a Simple Random Sampling technique was utilized, and a structured questionnaire was administered to 137 registered entrepreneurs who enrolled themselves in Entrepreneurship Association in Kanniyakumari district. Statistical analyses were conducted using SPSS. The findings of this study have practical implications for policymakers, educators, and researchers.

**Keywords:** Perceived relational support, Entrepreneurial intention, Social networks

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### **Introduction**

Entrepreneurship plays a pivotal role in the economic and social development of countries, particularly in developing nations. Entrepreneurship is the process of planning, starting, and maintaining a new company. It promotes economic growth, innovation, and job creation. Moreover, entrepreneurship can enhance economic resilience by diversifying the economic base and reducing dependence on a few dominant industries or sectors. The connection between perceived relational support and entrepreneurial intention is a significant focus in contemporary entrepreneurship research. Entrepreneurial intention, defined as the personal inclination and commitment to initiate a new business venture, is a precursor to entrepreneurial activity and innovation. Perceived relational support refers to the extent to which individuals believe they receive encouragement, guidance, and

resources from their social networks, including family, friends, and mentors. By exploring how relational support influences entrepreneurial intention, this study aims to contribute to the broader discourse on entrepreneurship and offer practical implications for nurturing entrepreneurial ecosystems.

### **Statement of the Problem**

Nowadays entrepreneurship research places a lot of emphasis on the relationship between perceived relational support and entrepreneurial intention. Entrepreneurial intention is the individual's inner inclination to start a business while PRS is the encouragement and assistance expected by the individuals from their family, friends and peers regarding initiating their intention to implementing their actions. This assistance seems to have a significant effect on one's intention to pursue entrepreneurial endeavours. This study seeks to address the following problem:

How does perceived relational support influence entrepreneurial intention?

By exploring this problem, the research aims to provide valuable insights for aspiring entrepreneurs, policymakers, educators, and support organizations, ultimately contributing to the creation of more supportive entrepreneurial ecosystems.

### **Review of Literature**

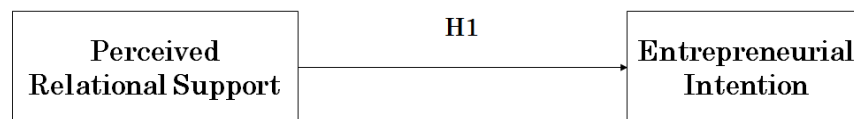
Perceived relational support significant influence the entrepreneurial intention of individuals found in the study conducted among 662 individuals (Tahir & Kutpudeen, 2023). Another study conducted by Elmer et al (2020) among 414 entrepreneurs, they concluded that as compared to male, female entrepreneurs' entrepreneurial intention was highly influenced through Perceive Relational Support. Pribadi et al (2023) carried out a survey among 113 individuals and found that perceived relational support act as an important predictor and antecedent of entrepreneurial intention. The relational support provided by their social networks inculcate the individual's entrepreneurial intention and aspirations effectively discovered in the survey among 450 participants (Si et al., 2022). Hamdani et al (2023) conducted a survey among 150 female entrepreneurs and concluded in their research that relational support provided by the family and friends by way of empathy, encouragement and motivations increase their self-efficacy levels which results into strong

entrepreneurial aspirations. Positive psychological attributes needed to develop entrepreneurial intention such as psychological capital and proactive personality are strongly influenced through relational support discovered in the survey among 222 individuals (Baluku et al., 2020). Based on the above empirical evidences we proposed the following hypothesis.

***H1: Perceived Relational Support is positively related to Entrepreneurial Intention***

Conceptual model for the article is presented in Figure 1.

**Figure 1. Conceptual model**



**Methodology**

This study based on both primary and secondary data. The research has focused on registered entrepreneurs in Kanniyakumari district. Primary data was collected using questionnaire under the survey method. Secondary data were obtained from research articles and websites. Total number of registered entrepreneurs in kanniyakumari district was 68,156. As a representative sample, the researcher used simple random sampling techniques and issued 150 survey instruments to the entrepreneurs via mail and phone calls. Out of 150, 145 were returned and 137 were found to be valid.

**Data Analysis**

Data analysis was done with SPSS package. Data were organized and tabulated for analysis. Percentage analysis was used to measure Gender, Age, Education qualification, Industry and annual income. Reliability analysis was used to check the validity of the indicators. Regression analysis was carried out to measure the relationship between dependent and independent variables.

**Demographic profile of the respondents**

Demographic profile of the respondents was grouped into different categories namely; Gender, Age, Education Qualification, Industry and Annual Income. Demographic profile of the respondents was captured in table 1.

**Table 1**

<b>Category</b>	<b>Profile</b>	<b>Total number</b>	<b>percentage</b>
Gender	Male	78	57
	Female	59	43
	<b>Total</b>	<b>137</b>	<b>100</b>
Age	17-22	16	12
	23-28	57	42
	29-34	38	28
	35-40	19	14
	40 and above	7	4
	<b>Total</b>	<b>137</b>	<b>100</b>
Education Qualification	10th or+2	6	4
	ITI or Diploma	38	29
	Undergraduate	50	36
	Postgraduate	43	31
	<b>Total</b>	<b>137</b>	<b>100</b>
Industry	Manufacturing	56	41
	Service	40	29
	Retail	31	23
	Others	10	7
	<b>Total</b>	<b>137</b>	<b>100</b>
Annual Income	Below 5,00,000	48	34
	5,00,000-10,00,000	46	32
	10,00,000-15,00,000	37	28

	Above 15,00,000	8	6
	<b>Total</b>	<b>137</b>	<b>100</b>

**Source:** Primary Data

Table 1 implied that 57 per cent (78) of the respondents were male and 43 per cent (59) of the respondents were female. This proved that male entrepreneurs are more inclined towards entrepreneurial career than female.

42 per cent (57) of the respondents were belong to 23-28 years age group. 4 per cent (7) of the respondents were belong to 40 and above age group. This explored that younger individuals are more inclined towards entrepreneurial activities.

36 per cent (50) of the respondents completed their undergraduate course. 4 per cent (6) of the respondents completed their schooling and engaged in entrepreneurial activities. It is inferred those who completed undergraduate courses initially developed their entrepreneurial tendency.

41 per cent (56) of the respondents running manufacturing industrial business. 7 per cent (10) of respondents engaged in other types of entrepreneurial activities. It proved that majority of the entrepreneurs explore their innovation in manufacturing industrial business.

34 per cent (48) of the respondents come under the annual income of below Rs. 5,00,000. 6 per cent (8) of respondents obtained annual income of Above Rs. 15,00,000. It illustrates that majority of them started their business recently such that they are in the initial stage of business to promote their business to the next growth stage.

### **Measures**

The questionnaire used in this study consists of 7 items adapted from previous studies. Adapting questionnaire from previous studies was to ensure its validity and reliability. All constructs were measured on a Likert-type five-point scale (anchored as ‘1’ = strongly disagree; and ‘5’= strongly agree). The detail Survey instrument was provided in Appendix I.

*Perceived Relational Support* was measured with two indicators adapted from Turker et al (2005) the sample item read as “If I decided to be an entrepreneur, my family members support me”,

and “If I decided to be an entrepreneur, my friends support me”. The reliability coefficient Cronbach’s alpha for Perceived Relational Support was 0.76.

*Entrepreneurial Intention* was measured with five items adapted from Liñán and Chen (2009) and the sample item read as, “Make every effort to start and run own firm”, and “Very serious thought of starting a firm”. The reliability coefficient Cronbach’s alpha for Entrepreneurial Intention was 0.86.

The reliability coefficients of all the constructs are over the acceptable level of 0.6 and less than the threshold level of 0.9 (Hair et al., 2019). This provides evidence for the reliability and validity. The reliability of the instrument is presented in Table 2.

**Table 2**

Variables	Cronbach’s Alpha
Perceived Relational Support (Turker et al., 2005)	<b>0.76</b>
Entrepreneurial Intention (Linan and Chen, 2009)	<b>0.86</b>

**Source:** Computed Data

### Testing Hypothesis H1

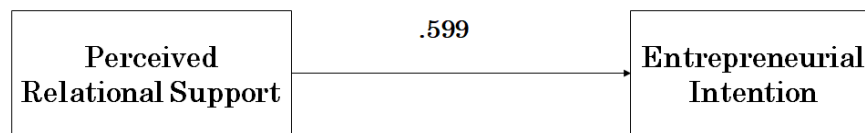
As hypothesized Perceived Relational Support was significantly and positively related to Entrepreneurial Intention ( $\beta = 0.599$ ;  $p < .001$ ). The model was significant and explained 29.6% variance ( $R^2 = 0.296$ ; adjusted  $R^2 = 0.258$ ;  $F = 41.92$ ;  $p < .001$ ). These results provided evidence for supporting H1. Regression model summary of H1 is captured in Table 4 and also the visual representation showing the impact of perceived relational support on entrepreneurial intention is presented in Figure 2.

**Table 4**

R	R square	Adjusted R Square	Std. Error of the Estimate	F	Sig.	H1 Result
.544	.296	.258	.55292	41.921	<b>.000</b>	Accepted

				<b>Coefficients</b>			
<b>Unstandardized coefficients</b>		<b>Standardized coefficients</b>					
B	Std. Error	Beta	T		Sig.		
1.518	.517		2.935		<b>.000</b>		
.599	.093	.497	6.475		<b>.000</b>		

Source: Computed Data



### Findings

- 57 per cent (78) of the respondents were male and 43 per cent (59) of the respondents were female.
- 42 per cent (57) of the respondents were belong to 23-28 years age group. 4 per cent (7) of the respondents were belong to 40 and above age group.
- 36 per cent (50) of the respondents completed their undergraduate course. 4 per cent (6) of the respondents completed their schooling and engaged in entrepreneurial activities.
- 41 per cent (56) of the respondents running manufacturing industrial business. 7 per cent (10) of respondents engaged in other types of entrepreneurial activities.
- 34 per cent (48) of the respondents come under the annual income of below Rs. 5,00,000. 6 per cent (8) of respondents obtained annual income of Above Rs. 15,00,000.
- Since, the regression model is significant at ( $\beta = 0.599$ ;  $p < .001$ ) 0.000, thus there is a positive association between perceived relational support and entrepreneurial intention.

### **Suggestions**

- Government, Academics and Entrepreneurship supporting Organisations can conduct workshops and seminars to educate family members and peers on how to effectively support aspiring entrepreneurs.
- Government and supporting Organisations encouraging a culture of support within one's immediate community and family who can play a crucial role in fostering entrepreneurial intentions. Positive reinforcement, encouragement, and emotional backing from family and friends can significantly impact an individual's decision to pursue entrepreneurial endeavors.
- Aspiring entrepreneurs can utilize the online platforms to connect with successful business owners, investors, and industry experts. This network can offer emotional support, practical advice, potential business opportunities and boosting entrepreneurial intentions.

### **Conclusion**

This study shed light on the significance of social networks in the entrepreneurial process by examining the relationship between perceived relational support and entrepreneurial intention. The findings clearly indicate that relational support, which includes emotional, informational, and tangible assistance from family, friends, and mentors, significantly enhances individuals' entrepreneurial intentions. The findings suggest that when individuals feel supported and encouraged by their social networks, their confidence and willingness to take entrepreneurial risks increase. This support system not only reduces the perceived risks and challenges associated with starting a business but also provides the necessary guidance, resources, and emotional encouragement. As a result, individuals are more likely to develop a strong entrepreneurial intention and pursue their business goals with greater determination and resilience.

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## **Enhancing Library Services through Information and Communication Technology Integration**

**Nadar Caramel Rosy Anthony Selvaraj<sup>1</sup>, R. R. Saravanakumar<sup>2\*</sup> and  
S. Mary Pearly Sumathi<sup>3</sup>**

<sup>1</sup>*Research Scholar, Reg.No: 23113041112004, Department of Commerce, Holy Cross College (Autonomous)  
Nagercoil – 629004.*

<sup>2</sup>*Research Supervisor, Department of Library and Information Science,  
Sadakathullah Appa College (Autonomous), Palayamkottai,*

<sup>3</sup>*Research Co Supervisor, Department of Commerce, Holy Cross College (Autonomous) Nagercoil – 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [carmelrosy1992@gmail.com](mailto:carmelrosy1992@gmail.com), [rrsaravanakumar@gmail.com](mailto:rrsaravanakumar@gmail.com), [pearlysumathi@gmail.com](mailto:pearlysumathi@gmail.com)*

### **Abstract**

This study reveals that the incorporation of ICT into libraries has transformed the way information is accessed and disseminated. Users can explore, retrieve, and interact with huge repositories of resources using digital catalogues and databases, overcoming the limits of physical collections. The internet and online resources enable rapid access to a variety of information, eradicating geographical limitations and allowing for lifelong learning. Libraries will remain important in an increasingly digital environment as a result of this digital accessibility. Libraries have transformed from static stores of knowledge into dynamic centres of digital information in a time of fast technological advancement. This also uncovers the usage of ICT tools, such as online catalogues, electronic resources, and library management systems, and their role in improving accessibility, efficiency, and user experience through thorough surveys, interviews, and data analysis. This study highlighted the vital role of ICT in modernizing and enhancing the library's commitment to education, shedding light on the significant changes taking place in the library. As a result, ICT has catapulted libraries into the digital era by improving accessibility, providing novel services, and encouraging community engagement. Libraries' dedication to using ICT will surely affect the future of knowledge distribution and community involvement as they expand.

**Keywords:** ICT, Information Technology, Internet, E- resources, Library

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### **Introduction**

Libraries are at the intersection of tradition and innovation in the ever-changing information distribution ecosystem. Libraries have historically provided their communities with vital resources and services by acting as knowledge repositories and hubs for intellectual study. But the emergence of information and communication technology (ICT) has brought about a paradigm shift for libraries,

changing their function and enabling them to do previously unthinkable things. ICT integration into library services is a fundamental shift that is redefining how libraries function and serve their users, not just an improvement. Electronic journals, online databases, and e-books are examples of digital resources that give consumers access to a wealth of knowledge at any time and from any location. Digital resources make knowledge more accessible to a wider audience by filling in gaps left by physical and geographic constraints. ICT integration into library services is not without obstacles. It is vital to tackle concerns like the digital divide, cybersecurity, and ongoing employee training to guarantee that the advantages of technology are dispersed fairly and efficiently administered. Libraries have to overcome these obstacles while continuing to fulfil their primary goals of facilitating information access and encouraging lifelong learning.

### **Literature Review**

Improving user self-efficacy in libraries is a worthwhile investment for library management since it can encourage more independent search habits and less reliance on staff. Especially in light of contemporary ICT contexts, these tools can aid in directing decisions regarding modifications to user behavior in the usage of Electronic Information Resources (EIR) (Alahakoona & Somaratne, 2018). The many facets of information and communication technologies (ICTs) in libraries, emphasizing how they might improve the provision of information and services. It highlights the advantages of library automation while talking about the use of technologies like RFID, QR codes, and RemoteXs in library operations. The benefits of institutional repositories for resource archiving are also included (Bhoi, 2017) The impact of information and communication technology (ICT) on libraries is examined in this research, with a focus on how libraries are changing to become digital, electronic, and virtual. It emphasizes how important it is for college librarians to learn ICT abilities because many of these professionals are currently underqualified in this field (Mani et al., 2019). The impact and usage trends of ICT-driven library services at IIT Roorkee and IIT BHU are compared in this study. According to the analysis, users at IIT Roorkee report higher levels of satisfaction and make greater use of and profit from ICT services than do users at IIT BHU. The inability to find specific information is a major problem that has been recognized, affecting a considerable portion of

users. (Faizan, 2023). Using Integrated Library Management Systems and conventional IT tools, ICT has revolutionized resource management and housekeeping tasks in libraries, including acquisition, cataloging, and circulation control. The internet has also become into a vital resource and means of delivering library and information services (LIS) (Kavita, 2016). The social media is still underutilized, even if ICT improves Reference, Digital, and Circulation services efficiently. Issues with power, inadequate internet access, and a shortage of skilled staff were noted. The report suggests using social media to improve outreach and services offered by libraries (Essien et al., 2022). In order to adapt libraries to the changing demands of users in the digital era, libraries can provide a variety of digital resources and services, including multimedia content, online databases, and e-books, that are available anywhere at any time by integrating ICT. Above all the added value provided by these ICT-enabled services, as well as the difficulties libraries may encounter in putting them into practice and keeping them up to date. It also offers solutions to these difficulties. (Hoque, 2023). It raises awareness of technology in libraries and explains why it's important to comprehend how to use ICT there in order to provide patrons with better services and information. Primary goal is to demonstrate the value of various ICT for the most rapid and accessible information distribution (Mishra, 2022).

### **Statement of the Problem**

This investigation addresses the issue of insufficient information and communication technology (ICT) integration in library services, which negatively impacts user engagement and information distribution in terms of effectiveness, accessibility, and general quality. ICT has the ability to turn traditional libraries into vibrant information hubs, yet many libraries still struggle with issues including obsolete infrastructure, a lack of technological know-how, and inadequate financing. The purpose of this study is to examine these issues and provide suggestions for improving library services by integrating ICT effectively.

### **Objectives**

To assess how Information and Communication Technology (ICT) affects the resources and services offered by libraries, to pinpoint obstacles and constraints encountered in integrating ICT, within the library system.

## **Methodology**

The main source of information for this study is secondary data. These information was gathered from numerous publications, journals and research articles. The study has a conceptual and descriptive focus.

## **Application of ICT**

Automating library tasks including acquisition, cataloging, circulation, and serials management is possible with a variety of software programs, including Libsys, Koha, and SLIM21. Here are the specific ways that ICTs are used in library operations.

- **Acquisition:** Using ICT techniques, order placement, price checking, duplication checking, and other tasks are completed extremely well. Online ordering has made it simple to place orders for library materials. Email is useful for reminding book publishers, sellers, and even book borrowers.
- **Cataloguing:** Publicly available records of various resources (books, serials, manuscripts, cartographic materials, etc.) can be simply imported or copied using the LC catalogue. Cataloguing time has been greatly shortened by importing bibliographic records from reliable websites like "OCLC World Cat" and "Trove - National Library of Australia."
- **Classification:** One can obtain the whole bibliographic record of the library materials from a number of online catalogue entries. You can search catalogue records and copy data for your own catalogue preparation by using the British Library catalogue, Trove-National Library of Australia's catalogue, and the Library of Congress's online catalogue. Examples of online categorization tools are Web Dewey, LOC classification web, and OCLC classify.
- **Serial Control:** Periodicals and serials form the core of the library. The fastest information about the specific resources can be accessed through automated serials management. The serial control software can be used to complete the following tasks:
- Existing holdings status, Tracking issue and missing volume, Budget preparation for subscription to periodicals.

- Circulation: The simplest and fastest way to complete regular tasks related to circulation is by using electronic devices like computers, barcode scanners, and library management software. All forms of communication that we engage in these days rely on the internet, email, phone, etc. The daily operations of the library's circulation also make use of these technology. Essentially, ICT is used to carry out the following tasks in the circulation:
  - Returns and issues, Book and document reservations, Membership registration, etc.
  - Stock-taking or Verification: The most crucial application of computers is in stock verification. Using an RFID reader and barcode scanner, the library's stock is scanned, and data is gathered. This allows us to determine how many books have been lost.

#### **ICT Tools used in Library Services**

- On-Line Public Access Catalogue (OPAC): ICT has transformed library cataloging by enabling users to access the library's collection holdings digitally. OPAC reduces the cost and complexity of maintaining a traditional library catalog.
- Reprographic Service: This service reproduces documents by first converting printed materials into digital format and then creating photocopies. It facilitates easy duplication and dissemination of information.
- Document Delivery Service: Documents are digitized and delivered electronically, allowing users to receive them via email from anywhere. Additionally, electronic resources like periodicals and documents can be provided to users on demand.
- Bibliographic Service: Putting together the list of references for a research project, bibliographic software like Mendely, EndNote, RefWorks, and Zotero is incredibly helpful.
- Translation Service: You can translate text from a foreign language into English and vice versa using a number of internet programs, such as Bablefish and Google translators.

### **Challenges in Implementing and Maintaining ICT-Based Services**

- Funding is one of the biggest issues libraries have when implementing ICT solutions. It can be expensive to purchase, install, and maintain new technology, particularly for libraries with limited funding.
- For libraries with limited resources, providing proper user training can be difficult, particularly when the new technologies are sophisticated.
- Sensitive user data must be collected and stored by ICT systems, and this data must be secured against unwanted access. Libraries need to take the necessary precautions to guarantee data security and privacy, especially when it comes to sensitive personal information.
- Keeping up with the quick speed of technical advancements is another issue. To be current and useful, libraries need to upgrade their software and systems on a regular basis. This can be quite difficult for libraries with little funding because it calls for constant training and investment in the newest technologies.

### **Suggestions**

- Prior to putting any ICT-enabled service into action, a thorough strategy outlining the goals, objectives, schedule, and budget must be created. All parties involved will benefit from careful planning regarding their objectives and the tasks at hand. Throughout the planning and execution phase, involve all pertinent stakeholders, including end users. This will make it easier to make sure the service satisfies user needs and advances organizational objectives.
- Implementing and maintaining ICT-enabled services successfully depends on proper training. By doing this, consumers can make the most of the service and take care of any potential technical problems.
- It is imperative to address cybersecurity concerns throughout planning and execution due to the rise in cyber-attacks. This can be accomplished by putting in place the proper security measures and making sure everyone involved is aware of their roles.

## **Conclusion**

In conclusion, the integration of Information and Communication Technology into library services represents a profound shift that enhances the efficiency, accessibility, and relevance of libraries in the modern age. By leveraging ICT, libraries can offer expanded resources, improved services, and innovative solutions that meet the evolving needs of their patrons. As libraries continue to adapt to the digital age, it is essential to explore and address the associated challenges to fully realize the potential of ICT in enhancing library services. This paper aims to delve into these aspects, examining how ICT integration can be strategically implemented to optimize library services and support the dynamic information needs of contemporary users.

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## **The Role and Contributions of Indian Migrant Workers in India's Development**

**J. Jemi Rooth Kanosa\* and J. Divya Merry Malar**

*Department of Commerce, Holy Cross College (Autonomous), Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

*Email: [jemiroothkanosa@holycrossngl.edu.in](mailto:jemiroothkanosa@holycrossngl.edu.in)*

### **Abstract**

The vital role of Indian migrant workers in shaping the country's economic and social landscape. Migrant workers contribute significantly to key sectors such as construction, agriculture, manufacturing, and mining, driving economic growth and infrastructure development. Their presence helps fill labour shortages, enhances productivity, and supports local economies. Despite these contributions, migrant workers face significant challenges including poor working conditions, inadequate wages, and limited access to healthcare and education. This study highlights the benefits of migration, such as increased GDP, poverty reduction through remittances, and regional balance. It also identifies the need for improved labour laws, better living conditions, and enhanced social integration. By addressing these issues, India can ensure fairer treatment for migrant workers and maximize their positive impact on national development.

**Keywords:** Migrant workers, Economic Contribution, Sectoral Impact

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### **Introduction**

Indian migrant workers play a key role in the country's development, whether they move voluntarily for better opportunities or are forced to migrate due to difficult conditions. With over 140 million workers in sectors like construction, agriculture, fishing, production, and mining, they help drive economic growth by filling labour gaps, increasing productivity, and boosting regional economies with their remittances. They help balance regional economic differences and support urban growth by contributing to essential services and industries. However, they face major challenges, such as poor working conditions, lack of formal contracts, and limited social security. Addressing these problems is essential for ensuring they are treated fairly and can continue to positively impact development. Their remittances also support their families and encourage small businesses in their home regions. This study aims to explore the role and contributions of Indian

migrant workers in India's development and how migrant workers contribute to key sectors, drive industry growth, and support infrastructure development. It will also examine how migration balances regional disparities, fosters urban growth, and boosts local economies through their financial contributions and entrepreneurial efforts.

### **Statement of the Problem**

Indian migrant workers are pivotal to various sectors, such as construction, agriculture, and manufacturing, and their migration has significant benefits for regional and national development. However, their contributions and the benefits of migration are often diminished by ongoing challenges, such as poor working conditions and lack of formal employment protections. This study aims to highlight the crucial contributions of migrant workers across different sectors and explore how migration supports regional and national development while acknowledging the need to address existing issues to fully realize these benefits. Additionally, it will investigate how improving working conditions and protections can enhance the positive impact of migration on India's progress.

### **Review of Literature**

Migration significantly affects both urban and rural labour markets worldwide. In India, migrants play a vital role in the urban workforce by providing affordable and readily available labour for sectors like construction and mining (Kallevik, 2014). Migrants are crucial for urban development in cities like Gurgaon and play a significant role in agriculture. Despite a decline in agricultural labour, about 45% of the workforce was in this sector in 2020, supporting food security and infrastructure development in India (V.V. Giri National Labour Institute, 2022). Labor migration in India, driven by the quest for better opportunities, socio-economic issues, and urban growth, involves around 140 million workers. They contribute 10% to the GDP but face challenges such as lack of formal contracts, paid leave, and social security (Shukla, Sanjay, Sanyukta, & Chainani, 2023). Migration also brings benefits through remittances, which help increase incomes, reduce poverty, and improve health and education in the workers home countries (Ratha, Mohapatra, & Scheja, 2011). In India, migration is influenced by job competition and better opportunities elsewhere (Khan & Arokkiaraj, 2021).

### **Objectives of the Study**

1. To highlight the contributions of Indian migrant workers to various sectors.
2. To explore the benefits of migration on regional and national development.

### **Research Methodology**

This study employs a qualitative research approach, using secondary sources. It involves collecting relevant data from existing materials, including government reports, surveys, and news articles.

### **Internal Migration in India: Census Insights and Trend**

Migrant workers move from their usual residence to find employment opportunities, either domestically or internationally, in sectors where labour is needed.

The 2011 Census recorded 454 million migrants, up from 220 million in 1991 and 315 million in 2001. From 2001 to 2011, 74.7% of migration was due to marriage and family, with 40% of rural-to-rural and 4.8% of interstate moves. Conversely, 43% of rural-to-urban migration was for employment, highlighting the importance of interstate migration in the labour market.

### **Sector-Wise Contributions of Indian Migrant Workers**

Indian migrant workers are crucial across various sectors. In construction, they build infrastructure, driving urban growth. In agriculture, they handle seasonal tasks, supporting food production. Manufacturing relies on their labour for industrial expansion. In mining, they extract and process minerals for various industries. They also contribute significantly to services like domestic work, hospitality, and retail, bolstering urban economies.

### **Major Sectors Employing Migrant Workers: Economic Impact**

The circular migration, prevalent among poorer communities and especially SCs and STs, involves significant numbers of women and children. Migrants are crucial across all major sectors including agriculture, industry, and services. Key areas employing migrant labour include textiles, construction, mining, brick kilns, small-scale industries, crop harvesting, and various other roles such as rickshaw pulling and food processing. The detailed data on every sector is lacking, the evidence demonstrates the crucial role of migration in India's economy.

## **Contributions of Migrant Workers**

Migrant workers boost India's economy by contributing to sectors like construction, agriculture, manufacturing, and mining. They fill labour gaps, enhance productivity, and support infrastructure.

### **Economic Sector and Labor Market Contributions**

- **Participation in key sectors and GDP Contribution:** Migrant workers significantly contribute to key sectors like construction, agriculture, manufacturing, and mining, thereby impacting the country's Gross Domestic Product (GDP).
- **Filling Labor Gaps and Enhancing Productivity:** Migrant workers address labour shortages in specific industries and enhance productivity by increasing efficiency and output across various sectors.

### **Skill and Expertise**

- **Diverse Skills and Entrepreneurial Activities:** Migrant workers bring diverse skills and specialized knowledge to various industries while also engaging in entrepreneurial activities and small businesses, boosting the informal economy.

### **Regional and Sectoral Contributions to Infrastructure**

- **Construction Projects:** Involvement in building infrastructure such as roads, bridges, and buildings.
- **Support to Local Economies:** Contributing to local economic activities and businesses.
- **Regional Development:** Stimulating economic growth in both urban and rural areas.

### **Benefits and National Development**

Migration benefits regional and national development by driving economic growth, increasing GDP, and reducing poverty through remittances. These funds improve access to education and healthcare and help balance regional disparities by redistributing labour and resources. Migrants also contribute to infrastructure and public services, while their diverse backgrounds enhance cultural exchange and foster community integration.

### **Economic Growth and Social Development**

- **GDP Growth and Increased Incomes:** Migrant workers boost national GDP growth and increase disposable income for families and local businesses through their contributions and remittances.
- **Poverty Reduction and Education and Health:** Remittances from migrant workers improve living standards and reduce poverty, while also funding better access to education and healthcare services.

### **Regional Balance and Infrastructure and Public Services**

- **Urban-Rural Balance and Economic Mobility:** Migrants help balance urban-rural disparities by redistributing labour and resources, while also providing opportunities for economic mobility and reducing regional imbalances.
- **Urban Development and Community Services:** Migrants contribute to urban development by advancing infrastructure and services, while their remittances enhance community services and public facilities.

### **Cultural and Social Integration**

- **Cultural Exchange and Social Cohesion:** Migrants enhance local cultures through cultural exchange and foster social cohesion by promoting integration and understanding among diverse community groups.

### **Factors Influencing the Engagement of Migrant Workers**

- **Decreased Preference for Native Workforce:** Employers are increasingly preferring migrant workers over locals due to cost and flexibility.
- **Migrant Worker Availability:** Migrants are readily available and fill roles in sectors where local labour is scarce.
- **Labor Shortages and Limited Local Availability:** Many regions face labour shortages, and local workforce availability is often limited.

- **Fulfilling Labor Demand:** Migrant workers help meet the high demand for labour in various industries.
- **Willingness to Accept Low-Profile Jobs:** Migrants often accept jobs that locals may avoid, including low-wage or low-status positions.
- **Economic Contribution:** Migrant workers significantly contribute to the economy by boosting productivity and supporting key industries.

### **Challenges and Problems Faced by the Migrant Workers**

- **Poor Working Conditions:** Migrant workers often face unsafe environments and inadequate facilities like sanitation and clean drinking water.
- **Lack of Legal and Social Protections:** They frequently lack necessary legal and social safeguards, making them vulnerable to exploitation and difficulties accessing legal support.
- **Economic Exploitation:** Migrants generally earn lower wages than locals and may experience unfair wage deductions.
- **Health and Safety Concerns:** Limited access to healthcare and inadequate protective measures expose them to occupational risks.
- **Social Integration Issues:** Cultural and language barriers lead to social isolation and difficulty in forming community connections.
- **Overcrowded and Unsanitary Living Conditions:** Migrants often live in poor conditions that affect their health and living standards
- **Discrimination and Exploitation:** Ethnic or national discrimination exacerbates their situation, leading to exploitation by middlemen or employers

### **Findings of the Study**

1. Migrant workers are essential across construction, agriculture, manufacturing, and mining, significantly boosting GDP and supporting infrastructure development.
2. They fill critical labour shortages, enhance productivity, and drive local economic growth through their skills and entrepreneurial activities.

3. Migrants contribute to both urban and rural economic growth, reducing regional disparities and encouraging balanced development.
4. Migration significantly boosts economic growth, enhances GDP, and reduces poverty through remittances, which improve education and healthcare access and support local economies.
5. Migrants help balance regional disparities by redistributing labour and resources, contributing to promoting economic mobility.
6. Migrants' contributions enhance urban infrastructure and public services, with their earnings funding various community and service improvements.
7. Migration enriches local cultures and promotes social integration, though challenges like poor working conditions and limited legal protections remain.

### **Suggestions**

1. Strengthen labour laws and ensure that migrant workers have access to formal contracts, social security, and fair wages to protect their rights and improve their working conditions.
2. Provide better access to healthcare services and educational opportunities for migrant workers and their families to improve their overall well-being and prospects.
3. Ensure that migrant workers have access to safe, clean, and affordable housing to enhance their quality of life and prevent health issues related to overcrowded and unsanitary living conditions.
4. Offer training programs and skill development opportunities to help migrant workers acquire new skills, improve their employability, and advance their careers.
5. Create programs to help migrant workers fit into local communities better and overcome language and cultural barriers.

### **Conclusion**

Indian migrant workers are vital for many sectors and boost the country's economy. They help with construction, agriculture, manufacturing, and mining, driving economic growth and reducing regional gaps. However, they face problems like poor working conditions, low wages, and lack of access to healthcare and education. To improve their situation, we should strengthen labour laws,



ensure fair pay, and provide better healthcare and housing. Offering training and supporting social integration will also help. Addressing these issues will lead to a fairer and more balanced economy, benefiting both migrants and the wider community.

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## **Factors Influencing Coconut Farming in Kanyakumari District**

**S. Ramalekshmi<sup>1</sup>, S. Mary Pearly Sumathi<sup>2</sup>**

<sup>1</sup>*Research Scholar in Commerce, Reg.No. 23113041012002, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

<sup>2</sup>*Assistant Professor and Head of the Department of Commerce, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

Agriculture is the cornerstone of India's economy, employing a significant portion of the population and supporting various industries. This study focuses on coconut farming in Kanyakumari District, a major agricultural activity providing vital income for many farmers. Coconut cultivation in the region benefits from fertile soil, ample water supply, and Government support. However, it faces challenges such as pest infestations, climate change, aging plantations, and fluctuating market prices. This research identifies key factors influencing coconut farming, including environmental, agronomic, economic, social, and technological aspects. The study also examines the problems faced by coconut farmers and offers practical suggestions to improve productivity and profitability. Based on secondary data and the opinions of local farmers, the findings highlight the need for better pest management, fair pricing, and enhanced government support. By addressing these issues, the study aims to enhance the sustainability and success of coconut farming in Kanyakumari District.

**Keywords:** Coconut, climate change, soil fertility.

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### **Introduction**

In India agriculture is the main occupation of a large number of people. Agriculture depends on soil fertility, rainfall, climatic conditions, irrigation facilities, availability of manures, fertilizers, pesticides, improved varieties of seeds, adoption of scientific methods of cultivation and the like. For a long time in India agriculture has been regarded as a way of life. Agriculture the backbone of Indian economy, not only feeds the teeming millions of people in India and abroad but also provides raw materials to many industries and earns precious foreign exchange. The purchasing power of the people of India is generated by agriculture, which creates demand for the various goods and services in the country. The cost of the various inputs used in agriculture increases day-by-day but the price

of agricultural produce does not increase proportionately and so the farmers are left with no surplus. In this context there is a need for the application of scientific management practices in agriculture.

Agriculture involves the production of food crops and cash crops. The main food crops are paddy, banana, vegetables and the horticulture crops producing various types of fruits. Coconut cultivation is a major cash crop grown in Kanyakumari district. In many places paddy fields are converted into coconut farm. Coconut is used for producing oil and coconut husk is used for making coir. The coir industry is a prominent industry of Kanyakumari district.

Coconut farming is an important agricultural activity, which provides a significant source of income for many farmers. It provides food, drink, fuel and timber. Millions of families in India depend on coconut for their livelihood directly or indirectly. India ranks third in area and production of coconut in the world. The major coconut producing states in India account for more than 90 percent of area and production.

### **Statement of the Problem**

The coconut production has been one of the most important components of the Indian agriculture. Kanyakumari district is endowed with fertile soil and regular water supply. The district has three major dams namely Pachiparai, Peruchani, Chittarpattinam and Mampalatharu Dam. These dams store the rain water and supply to the farmers throughout the year. The district administration maintains large number of small and big tanks, for irrigating vast area of land. The land becomes wet throughout the year due to rainfall and water from tanks and the supply of dam water through channels. The ground water level is maintained throughout the year.

Traditionally the farmers were concentrating on the cultivation of short-term crops like paddy, banana and vegetables. These agricultural crops need regular supervision and care for cultivation. Due to the passage of time the size of land has become tiny, because of sub-division and fragmentation. The holding of land becomes uneconomical and hence the farmers resorted the cultivation of long-term crops like coconut, mango, jack fruit and various fruit bearing trees. The cultivation of long-term crops does not involve supervision and day to day care. The farmers cultivating long term crops get perennial income on a monthly and seasonal basis. The farmers

choose coconut cultivation, since coconut provides income continuously on a monthly or bi monthly basis. Besides the facilities available for coconut cultivation, the infrastructural facilities created by the Government promote coconut farming in the district. This present study highlights the coconut farming in Kanyakumari district with particular reference to the factors influencing growth of coconut farming in Kanyakumari district and the problems and suggestions for solving the problems.

### **Objectives of the Study**

The present study has the following objectives:

1. To identify the factors influencing coconut farming in Kanyakumari district and to bring out the significance of each factor.
2. To examine the problems of coconut cultivation in Kanyakumari district.
3. To give suitable suggestions for solving the problems.

### **Research Methodology**

The research design of the study is basically descriptive. The study is based on secondary data. The secondary data were collected from various books, reports and journals of the Coconut Development Board. The suggestions included in the paper are the outcome of the opinions expressed by many coconut farmers.

### **Review of Literature**

1. S.M. Yamuna and R.Ramya (2016) in their study titled “A Study of Coconut Cultivation and Marketing in Pollachi Taluk” have explained cultivation of coconut in Pollachi taluk the prime area for cultivation of coconut. A concerned effort from all stakeholders in the development of coconut cultivation is vital for including sustainable progress in this sector. It is also brought out the profitability involved in the cultivation and economic aspects of coconut.
2. S. Raj Kumar and R. Tamil Selven (2022) in their study entitled “Importance of Coconut Cultivation” pointed out the significance of coconut as a source of edible oil and as an agro-based raw material for many industries such as manufacture of shell powder, and handicrafts. The tree trunk is used as a building material and for making furniture. Fifty percent of the total coconut production is converted into copra.

3. E.C. Mwachiro and R.W. Gakure (2011) in their study entitled “Factors Affecting the Coconut Industry from Benefitting the Indigenous Communities of Killifi District, Kenya” have explained the results indicated that low prices of the coconut products, unclear legal framework, lack of proper markets, poor farming methods, low productivity and lack of financial support from the Government and financial institutions are some of the factors that hinder the indigenous community from benefiting from the coconut products in the region.

### **Factors Influencing Coconut Farming in Kaniyakumari District**

The factors influencing cultivation of coconut in Kaniyakumari district are the following

#### **Environmental Factors**

- **Climate:** Coconuts thrive in tropical climates with temperatures between 21°C to 32°C (70°F to 90°F). High humidity and rainfall (1500-2500 mm annually) are crucial.
- **Soil:** Well-drained sandy loam soils with a pH of 5.0-8.0 are ideal. Good aeration and fertility are important for growth.
- **Water Availability:** Adequate irrigation is necessary, especially during dry periods. Water stress can reduce yield significantly.
- **Sunlight:** Coconuts require full sunlight for optimal growth. Shaded areas can hinder development.
- **Elevation:** They grow best at sea level up to 600 meters above sea level.

#### **Agronomic Factors**

- **Planting Material:** The quality of seedlings or nuts used for planting affects the growth and yield. Choosing high-yielding and disease-resistant varieties is crucial.
- **Fertilization:** Proper fertilization with nitrogen, phosphorus, potassium, and trace elements ensures healthy growth and higher yields.
- **Pest and Disease Management:** Effective control of pests like rhinoceros beetles and diseases such as bud rot is essential.

- **Intercropping:** Growing other crops alongside coconuts can enhance soil fertility and provide additional income but must be managed to avoid competition for resources.

### **Economic Factors**

- **Market Demand:** High demand for coconut products like oil, water, and coir can drive profitability and expansion of coconut farming.
- **Price Fluctuations:** Prices of coconuts and derived products can be volatile, impacting farmers' incomes.
- **Cost of Inputs:** Costs of fertilizers, pesticides, labour, and equipment can influence the economic viability of coconut farming.
- **Government Policies:** Subsidies, support programs, and policies promoting coconut farming can significantly impact the industry.

### **Social Factors**

- **Availability of labour:** Coconut farming is labour-intensive, and the availability of skilled labour affects productivity.
- **Knowledge and Training:** Access to modern farming techniques, training programs, and extension services helps improve practices and yields.
- **Community Practices:** Traditional and community-based practices in coconut farming can influence techniques and productivity.

### **Technological Factors**

- **Irrigation Systems:** Advanced irrigation methods like drip or sprinkler systems can optimize water use and enhance growth.
- **Machinery:** Mechanization of processes such as harvesting and processing can improve efficiency and reduce labor costs.
- **Research and Development:** Ongoing research in crop improvement, pest control, and farming techniques can lead to better yields and resilience.

### **Environmental Challenges**

- **Climate Change:** Changes in temperature and precipitation patterns can affect coconut growth and productivity.
- **Natural Disasters:** Hurricanes, cyclones, and floods can devastate coconut plantations.

### **Problems of Coconut Cultivation**

Coconut farming is a crucial agricultural activity in many tropical regions like kaniyakumari district. Coconut farming is a source of livelihood for millions of small farmers. The coconut farming faces several problems. They are as follows

#### **Pest and Diseases**

- Coconut palms are vulnerable to a variety of pests and diseases. The pests and diseases results in the reduction of yield and sometimes lead to total loss of the plantation.

#### **Climate change**

- Changing weather patterns and rising temperature affect coconut farming. Droughts, heavy rains and cyclones can damage crops and reduce productivity.

#### **Aging plantations**

- Many coconut plantations are aging, with trees beyond their optimal productive years. Older trees produce fewer coconuts. Re planting efforts are not adequate to bring new trees.

#### **Lack of fair price for the farmers produce**

- There is lack of value addition process such as production of coconut oil, milk and other derivatives.

#### **High cost of cultivation**

- Cost of fertilizer, pesticides, labour and equipment influence the economic viability of coconut farming.

#### **Environmental changes**

- Changes in climate, non-availability of water, lack of sunlight for optimal growth and natural disasters like hurricanes, cyclones and floods affect coconut plantations.

### **Suggestions**

- It is difficult to prepare instant coconut oil without any equipment so, the Government can provide equipment at a subsidized rate to help the farmers.
- Coconut farmers in rural areas should be given better exposure to agricultural practices by conducting periodic agriculture camps.
- The Government gives only two coconut seedlings to some farmers, so it can provide many free coconut seedlings to all farmers.
- Since most of the people use coconut oil, our government can reduce the usage of palmolein oil and increase the production of coconut oil.
- The government can provide fertilizers and pesticides that are suitable for crops at reasonable guidelines.

### **Conclusion**

The study identified various factors influencing coconut production in Kanyakumari District. It includes environmental, economic, and social factors. "In Kanyakumari district, the major agricultural activity is coconut farming. For farmers to improve their satisfaction with production, they need to be aware of the factors influencing coconut production. This awareness will, in turn, improve their practices.

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## **To Study the Importance of Electronic Word of Mouth and Trust on Online Sellers in Social Media among the Female College Students in Kanyakumari District**

**Regina V<sup>1</sup>, C. K. Sunitha<sup>2</sup>**

<sup>1</sup>*Research scholar in Commerce, Reg. No.22113041012008, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

<sup>2</sup>*Assistant Professor and Research Supervisor in Commerce, Holy Cross College (Autonomous),  
Nagercoil – 629004.*

*Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012.*

*Email: [reginarun180@gmail.com](mailto:reginarun180@gmail.com), [sunithaabel@gmail.com](mailto:sunithaabel@gmail.com)*

### **Abstract**

Nowadays, social media platforms are widely used by people of all ages for various purposes. However, it is observed that the younger generation is mainly utilizing these platforms for both educational and entertainment purposes. As a result, my research focuses on young individuals who use social media for online shopping. My investigation focuses on how positive conversations, also known as EWOM influence consumers to trust retailers, and how this trust subsequently impacts consumers' decisions to shop online. Most existing literature emphasizes the direct impact on consumer online shopping behavior. This study concentrates on young users of social media users. The data were collected from Agastheeswaram taluk in Kanyakumari district (Nagercoil and Chungankadai) with the help of survey instruments by adopting simple random sampling method of 150 sample respondents. Therefore, the findings of this study will assist online sellers in understanding the level of trust that users have in online transactions and their willingness to use social media platforms for such purposes.

**Keywords:** EWOM, Online transactions

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### **Introduction**

Social media platforms provide people with the opportunity to express their opinions about retailers products and services through electronic word-of-mouth (e-WOM). Many of the largest online retailers like Walmart, Amazon, Costco, Home Depot enabling customers to leave online reviews of the products they sell. Trust forms the foundation of online shopping and is established through the credibility and reliability demonstrated by e-retailing companies. In traditional brick-

and-mortar stores, consumers have the opportunity to examine products, interact with salespeople, and assess the overall credibility of the establishment. However, in online transactions, these elements of personal interaction and physical inspection are absent. Electronic word-of-mouth (eWOM) on the internet, such as online consumer reviews, offers some advantages over traditional word-of-mouth. One of the key differences is that eWOM is measurable since comments and reviews are written and available on websites, making it easier to track and analyze. Furthermore, marketers have more control over certain types of eWOM messages. For example, in platforms like Amazon.com, marketers can decide whether to allow consumer reviews to be displayed or not. They can also offer specific review formats or guidelines to guide consumers in posting their opinions in a desired way. This level of control provides marketers with opportunities to strategically manage and shape the eWOM surrounding their products or services. By encouraging positive reviews, addressing negative feedback, and guiding the overall sentiment of eWOM, marketers can leverage eWOM as part of their marketing strategies. They can also analyze the content of eWOM messages to gain insights into consumer perceptions, preferences, and areas for improvement. However, it's important to note that while marketers have some control over eWOM, it is ultimately a dynamic and organic form of communication. Consumers have the freedom to share their opinions and experiences, and their authentic feedback can significantly impact the perception and reputation of a product or brand.

### **Statement of the Problem**

The landscape of marketing has significantly shifted with the advent of electronic word of mouth (eWOM) in online shopping, disrupting the traditional profit generation model reliant on advertisements and discounts. As social media gains global prominence, online sellers face the daunting task of establishing a reputable presence to attract customers. To achieve success in the online marketplace, retailers must specifically target the ever-growing population of active young adult netizens. Furthermore, it is noteworthy that female consumers exhibit higher engagement and purchasing behavior in the online realm compared to their male counterparts. Consequently, my

study centers on understanding the online shopping preferences and behaviors of young college students.

### **Methodology**

To investigate the influence of electronic word of mouth (eWOM) on female college students in Kanyakumari district, a study was conducted using a simple random sampling method. A self-constructed questionnaire was designed to collect data aligned with the research objective. The questionnaire utilized a Likert five-point scale, allowing respondents to express their agreement or disagreement on various statements. The target group consisted of 150 participants, including undergraduate (UG) and postgraduate (PG) students, who had varying levels of experience in online shopping. All 150 valid responses were included in the analysis, which was performed using the SPSS package. The collected data will provide insights into the influence of eWOM on the online shopping behavior of female college students in the study area.

### **Objectives of the Study**

- To find out the demographic profile of the social media users.
- To analyze whether the users are trust the online sellers for the subsequent use of online shopping.
- To inculcate the various components of electronic word of mouth commonly used by the users of the social media.

### **Review of Literature**

WOM (Word-of-Mouth) has been consistently found to exert a considerable influence on consumer decision-making (Katz and Lazarfeld, 1955). In line with the findings on WOM, studies have demonstrated that eWOM (electronic Word-of-Mouth) tends to possess greater credibility, empathy, and relevance for customers compared to information generated by marketers on the Web (Bickart and Schindler, 2001). Trust is established when buyers have certain expectations that the seller will act in a reliable, ethical, and socially appropriate manner, without taking advantage of the situation. It involves the seller fulfilling their commitments and behaving in a dependable way, even in situations where the buyer may be vulnerable or dependent on the seller (Gefen et al., 2003).

Indeed, consumers' perceptions of trustworthiness play a significant role in shaping their ultimate purchasing decisions when interacting with sellers (Gupta et al., 2009). Trust plays a crucial role in online commerce. In order to encourage consumers to make purchase decisions and complete transactions, sellers must establish a level of trust that surpasses the threshold for trustworthy behavior. When consumers trust a seller, they are more likely to feel confident in buying their products and transferring money. By focusing on these trust-building factors, sellers can create an environment where consumers feel confident and comfortable making purchase decisions and transferring money online. Building trust is an ongoing process, and consistently delivering on promises and maintaining a positive reputation are key to fostering long-term customer trust and loyalty (Bente et al., 2012).

#### **Data analysis and discussion**

**Table 1**

**Demographic profile of the respondents**

<b>Variables</b>	<b>Particulars</b>	<b>No. of Frequency</b>	<b>Percentage</b>
Age	Less than 18	11	7.3
	18-25	131	87.3
	26-30	3	20
	31-35	5	3.3
	Over 35	-	-
	<b>Total</b>		<b>150</b>
Education	Basic/secondary	85	56.7
	Undergraduate	62	41.3
	Graduate/Master degree	3	2

	<b>Total</b>	<b>150</b>	<b>100</b>
Frequency of buying (PER MONTH)	None/one time	41	27.3
	2-3 times	81	54
	4-5 times	15	10
	Over 5 times	13	8.7
	<b>Total</b>	<b>150</b>	<b>100</b>
Experience of buying (Years)	Less than 1	4	2.7
	1-2	26	17.3
	3-4	31	20.7
	Over 5	89	59.3
	<b>Total</b>	<b>150</b>	<b>100</b>
Social media platforms used frequently	Facebook	3	2
	Whats App	61	40.7
	Twitter	1	.7
	Instagram	85	56.7
	<b>Total</b>	<b>150</b>	<b>100</b>

**Source: Statistical Analysed Data**

Table 1 shows that 87.3 per cent (62) respondents belonging to the age group of 18-25 years. 56.7 per cent (85) respondents are completed their undergraduate. 54 percent (81) respondents are buying 2-3 times in a month frequently bought in the social media platforms. 59.3 per cent 89 respondents having a over 5 years of experience in purchasing in the online platforms. 56.7 percent(85) of the respondents using Instagram. Hence, it is clearly shows that mostly the college students are having the awareness about the social media platforms.

**Trust in online retailers and frequency of buying**

Trust is a key factor that influences consumers' online shopping intentions and behaviors. When consumers trust an online platform or retailer, they are more likely to engage in online shopping and make repeated purchases. Building trust can be achieved through transparent policies, secure payment systems, reliable customer service, and positive customer reviews. Prioritizing trust-building efforts is crucial for online businesses to attract and retain customers.

**Table 2**

Statements	None or one time	2-3 times	2-3 times	Over 5 times	F Value	P Value
If I required help, the seller would do his/her best to help me	2.95	3.01	3.50	4.08	3.804	.012
I expect that the seller's intentions are benevolent	2.93	3.26	3.25	3.92	2.605	.054
I do not doubt the honesty of the vendor	2.85	3.25	3.17	3.92	2.836	.040
The vendor is sincere and genuine.	2.80	3.21	3.50	3.83	3.285	.023
I expect that the vendor will keep promises he/she make	2.90	3.48	3.67	3.67	2.861	.039

**Source: Statistically Analyzed Data**

Note: \*\* Denotes significance at 1 per cent level.

Since P value is less than 0.01, the null hypothesis is rejected at 1 per cent level of significance and result state that there is a significant difference between the trust in online retailers and frequency

of buying. It suggests that Trust in online retailers refers to the level of confidence and belief that consumers have in the credibility, reliability, and overall reputation of online stores or e-commerce platforms. When consumers trust an online retailer, they are more likely to feel comfortable and confident in making purchases from that retailer.

**Electronic word of mouth and social media platforms used frequently**

**Table 3**

<b>Particulars</b>	<b>Facebook</b>	<b>WhatAapp</b>	<b>Twitter</b>	<b>Instagram</b>	<b>F value</b>	<b>P value</b>
I often read other consumer's online review to purchase product from online retail store.	5.00	3.71	4.06	3.70	1.481	.222*
To make sure I usually purchase product from online retail store after viewing the consumer's review.	4.00	4.00	4.09	3.91	.433	.730*
I often consult other consumer's product review to help choose	3.00	3.86	3.88	3.84	.263	.852*

right online retail store for product.						
I frequently gather information from online consumer's product reviews before I purchase product from online retail store.	4.00	3.79	4.15	4.03	1.187	.317*
When I purchase product from online retail store, consumer's online reviews make me confident whether purchase the product or not.	3.00	3.69	3.42	3.70	.787	.503*

**Source: Statistically Analyzed Data**

Since P value is less than 0.01, the null hypothesis is accepted at 1 per cent level of significance and result state that there is no a significant difference between the electronic word of mouth and social media platforms used frequently.

**Findings**

- During the online consumer buying behavior journey, it has been observed that retailers play a vital role in ensuring customer satisfaction. One of the key ways retailers can achieve this is by actively engaging with customer recommendations and feedback in the form of comments and reviews on their official website or within the shopping environment.



- It is found that electronic word-of-mouth (e-WOM) plays a crucial role for retailers in aligning their product launches with the needs and demands of consumers. This is achieved through the continuous flow of information provided on the retailer's website.

### **Suggestions**

- Retailers should actively engage with consumers through social media platforms, online reviews, and customer feedback to shape and influence e-WOM.
- It is important to conduct retailer-initiated e-WOM campaigns, such as influencer marketing or brand ambassador programs, on consumer buying behavior.

### **Conclusion**

In conclusion, this study has shed light on the significance of electronic word of mouth (eWOM) and trust in online sellers operating on social media platforms, particularly among female college students in the Kanyakumari district. The findings have emphasized the growing influence of social media in shaping consumer behaviors and purchase decisions. The study has highlighted that eWOM plays a pivotal role in building trust and influencing the online buying behavior of female college students. The power of recommendations, reviews, and endorsements shared through social media platforms has proven to be instrumental in shaping their perceptions and preferences. Furthermore, trust has emerged as a crucial factor in establishing a successful online seller-customer relationship. Trust is cultivated through factors such as secure transactions, transparent communication, reliable product information, and prompt customer support. When online sellers can establish trust with female college students, it leads to increased engagement, repeat purchases, and positive brand advocacy. In summary, this study has underscored the importance of eWOM and trust in online sellers operating on social media platforms. It has revealed the influential role of these factors on the online buying behavior of female college students in the Kanyakumari district.

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## **Impact of GST on Branded Clothes: An Overview**

**Thushara Antony .M<sup>1</sup> and S. Mary Pearly Sumathi<sup>2\*</sup>**

<sup>1</sup>*Research Scholar, Reg. No: 23113041012001, Department of Commerce, Holy Cross College (Autonomous)  
Nagercoil – 629004.*

<sup>2\*</sup>*Research Supervisor, Department of Commerce, Holy Cross College (Autonomous), Nagercoil-629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.  
Email: [thusharaantony12@gmail.com](mailto:thusharaantony12@gmail.com) , [pearlysumathi@gmail.com](mailto:pearlysumathi@gmail.com)*

### **Abstract**

This study investigates the impact of the Goods and Services Tax (GST) on consumer attitudes towards branded clothing in India. A brand encompasses the entire customer experience and differentiates a product in the consumer's eyes, with branding strategies aimed at creating lasting impressions. The introduction of GST has restructured indirect taxation replacing multiple taxes with a unified system. Under the new tax regime man-made clothing priced below ₹1000 is taxed at 5%, while those above ₹1000 incur an 18% tax, making branded clothing more expensive. This research explores whether consumers continue to prefer branded clothes despite the higher GST rates and analyzes the effect of GST on consumer purchasing behavior. The study utilizes secondary data from various sources to offer a conceptual and descriptive analysis. Findings indicate that, despite the increased cost due to GST, consumer preference for branded clothing remains largely unchanged. Suggestions include reducing GST rates on essential goods to make branded clothing more accessible. The study concludes that while GST influences the cost of branded clothing, it does not significantly alter consumer preferences.

**Keywords:** Buying behaviour, GST, Branded clothes

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### **Introduction**

A brand is characterized as an entire customer experience that sets a product apart from its competitors in the eyes of consumers. A company's branding is a collection of marketing and communication strategies that set its product apart from those of its rivals. The primary goal of creating a ever lasting impression on consumers' thoughts is the goal of brand development. Man-made clothing up to ₹1000 is subject to 5% GST under the new tax law, which is less than the 7% previously levied under the previous indirect tax system. It is also true that the higher 18% GST

charge, which is undoubtedly greater than the current 7%, is applied on man-made garments valued at more than ₹1000, making branded clothing more expensive.

### **Goods and Service Tax**

GST is known as the Goods and Services Tax. It is an indirect tax which has replaced many indirect taxes in India such as the excise duty, VAT, services tax, etc. The Goods and Service Tax Act was passed in the Parliament on 29th March 2017 and came into effect on 1st July 2017.

In other words, Goods and Service Tax (GST) is levied on the supply of goods and services. Goods and Services Tax Law in India is a comprehensive, multi-stage, destination-based tax that is levied on every value addition. GST is a single domestic indirect tax law for the entire country.

### **Statement of the problem**

Consumers are essential to the existence of businesses. The pricing of goods is affected by taxes. This affects the buying habits of customers. A customer always buys a product that meets his needs at the lowest price. So, traders need to understand indirect taxes and how they relate. Consumer buying habits. The objective of this study is to determine relationships and customer behaviour. GST typically imposes a higher tax rate on luxury and non-essential items. This may discourage consumers from purchasing such products or least them to opt for more affordable alternatives. After the introduction of GST, the price of the branded clothes also increased. Hence this study was to analyze the impact of GST on branded clothes: An overview.

### **Objectives**

The present study has the following objectives:

1. To explore whether people prefer branded clothes even after GST.
2. To find out the impact of GST on consumer attitude towards branded clothes.

### **Review of literature**

1. **Samira Patra (2018)** In his “Impact of GST on the Prices in Odisha”, Has explored that GST will streamline indirect taxation by replacing the various taxes currently imposed by the government with a single simplified tax. GST will remove the cascading effect of taxes on the

production and distribution costs of goods and services leading to a reduction in their overall cost. It will also standardize tax rates across all states in India, ensuring uniformity.

2. **Siddaraju, H. B., & Muninarayanappa, M. (2020).** In their study “GST-Triggered Issues That Confront the Country’s Textile Sector Delays in ROSL” Explained that IGST refunds hinder capital inflow for units, highlighting a common issue in well-intentioned government schemes. While the schemes are commendable, their inefficient implementation is problematic. The delays in ROSL disbursements and IGST refunds are inexcusable. The government must ensure these delays do not negatively impact textile businesses, especially since the GST regime has brought more transparency to the sector's operations.
3. **Tomar, P., & Jain, A. (2020).** In their study “GST regime and its impact on retailers with reference to textile industry”. Have explained the Indian readymade garments industry, the second largest in the world, is significantly influenced by GST. Key aspects of GST that impact this industry include compliance costs, extensive documentation requirements, issues with the GSTN portal, and tax rates. Research identified three main factors affecting retailers' perceptions of GST: functionality, flexibility, and validity. These factors were analysed using ANOVA, with age as the independent variable and the identified factors as dependent variables. The study found a significant difference in how retailers of different ages perceive the flexibility of GST processing. Overall, while GST presents challenges to the textile industry, it is a crucial step for the Indian economy and could lead to profitability in the future.
4. **Chakraborty, S. (2018).** In his study “A study on impact of Goods and Services Tax on Indian Textile Industry” Has concluded that excise duty on cotton fabrics only 5% to 6% increase, Excise duty on synthetic textile inputs like Polyester and viscose increased to 12%, Reduction applicable to branded ready-made products Apparel has grown by 55% to 70% in retail sales Overall Impact of GST on Textile Industry and Consumers depend on the policy options available

## **Methodology**

This study is mainly based on the secondary data. These data are collected from various websites, journals and articles. The study's focus is both conceptual and descriptive.

## **Types of GST**

India currently recognizes four types of Goods service tax returns. These are:

- **Central Goods and Services Tax (CGST):** The central government collects the goods and services tax (CGST) on purchases and sales made within a state. This is done as an indirect tax to fund public services and infrastructure development
- **State Goods and Services Tax (SGST):** An SGST tax is levied by your state when you buy or sell something within it. The money collected goes toward funding community initiatives, educational initiatives, and other initiatives that benefit the state's whole population. The funds raised are used to support state programs or local needs right within the nation's borders.
- **Integrated Goods and Services Tax (IGST):** The Import Goods and Services Tax (IGST) is imposed on goods that are purchased from another state in order to streamline cross-border transactions and guarantee equitable revenue sharing among the involved states.
- **Union Territory Goods and Services Tax (UTGST):** Because UTGST is exclusively applied to sales that take place within Union Territories that are under the direct authority of the federal government, more uniform financial administration and development are made possible throughout these areas

## **Tax rate under GST**

The primary GST slabs for any regular tax payers are presently pegged **at 0% (nil-rated), 5%, 12%, 18% & 28%**. There are a few lesser-used GST rates such as **3% and 0.25%**.

Also, the composition taxable persons must pay GST at lower or nominal rates such as **1.5% or 5% or 6%** on their turnover. There is a concept of TDS and TCS under GST as well, whose rates are **2% and 1%** respectively.

These are the total GST rate of IGST for interstate supply or the addition of both CGST and SGST for intra state supply. The GST rates shall be multiplied by the assessable value of the supply to arrive at the GST amounts in a tax invoice.

Further, the GST law levies cess in addition to the above GST rates on the sale of some items such as cigarettes, tobacco, aerated water, petrol, and motor vehicles, rates widely varying from **1% to 204%**.

The GST rate structure for some of the commonly-used consumable products is given in the below table.

<b>Tax Rates</b>	<b>Products</b>
0%	Milk, Kajal, Eggs, Educational Services, Curd, Lassi, Health Services, Children’s Drawing & Colouring Books, Unpacked Foodgrains, Unbranded Atta/Maida, Unpacked Paneer, Gur, Besan, Unbranded Natural Honey, Fresh Vegetables, Salt, Prasad, Palmyra Jaggery, Phool Bhari Jhadoo, etc
5%	Sugar, Packed Paneer, Tea, Coal, Edible Oils, Raisin, Domestic LPG, Roasted Coffee Beans, PDS Kerosene, Skimmed Milk Powder, Cashew Nuts, Footwear (< Rs.500), Milk Food for Babies, Apparels (< Rs.1000), Fabric, Coir Mats, Matting & Floor Covering  Spices, Agarbatti, Mishti/Mithai (Indian Sweets), Life-saving drugs, Coffee, etc (except instant)
12%	Butter, Computers, Ghee, Processed food, Almonds, Mobiles, Fruit Juice, Preparations of Vegetables, Fruits, Nuts or other parts of Plants, including Pickle Murabba, Chutney, Jam, Jelly, Packed Coconut Water, Umbrella, etc
18%	Hair Oil, Capital goods, Toothpaste, Industrial Intermediaries, Soap, Ice-cream, Pasta, Toiletries, Corn, Flakes, Computers, Soups,  Printers, etc

28%	Small cars (+1% or 3% cess), High-end motorcycles (+15% cess), Consumer durables such as AC and fridge, Beedis are NOT included here, Luxury & sin items like BMWs, cigarettes and aerated drinks (+15% cess), etc
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### **Overview of GST on Clothes**

Value-added taxation, or GST, is a multi-phase tax that is applied to each step of the supply chain. Numerous indirect taxes, including VAT, Central Excise Duty, and Service Tax, have been substituted by it. The final value of the product, which includes the price of raw materials, production, and distribution, is where GST is applied in the case of clothing.

### **GST on clothes**

<b>Clothes</b>	<b>GST</b>
Clothes with a sale price below Rs. 1,000	No GST
Clothes with a sale price of Rs. 1,000 or more	5%
Ready-made garments	12%
Synthetic and man-made fibers and fabrics	18%

### **Suggestion**

- As the impact of GST on branded clothes is high, Indian Government authorities are empowered to reduce the GST rates applicable on essential goods, thus helping consumers to purchase essential goods at lower prices.
- The reason people want to buy branded clothes is because of their quality. However not everyone can afford them because of the price so if the price is reduced everyone can buy them.
- A reduction in GST on consumer goods will help everyone buy essential goods



## **Conclusion**

GST (Goods and Services Tax) may affect customer choices and branded clothing. Despite the introduction of GST, the survey found that consumer preferences for branded clothing have not changed significantly. In the analysis, despite the tax changes, consumers still prefer these products so for branded apparel, even after GST, there is no change.

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## **Impact of Green Adoption Practices in the Banking Performance**

**Saromi. N<sup>1</sup>, S. Sahayaselvi<sup>2\*</sup>**

<sup>1</sup>*Research Scholar, Reg. No: 21113041012001, Department of Commerce, Holy Cross College (Autonomous)  
Nagercoil - 629004.*

<sup>2</sup>*Research Supervisor, Department of Commerce, Holy Cross College (Autonomous), Nagercoil - 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.  
Email: [sn70174@gmail.com](mailto:sn70174@gmail.com). [sahayaselvi@holycrossngl.edu.in](mailto:sahayaselvi@holycrossngl.edu.in)*

### **Abstract**

This conceptual study explores the relationship between green adoption practices and banking performance, focusing on environmental, financial, and operational impacts. By reviewing current literature, the study highlights how the impact of green adoption practices such as, eco-friendly initiatives, energy efficiency, waste reduction, and sustainable product offerings, enhances environmental sustainability while simultaneously improving financial outcomes and operational efficiency. Despite initial costs and challenges, the long-term benefits of green adoption are significant, making it a crucial strategy for businesses aiming for sustainable growth and competitive advantage.

**Keywords:** Energy- efficiency, sustainability, banking performance

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### **Introduction**

Banking sector is one of the leading sectors which promote the growth of the economy of the country. Banking industry consumes natural resources more and this consumption impacted in, inner and outer emission of carbon footprints. After the awareness to safeguard our environment, banking sector takes the initial step toward to move green; hence the term green banking emerges in the banking sector. The term Green banking is a wide concept with a vast meaning. Green banking is an umbrella concept in which it comprises all the eco friendly banking activities.

### **Review of Literature**

In the financial sector, green banking practices are gaining momentum. Research by Nguyen et al. (2021) indicates that banks implementing green initiatives, such as offering green loans and promoting paperless banking, can achieve better financial performance and customer satisfaction. These practices not only help in reducing operational costs but also attract environmentally conscious

customers, thereby enhancing market competitiveness. Despite these advantages, the transition to green practices is not without challenges. Costs associated with the initial implementation of green technologies and practices can be high, which may deter some organizations from adopting them (Azevedo, Brandenburg, Carvalho, & Cruz-Machado, 2017). Furthermore, the impact of green adoption on performance can vary across different industries and organizational contexts, necessitating further research to understand these dynamics comprehensively (Daddi, Magistrelli, Frey, & Iraldo, 2011).

### **Statement of the Problem**

The problem addressed in this study is the lack of understanding about how adopting green practices impacts the performance of organizations, particularly in the banking sector. Despite the growing emphasis on sustainability, there is limited research on the effectiveness of green initiatives in enhancing operational and financial outcomes. This study seeks to explore the relationship between green adoption practices and organizational performance, aiming to provide insights that can guide businesses in implementing sustainable strategies effectively.

### **Objectives**

The general objectives of the study are to know the overview of green adoption practices and performance. The following are the specific objectives of the study.

1. To study the concept of green adoption practices
2. To study the various aspects of green adoption practice in global, in India and in Tamil Nadu.
3. To identify the impact of green adoption practices in banking performance.

### **Methodology**

The study is based on conceptual model. The data from various sources were extracted from relevant articles, websites and magazines.

### **Green Adoption Practices**

Adoption practice means the degree to which an individual is willing to employ innovation in the future and suggest it to other customers, from which the actual adoption decision is built. The Green Banking adoption model is founded on the notion of human ecology, which considers the

interdependence and interconnectedness of the elements that influence the phenomenon of environmental sustainability. These influencing variables are linked to the natural environment (Bukhari et al, 2020). The study on green adoption practices discovered that green practices had a favourable impact on financial performance (Bag et al, 2020). Many studies have mentioned that green banking adoption practices leads to a better bank performance. This can include reducing energy consumption and carbon emissions in bank buildings, using environmentally friendly materials and technologies, and implementing sustainable supply chain practices. Overall, by promoting environmentally sustainable practices and supporting green initiatives, green banking can help to create a more sustainable and environmentally responsible society.

### **Green Adoption Practices in Global**

In other countries the studies demonstrated that green banking adoption practice had a favourable impact on banks' environmental, operational, and financial performance. The data also demonstrated that green banking adoption practice has a significant impact on environmental performance, followed by operational performance and financial performance. Following increased public concern for the environment around the world, firms have been under increasing pressure to use eco-friendly procedures and produce eco-friendly products. Many developed countries, such as Germany, Japan, China, and the United States, have made significant strides in promoting renewable energy, energy efficiency, and sustainable transportation. Meanwhile, developing countries such as Brazil and India have focused on expanding access to clean energy, improving waste management practices, and conserving natural resources. Some countries, such as Costa Rica and Bhutan, have set ambitious goals to achieve net-zero emissions and promote ecological sustainability. However, many countries still face significant challenges in adopting green practices due to economic constraints, lack of political will, or inadequate infrastructure. International collaboration and support will be critical to accelerating the adoption of green practices and achieving global environmental sustainability.

### **Green Adoption Practices in India**

An increased awareness of environmental protection in India and around the world has resulted in an overwhelming response to a green trend in natural resource conservation and environmental protection, putting pressure on industries operating not just in India but also around the world. Indian companies have aligned with Intended Nationally Determined Contributions (INDC) targets, but not adopted green practices in practicing ,resulting in below expected environmental performance. Informative pressure is not prioritized over coercive techniques by enterprise and government, which are not yielding positive results. Green practices improve environmental and operational performance but reduce economic performance, as shown by statistical results (Choudhary and Sangwan, 2019). Increased awareness has been found among Indian producers as a competitive production practice and a measure of sustainable production management. Many multinational corporations have identified India as a potential market for rapid product expansion and have begun to invest extensively in the establishment of production and distribution facilities. So, India has been adopting various green adoption practices to mitigate the negative impact of human activities on the environment. These include the promotion of renewable energy, electric mobility, waste management, green buildings, afforestation, and water conservation. The government has launched various schemes and incentives to promote these practices and create a sustainable and eco-friendly environment. However, more efforts and collaborations are required to achieve the desired results and mitigate the impact of climate change.

### **Green Adoption Practices in Tamil Nadu**

Tamil Nadu has emerged as a forerunner in green adoption practices, reflecting its commitment to sustainability and environmental development. The state's proactive approach encompasses a broad spectrum of initiatives, from harnessing renewable energy sources like solar and wind power to promoting sustainable agricultural techniques such as organic and precision farming. The implementation of green building standards, comprehensive waste management systems, and water conservation measures further underscores Tamil Nadu's dedication to creating a sustainable future. Additionally, the state has embraced afforestation efforts, the development of urban green spaces,

and the adoption of electric vehicles and efficient public transportation networks. Together, these practices highlight Tamil Nadu's strategic focus on reducing its environmental footprint while fostering economic growth and enhancing the quality of life for its residents. Tamil Nadu has been proactive in adopting various green practices to promote sustainability and environmental conservation. Some notable green adoption practices in the state include:

- Renewable Energy
- Sustainable Agriculture:
- Green Buildings:
- Waste Management:
- Water Conservation:
- Afforestation and Urban Greenery
- Public Transportation:
- Industrial Initiatives

These green practices collectively contribute to Tamil Nadu's sustainable transformation, addressing environmental challenges while promoting economic development.

### **Green Banking Performance (Environmental, Financial, and Operational)**

Green banking refers to the practices and policies that banks and financial institutions adopt to support environmentally sustainable economic activities. It encompasses a wide range of activities aimed at promoting environmental sustainability through responsible banking operations, investments, and lending practices. Here's an elaborate explanation of green banking performance across environmental, financial, and operational dimensions

#### **Environmental Performance**

Green adoption practices significantly enhance environmental performance by reducing carbon emissions, minimizing waste, conserving water, and improving resource efficiency. These practices include using renewable energy, implementing recycling programs, and optimizing supply chains, which collectively lower the environmental footprint of organizations. Additionally, green practices

help in pollution control and biodiversity protection by promoting sustainable product design and eco-friendly operations. Overall, adopting green initiatives leads to a healthier environment, contributing to long-term sustainability and resilience for both businesses and the planet.

### **Financial Performance**

Green adoption practices positively impact financial performance by reducing operational costs, attracting environmentally conscious customers, and enhancing brand reputation. Implementing energy-efficient technologies and waste reduction programs lowers utility and disposal costs. Offering green financial products and services can increase customer loyalty and open up new market segments. Moreover, a strong commitment to sustainability can improve a company's image, leading to higher customer retention and potentially attracting investors who prioritize environmental responsibility. Overall, these factors contribute to increased profitability and long-term financial stability for organizations.

### **Operational Performance**

Green adoption practices significantly improve operational performance by enhancing efficiency, reducing waste, and streamlining processes. Implementing energy-efficient systems and sustainable resource management leads to lower operational costs and less resource consumption. Digital transformation and paperless operations reduce administrative burdens and improve workflow efficiency. Additionally, sustainable practices such as optimizing supply chains and adopting eco-friendly technologies can lead to more reliable and resilient operations. Overall, these improvements result in smoother, more cost-effective and environmentally responsible operational performance.

### **Conclusion**

Green banking adoption practices in banks involves more than just being environmentally beneficial. It has many financial benefits for the bank, including cost and risk reduction. Enhancing the bank's position and provide assistance of environmental protection in addition to improving the bank's reputation. By reducing the carbon footprint, promoting sustainable financing, and adopting eco-friendly operational practices, banks can significantly contribute to environmental sustainability.

Financially, green banking leads to cost savings, new revenue opportunities, and enhanced risk management. Operationally, it involves integrating sustainability into internal policies, products, services, and technological advancements. Overall, green banking is a strategic approach that aligns financial institutions with global sustainability goals, driving long-term economic and environmental benefits.

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## **Value Added Products of Palmyra Palm – An Overview**

**Maria Antony Salomiya. J and C. Braba<sup>2\*</sup>**

<sup>1</sup>*Research Scholar, Reg. No: 241120806023, Department of Commerce,*

<sup>2\*</sup>*Research Supervisor, Department of Commerce, Holy Cross College (Autonomous), Nagercoil – 629004*

*Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli – 627012.*

Email: [salosuri3@gmail.com](mailto:salosuri3@gmail.com).

### **Abstract**

Palmyra palm has great economic potential and every part of the palm is useful in one way or the other is considered as ‘kalpaga tharu’. The palm is found growing widely in southern states of India. As the value addition in palmyra is not standardized, the palmyra products viz. tender fruit endosperm (Nungu), neera, jaggery and tuber flour are not commercialized so far. Even though palmyra is an economically important palm for its nutritional aspects, it has not received proper attention, probably on account of the fact that it is very slow growing plant and mostly found in the wild state. In this context, knowing the value-added products and popularizing the same is essential.

**Keywords:** Nungu, neera, Jaggery, Tuber flour, Value addition, Palmyra palm

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### **Introduction**

Palmyra (*Borassus flabellifer* L.) belongs to family Arecaceae and order Arecales. Palmyrah belongs to very ancient family of trees. Palmyra is also known as toddy palm and sugar palm. It is a tropical palm tree which is easily cultivated and also found to grow wild. It is native to Indian sub-continent and South-East Asia. It is widely cultivated from Western India through Indo-China to the lesser Sunda Islands of Indonesia including Bangladesh, Cambodia, China South-Central, Jawa, Laos, Malaya, Myanmar, Socotra, Sri Lanka, Sulawesi, Thailand and Vietnam. The name borassus was derived from a Greek word means leathery covering of the fruit and the word flabellifer means Fan bearer. *Borassus flabellifer* is a robust tree that can live more than 100 years and reach the height of 50 to 60 meters. These can be grown in waste lands, farm filed boundaries, sea costs, parks, industrial estates and house colonies. The trunk is grey, robust and old leaves remain attached to the trunk for several years before falling cleanly. The leaves are look like fan-shaped and it grow up to 3 meters long with robust black teeth on the petiole margins. The palmyra palm throws out spathes

during the flowering season and on tapping the young inflorescence a clear, transparent, sweet, pleasant smelling and refreshing and popular drink called neera is obtained with high nutritional value, delicious taste and agreeable flavor. The tapping of neera and making it into sugar candy was observed by Chinese traveler Magestanes. The different parts of the plant such as roots, leaves, seeds and fruits are used for various purposes. Now a day's palm trees are being cut by people because of not knowing the medical and commercial values. In India, palmyra adorns the dry landscape of the semi arid regions of Tamil Nadu, Andhra Pradesh, Gujarat, Odisha, West Bengal, Bihar, Karnataka and Maharashtra. Currently, palmyra palm wealth of India is estimated as 102 million palms and half of them are in Tamil Nadu. Out of 51.90 million palms in Tamil Nadu, more than 50% of palms are concentrated in the Southern district of Thoothukudi . Government of Tamil Nadu in the year 1978 recognized Palmyrah as State Tree. Based on the pigmentation of fruit skin Palmyrah palm can be broadly classified into two varieties.

### **Review of Literature**

Selvakumar and Thanapaul (2021) have a study on “An insight into the polymeric structures in Asian palmyra (*Borassus flabellifer*. Linn)” pointed out that the palmyra palm is the most advantageous species for each component since it has economic and therapeutic value, can withstands harsh climate condition, and can fend against natural disaster. The uses of the plant can be broadly divided as non-edible, edible and value added.

Nutsuda Sumonsiri et al.,(2021) have study on “ Value added product Gummy Jelly from Palmyra Palm (*Borassus flabellifer* L.)” resulted that The results showed that up to 26% (w/w) of fruit juice (prepared by mixing the mesocarp of ripe palmyra fruit with water (at a 1:1 w/w ratio) and then removing the insoluble pulp) can be added to the gummy jelly recipe with significant effects on textural and color characteristics, as well as changes in moisture, protein, carbohydrate and energy content.

T. R. Sridevi Krishnaveni et.al., (2020) have a study on “Potential Review on Palmyra palm” introduced *Borassus flabellifer* is found to have Indian subcontinent and Southeast Asia to be

the place of origin. It is also considered to be a nature's perennial gift that could flourish well in arid and semi-arid conditions and, also could withstand any adverse climatic conditions.

Merugu Chandra Surya Rao et al., (2020) had a study on “Scope, Nutritional Importance and Value Addition in Palmyra (*Borassus flabellifer* L.): An Under Exploited Crop” concluded that the palmyra palm is one such under exploited crop having a good number of produce in fresh form (palm neera, nungu) as well as in value added form with a capacity to provide high nutritional value and having the potentiality to overcome the problem of malnutrition in developing countries like India. Palmyra palms are suitable for popularization through value addition n (tuber flour, jaggery) which helps in income generation and thus it will improve food security to the poor and livelihood security of the marginal farmers.

Renuka et al., (2018) have a study on “Phytochemical screening and evaluation of in vitro antioxidant potential for immature palmyra palm (*Borassus flabellifer*. Linn)” fruits expressed that, India which has a population of more than 125 million and is known as the “tree of life” with approximately 800 established applications, including food, beverage, fiber, medicinal, and lumber, leads the globe in the abundance of palmyra palms. It is referred to as the “Karpaha Veruksham” in tamil culture since each of its components has a specific use.

### **Statement of the problem**

Nowadays consumers are very much addicted to fast food and aware of the impact of the unhealthy food. They are also aware of the need to protect the traditional food products for the future generation. The concept of value addition of palmyra palm products is relevant as there is a need of an hour. The value addition of palmyra palm products generate economic benefits, such as helping to improve foreign exchange for, increasing the income of the people, as well as producing food, biofuels, biomass and biomaterials. In this context, this study on palmyra products becomes very important. The introduction of novel species of Palmyra palm into India's agricultural production system is critical for increasing agricultural resilience.

## **Objectives**

The main objective of the study is to create an awareness on the palmyra palm products and also to explore the possibility of value-added product from the palmyra palm.

## **Methodology**

This study is mainly based on the secondary data. These data are collected from various websites, journals, and newspaper articles. The study is descriptive & conceptual in nature.

## **Value addition of Palmyra Palm**

The value-added products of palmyra palm is edible and non-edible. Some of the edible value-added products of palmyra palm is

### **Neera (Edible Products)**

Neera, also called palm nectar extracted from the inflorescence of toddy palms which is used as a nutritious health drink. Neera is called sweet toddy since it contains zero percent alcohol and known as padaneer in Tamil Nadu and kallu in Telugu. Neera is susceptible to natural fermentation at ambient temperature within few hours of extraction due to enzymatic and microbial fermentation since it is rich in sugars, vitamins, proteins and minerals. Once fermented, neera becomes toddy which is unsuitable as health drink or as value added product. In a large scale neera production is noticed in an un-organized manner with major consumption by rural population.

### **Nungu**

The palmyra tender fruit has the outer fibrous layer containing the sugary gelatinous endosperm. Fresh tender endosperm is perishable and highly prone to postharvest losses due to spoilage as it is composed of living tissues. These tissues must be kept alive and healthy throughout the process of marketing.

### **Jaggery**

Palm jaggery is sweet and delicious. Palm jaggery gives mineral salts too. Nature has made this product in such a way that it cannot be manufactured in the Mills, it is produced in the Cottages. Where there are Palm trees, this jaggery can be easily produced.

### **Palmyra tuber flour**

Tuber is an edible shoot grown in loose soil from the seed of ripe fruit. Tuber is eaten by many people directly by cooking in open fire after peeling off outer layer. Palmyra tuber is rich in starch and fibre, which is helpful in controlling various diseases especially diabetic. Regular consumption of palmyra tuber flour increase the body strength, reduce hunger and mixing of palmyra tuber flour with other foods would positively reduce the malnutrition.

### **Palmyra Fruit**

Palmyra fruit pulp can be utilized to prepare food items and animal feed. About 40 per cent pulp is obtained from the fruit which is dark yellow in colour with a characteristic taste, flavor and bitterness. Palmyra pulp is mixed with other fruits to making jam, cordial, cream etc. As the palmyra pulp is bitter in taste, it is better to prepare mixed fruit jam instead of palmyra jam separately.

### **Palm sugar**

Palm sugar can be used as a substitute for cane sugar. To prepare palm sugar, Neera is strained from debris and it is boiled in an alloy vessel. Neera is boiled uniformly and the liquid is allowed to cool and all the sediments have to be removed. Clarification is carried out by adding triple super phosphate to form insoluble calcium calcium phosphate as it reacts with the lime which is already present. Later it is heated to a temperature of 110°C for 2 hours until it reaches honey like consistency then allowed to cool and passed through a crystallizer. After forming sugar crystals, it is centrifuged to collect sugar and dried and powdered to store.

### **Palmyra palm Jelly**

Ripe palmyra fruit pulp can be used to produce gummy jelly with significant effects on the textural and color characteristics of the product, as well as a slight increase in moisture and protein content, but a decrease in carbohydrate and energy content. Furthermore, the addition of fruit juice could also reduce the undesired adhesiveness of the final product.

## **Value addition from non- edible products**

### **Palmyra leaves products**

The tender leaves which are in ivory colour are harvested from the palm are sized into narrow strips that can be utilized for making umbrella, toys, baskets, flowers, garlands and fancy goods. Whereas, the matured leaves are used for making of containers. The harvested leaves have mid ribs that can be utilized for making of the brooms.

### **Palm leave umbrella**

Ola kuda which is also known as Palmyra leaf umbrella is one of the most unique craft of Kerala. Ola kuda were initially a status symbol in Kerala in past times. Its very difficult to find ola kuda in these days because people rarely use it.

### **Hand woven palm leaf mats**

Palm Leaf Mats beautifully crafted and are handmade mats. Only natural palm leaves are used to create these beautiful multi-purpose mats. It is durable, foldable, and can be rolled.

### **Palmyra Leaf Baskets**

Palm leaf is harvested and spread out like a fan to dry for between five to six days before being spliced with a knife into thin strips. The weavers braid the dried leaves into patterns using their hands to weave and feet to grip the base of the basket. Colorful cotton cloth and beads are sometimes used to enhance the object. Baskets were originally used for packaging gifts and containers filled with offerings to give at family functions and rituals. Baskets containing betel nut leaves and areca nuts were given to friends and people in general as a form of invitation or agreement.

### **Palmyra fibre products**

Fibre is extracted from the bifurcated base of leaf stalk. The palmyra fibre is the product that having good export market in countries like Australia and United Kingdom and Japan. The fibre obtained from palmyra palm leaf stalks is mainly valued for its high tensile strength leading itself for many industrial applications. Naar is the fibrous material obtained from stalk of the fronds. Karukku are the longitudinal splits which are obtained by soaking the stalks after removing the sharp serrated margins of the petiole which can be used for tying purpose.

## **Palmyra timber**

Palmyra timber is most valued for the construction of houses in the villages and sometimes the timber is also utilized as rafters and beams. The timber obtained from palmyra palm is also used as fire wood.

## **Conclusion**

Palmyra tree plays an important role in human life. Every part of the tree is used for preparation of various types of products and it gives more health benefits. But everyone is not aware of this tree. So, it is necessary to create awareness regarding palmyra natural (neera, nungu) and value-added products (palm sugar, honey, toddy, wine, jaggery and flour). Post harvest losses can be considerably minimized and their storage life can be greatly increased by careful manipulation of moisture content, rate of respiration and atmospheric composition. Value addition involves change in the physical form of the agricultural produce which leads to its greater acceptability, extended availability, enhanced market viability and increased cost to benefit ratio for the grower of the agricultural produce.

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## **The Cultural Identity of Kalabhras a Study**

**K. Baby**

*Assistant Professor, Department of History, Holy Cross College (Autonomous), Nagercoil – 629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

This article is an attempt to reconsider the widespread concept of a Dark Period in the Tamil-speaking South between the third and sixth centuries of the Common Era. Archaeological, epigraphical and literary evidence from the first few centuries before the common era to the seventh century are gathered here and carefully analyzed, showing no actual interruption. A decrease in the amount of data may easily be explained as the result of a change of practices—such as the use of perishable materials for buildings, for example. An important part of this article focuses on the Kaḷabhra dynasty, often thought to have been responsible for this so-called Dark Period. However, in the light of an accurate reading of peculiar passage of the Paṇḍyan copper-plates of Vēḷvikuṭi on which K.A. Nilakantha Sastri elaborated, probably for the first time, the concept of a Kaḷabhra interregnum responsible for the Dark Period, and after recontextualising this passage in the eighth-century South Indian history, it appears that the notion of a ‘break’ in the history of South India, as well as the three-century rule of an obscure dynasty, does not withstand a fact based investigation.

**Keywords:** Kaḷabhra, Interregnum, Dark Period, Paṇḍyan copper-plates

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### **Introduction**

Historians posit that the Kalabhras may have emerged from the Vellalar community of warriors, possibly former feudatories of the Cholas and Pallavas. Their roots are proposed to range from the southeast region of modern Karnataka to the Kalappalars of the Vellalar community or the Kalavar chieftains. This period is often dubbed “The Augustan age of Tamil Literature,” characterized by literary excellence despite historical ambiguity.

The origin and identity of the Kalabhras remain speculative. Theories range from their status as hill tribes rising to power to being Karnatas from the north of the Tamil-speaking region. Some historical documents link them to the Pīramalai Kallars, a formerly criminal tribe of Tamil Nadu. However, the lack of concrete evidence and the vilification of the Kalabhras in later texts complicate efforts to identify them definitively.

## **Sources**

Apart from Tamil /Navalar Charitai, a literary work which throws some light on the rule of the Kalabhras, we have a few epigraphical evidences to know about the Kalabhras.

The Kasakkudi Plates refer to Simhavishnu's quest of the Kalabhras late in the 6th century A.D. The Thiruppugalur inscription speaks of Kalappala raja by name Nerkumdrum The Korramangalam plates of Nandivarman (these refer to the Kalabhras as the enemies of Pallavamalla).The Velvikkudi plates of Nedunjadayan mention the Kalabhras who were defeated and destroyed by Kadungon in 600 A.D.) The Kuram plates of Narasimhavarman I Pallava mention his conquest of the Cholas, Keralas, Kalabhras and the Pandyas the Kalabhras might have continued to hold political power in different parts of the country. But it was only from the early 4th century A.D. to the early 7th century A.D. (their domination was perhaps at the highest). The Pallava occupation of Kanchi during the days of the Kings of the Sanskrit charters must have resulted after the Kalavar had moved southwards to overthrow the Cholas and the Pandyas.

## **The Dark Period**

The Kalabhra era is often referred to as the "dark period" of Tamil history. This nomenclature arises from the scarcity of information, with historical details primarily inferred from literature and inscriptions dating centuries after the Kalabhra rule. The dynasty's rise to power is shrouded in mystery, and their impact on the socio-political landscape is glimpsed through fragments of literature.

## **Rise and Fall**

The Kalabhras faced a decline in the 5th century, marked by the ascendance of new power centers led by the Chalukyas and Pallavas. However, conflicting views suggest that Shivaskandavarman rose in the 4th century, challenging the notion that Kalabhras were still in power at that time. Simhavishnu, a Pallava king, eventually consolidated his rule south of the Kaveri river, contributing to the end of Kalabhra dominance by the last quarter of the 6th century.

### **Epigraphs and Inscriptions**

The Pulankurichi inscription, dating back to 270 CE, is one of the earliest available records of the Kalabhras. It provides insights into the administrative divisions of the kingdom, Vedic sacrifices, and temples. Another significant epigraph is the Velvikudi grant copper plate inscription of Nedunjadaiyan, created at least 200 years after the Kalabhra rule. This inscription, though myth-laden and exaggerated, narrates the defeat of the Kalabhra king by Pandya king Kadungon.

### **Numismatics and Trade:**

Studies of coins from the Kalabhra era reveal Brahmi inscriptions in Prakrit language and diverse icons, including animals and religious symbols. Some coins depict Jain and Buddhist iconography, hinting at the dynasty's possible patronage of these religions. The sudden disappearance of mentions of Indian ports in Mediterranean texts around the mid-6th century suggests a potential link between the Kalabhra conquest and a subsequent "dark age" affecting trade.

### **Religion and Literature:**

The religious affiliation of the Kalabhras remains elusive. Some theories propose their patronage of Sramana religions, such as Buddhism and Jainism, possibly suppressing Vedic-Hinduism. Buddhadatta, a 5th-century Buddhist scholar, wrote manuals on the banks of the Kaveri River during the Kalabhra era. The twin Tamil epics, *Silappatikaram* (Jaina) and *Manimekalai* (Buddhist), were composed under Kalabhra patronage, reflecting a period of dialogue and mutual tolerance among different Indian religions.

The Kalabhra dynasty, despite its relatively brief rule, continues to captivate historians and scholars. The lack of concrete evidence, conflicting narratives, and the subsequent vilification in later texts contribute to the enduring mystery surrounding this enigmatic chapter in Tamil history.

When the political autonomy of the Sangam Tamils came to an end in the middle of the 3rd century A.D. and that from the middle of the third century A.D. to the end of the sixth century A.D. we do not hear of any Tamil dynasty ruling the Tamil country. For want of sufficient source materials, we may well conclude that period must be a dark period. During the period, the Kalabhras who ruled the whole or considerable parts of the Tamil country, after having

overpowered the traditional crowned monarchs of Tamizhagam. Later, political order was restored only when they were defeated at the hands of the Pandyas the Pallavas as well as the Chalukyas of Badami. We have as yet no definite knowledge of the Kalabhra. But we hear of a certain Accutavikkanta of the Kalabhrakula from some Buddhist books. In his reign Buddhist monasteries and authors were patronised in the Chola country. Accuta must have been a Buddhist and he should have brought about this political revolution prompted of course by religious hatred. They uprooted many adhirajas and abrogated brahmdeya rights.

### **Conclusion**

In common many of the Historians wrote about Kalabhras in their History of South India or History of Tamil Nadu book mentioned the period was dark age. After my study on that topic specially analyzed reason for the dark age even though many literary and other sources were available for the period but no monumental records and buildings spokes Kalabhra's period therefore they may mention that was dark age. But the real is non- Tamil people and also there was a confusion between their origin means that period was dark age.

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## **The role of Sensation seeking in Crime**

**V. Selva Meenakshi<sup>1</sup> and B. William Dharma Raja<sup>2</sup>**

*<sup>1</sup>. Research Scholar & <sup>2</sup>. Professor and Head, Department of Education  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli - 627012.*

### **Abstract**

There is an alarming increase in the rate of crime across the world. There are a lot of factors which leads to the criminal behavior of the individual such as economic deprivation, family disputes, unemployment, social crisis and so on. Among many of the objective factors many subjective also contributes to the criminal behaviour of the individual like biological factor of the individual, sexual abuse, personality factors, pathology. Any personality trait is likely to affect the way of our selective nature of our sensations, perceptions and cognitions. Sensation seeking is one such personality trait which is characterized by the need for varied, novel and complex sensations and experiences. Sensation seeing cannot be equate with the cognitive curiosity. One of the characteristics of high sensation seekers is their tendency to do things that lower sensation-seekers consider as too risky. Sensation seeking correlates with many of the pathology like sociopathy, Schizophrenia, Manic-depressive psychosis, Neurosis etc. Sensation seeking is characterized by risk taking for the varied and novel experiences which leads to the undesirable behavior like gambling, Drug abuse, volunteering for Risky activities, deviated sexual behaviour, rough driving and so on. The risk taking character of sensation seekers for novel experience strives to make them attempt to an extent which sometimes against laws. This paper attempts to find out the risk factors of individual with high sensation seeking indulging in the criminal behaviour. This paper also attempts to identify the various characteristic features of sensation seekers which lead to the criminal behavior for varied experiences if there is a sensory deprivation in their daily routine.

**Keywords:** Sensation seeking, criminal behavior, varied experience, Pathology

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### **Introduction**

“Crime is defined as conduct or failure to act in violation of the law forbidding or commanding it, and for which a range of possible penalties exist upon conviction. Criminal behavior, then, is behavior in violation of the criminal code. To be convicted of crime, a person must have acted intentionally and without justification or excuse” (Bartol and Bartol, 2014). Many factors contribute

to the criminal behaviour of the individual. We often attempt to explain the criminal behavior only through the eyes of psychological, environmental, biological or demographic factors have been for the most part inconsistent and unsuccessful. (Wilson & Herrnstein, 1985). A review on the research on personality types and criminal behavior indicates that there is a strong correlation between personality types and criminal behavior. Sensation seeking is one such personality types which show a strong link with the criminal behavior. (Fulper, 1988).

Sensation seeking is a trait defined by the need for varied, novel, and complex sensational experiences and the willingness to take physical, social and financial risks for the sake of such experience (Schultz, 2013). Most of the human beings seek for sensation to some extent that affords the experience within their threshold. But high sensation seekers prefer extremity for sensations in whatever activities they engage. Sensation seekers are preferable to perform jobs that are deviated from normal routine which require different dimensions. The term sensation is also used in contrast to cognition. The evidence put forward that sensation seeking cannot be equated with cognitive curiosity while it can be somehow compatible with intellectual curiosity (Zuckerman, 1979). Deprivation of sensation for high sensation seekers leads to frustration and make them deviated from social norms (Zuckerman, 2014).

Sensation seeking is the personality trait which is characterized to get bored to the usual way of life. Sensation seekers can't tolerate the daily routine activities and routine nature of jobs. Sensation seekers don't see the risk of criminal behavior as they are only concern about the thrill they pursue. High sensation seekers with higher degree of the unsocialised aspect of sensation seeking were more likely to report intentions to engage in both offense forms (Craig, 2016). Sensation seeking is only one of the traits that is related with the disorders such as mania, schizophrenia, sociopathy or phobic neurosis. Some of the common characteristic feature of sociopaths and criminals like impulsive activity, risk taking behaviour, low social anxiety also share with the same with the sensation seeking.

### **Risk Taking activities of sensation seekers**

Sensation seekers ready to volunteer for novel activities which are considered as risky by the normal persons. It is because that the sensation seeker always looking for experience deviated from usual ones which is the result of reduction as well as increase in stimulation and arousal.. The searches of novel stimulation make them to experiment the experience they can gain from using various drugs which in turn makes them addicted to drug. All novel situations cannot be considered as risky situation as normal individual tend to enjoy some novel situation without anxiety. But for sensation seekers the novel situation associated with the risk factor, instead of provoking anxiety creates curiosity and they engage in the appraised risk factor which may turn fatal to themselves and the people closer to them. Sensation seeking is a subtrait of impulsivity (Eysenck and Eysenck, 1977). Impulsivity is characterized by the tendency to act at the spur of the moment that lacks deliberation. They express immediate reaction to their thinking, feeling, wishes and show immediate emotional expression without thinking. This also leads them to go far way to take risk without thinking the consequences.

People who are low in sensation seeking exhibit risky behavior only when there is a survival need. Sensation seekers on the contrary ready to risk their life for such experience. The risk taking attitude of sensation seekers are also needed in some situation which required courageous attempt to safeguard the lives of others. Sensation seekers, even though they reduce the tension reduced by the sexual act, the same partner with the same way makes them feel less satisfied and boredom. They need more number of sexual partners and novel experience in their sexual life to make their sexual life more satisfied that may leads to risk taking behavior and also sometimes deviated from social norms. The studies also suggested that high sensation seekers also tend to have a high degree of interest in clothings. In some cases, they engage in risky behaviour affordable to buy the clothes they want. Sensation seekers are willing to choose profession which requires high risk to accomplish the task that may lead to choose two different paths. If opportunities are available, they choose to perform well in the risky jobs that result in the consequence of rewarding. Otherwise, they choose job which

is deviated from social norm that results in threatening to themselves, their loved ones and the society.

### **Sensation seeking and Psychopathic characters**

Sensation seeking is commonly related to risk taking mainly in six areas like smoking, drinking, drugs, sex, driving and gambling. (Zuckerman, 2000). Sensation Seeking is one among the many characteristic features of psychopath personalities and so the common characters of psychotics (Blackburn, 1969). There are many common characteristics for both sensation seekers and psychopaths. (Zuckerman,1994). Some of the common characters of psychopaths and sensation seekers are include impulsivity, boredom proneness, need for stimulation, promiscuous sexuality, drug and alcohol use, and consistent irresponsibility (Quayle, 2008 ). Many recurring sensation seeking characteristics are present in most of the psychopaths. The three factor model of psychopathy, proposed by Cooke and Michie (2001) proposed three factor model of psychopathy in which the Factor 2 is devoted to boredom proneness and impulsivity. The Psychopathic Personality Inventory (PPI) also allows for measurements regarding thrill seeking. It appears then, that throughout the history of psychopathy, several researchers have agreed that sensation seeking is a crucial component to put in their measurements of psychopathy. Emotional deficiency is common to both sensation seeking and psychopaths. (Herpertz & Sass, 2000). This Emotional deficiency leads to psychopaths low in arousability, so they need high stimulating behavior to increases their arousal level that makes them to engage in risky behavior.

Most of the serial killers and serial rapist are not doing crime for material benefit, they are doing that for experiencing something sensual. This is said to be sensation seeking. Most of the psychopaths show less sensitivity and fear to the consequences of their crime. One study showed that they have least emotions and that helps them to have less worried about the consequences of the crime. Sociopath's tendency to low arousal and rapid habituation to the optimal stimulation creates frustratingly low level of arousal. This makes them to crave for intense and very novel stimulation to reach the optimum level of arousal that is subjective. Ordinary stimulation and wok-activities provide low-intensity, repetitious stimulation forges the need to stir up some more excitement.



Normal criminals engage in criminal behavior for material rewards and try to minimize the risk as much as possible through proper planning and restraints. Sensation seekers often take unnecessary risk and mostly his criminal activities are mostly unaccountable in terms of material rewards.

### **Conclusion**

Sensation seekers if properly channelized by providing proper stimulus to explore novel experience can be productive to the society and to themselves. Most of the unexplored part of the earth was found out by the sensation seekers. Jobs which are considered threatening and risk by the normal individuals can be done with great enthusiasm by the high sensation seekers. But if no proper stimulation be provided there comes a problem. Lacking of empathy, low concern about the consequences, seeking for thrill, lack of concern about life, finance make them move to any extreme level to the experience they require. High sensation seekers with the tendency of sociopathic feature engage in the behavior which is threatening to the society. Thus apart from many other factors sensation seeking is one among the important factor that leads to criminal behavior. So it is necessary to identify sensation seeking in the early stage and it is mandatory to provide proper platform to explore novel experience.

### **Implications**

Proper identification of high sensation seeking should be made essential in the early stages of development. Our curriculum has to be customized according to the need of the high sensation seekers if it is necessary. Challenging task must be made available to the high sensation seekers to keep them stable. Complex and intense stimulation must be included in the teaching learning method to maintain their arousal and excitement to keep them free from boredom situation which is otherwise considered normal by the normal individual. Proper psycho education should be given as they are most of the time deviated from the normal sexual behavior and tend to have multiple partners. Proper Vocational guidance and career choices should be made available for identifying high risk jobs which give sensation seekers proper platform to explore novel experience.

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## **An Analysis of the Effectiveness of Social Work Counselors in De-Addiction Center**

**E. Sathia Raj**

*Assistant Professor, PG. Department of Social Work, Holy Cross College (Autonomous), Nagercoil-629004.  
Affiliated to Manonmaniam Sundaranar University, Tirunelveli – 627012.*

### **Abstract**

In many Indian households, alcoholism is a major problem. 10% of women and almost 40% of males in India routinely drink alcohol. India is a target market for multinational companies since it is the world's third-largest market for alcoholic beverages. Sales of alcohol have been rising at a rate of 8% per year on average, and a 12% yearly increase is predicted. In Indian cultures, alcohol misuse and the issues it brings about have become major concerns. Alcoholism causes problems with one's physical health, family conflicts, job problems, aggression, a breakdown in moral values, an ignorance of the seriousness of the situation, and a shortage of treatment facilities. All of these factors contribute to the worrisome expansion of the problem in both rural and urban areas. De-addiction facilities today are crucial to the recovery of alcoholic dependence. They participate in interventions, follow-up, counseling, and detoxification. According to the paradigm shift that has been detected in numerous research studies about alcoholism, family attitudes, behaviors, and coping mechanisms are the main factors in the treatment and rehabilitation of addiction. Since alcohol dependence considerably increases the burden of alcohol dependence syndrome, it is crucial to look at how the family responds and its own coping mechanisms to deal with the challenges brought on by the alcohol-dependent individual. The objectives of this study are to find out the role of social workers in de-addiction centres, to find out the awareness programmes in the centres, to study the screening and motivation of clients to take help, to access the aftercare treatment through counselling, to provide suitable suggestions. Thus, the researcher attempted to investigate the **study on social work counselors' effectiveness in a de-addiction center** among alcoholic dependent individuals receiving treatment in Tamil Nadu de-addiction centers. The researcher proposed conducting this study in Tamil Nadu JESUIT Ministry at Nagercoil, Kanyakumari District, which are run by the Ministry of Social Justice and Empowerment. Hence, the researcher plans to adopt a descriptive research design for the study. By using simple random sampling, the researcher intends to collect samples from the de-addiction centers. Based on the observations the findings and suggestions will be provided.

**Keywords:** Alcoholism, Alcohol abuse, Counselling and Addiction

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## **Introduction**

Abuse of alcohol and other drugs has been on the rise in India. In today's society, alcoholism is still a severe and pervasive health issue. Over time, the idea that alcoholism is a disease has become more prevalent. All alcoholics go through distinct disease stages based on the diversity of their drinking. What a fact! The moment a man begins to drink, he is unable to stop, and as a result, his entire family becomes a victim of his addiction. Alcoholism has long been a major issue of concern on a global scale. Alcohol's negative effects extend beyond an individual's physical health to include those in his immediate vicinity. According to research, men make up a sizable part of the country's alcohol consumers. They may drink to reduce their stress, but the trouble with this is that it may also cause problems for people around them in terms of social, emotional, and physical health. These constitute an additional cause of stress and further erode someone's confidence and self-esteem.

The World Health Organization (WHO) estimates that there are about 3 million people worldwide who consume alcoholic beverages, and 76.4% of those have diagnosable alcohol use disorder (2004). From a public health perspective, the global burden related to alcohol consumption, both in terms of morbidity and mortality, is considerable in most parts of the world. Alcohol consumption has health and social consequences via intoxication, alcohol dependence, and other biochemical effects of alcohol. In addition to the chronic diseases that may affect drinkers after many years of heavy use, alcohol contributes to traumatic outcomes that kill or disable at a relatively young age, resulting in the loss of many years of life due to death or disability. There is increasing evidence that, besides volume, the pattern of alcohol consumption can cause more than 60 types of disease and injury.

### **Some signs and symptoms of alcoholism, as well as alcohol abuse, include**

- Drinking alone.
- Drinking in secret.
- Not being able to limit how much alcohol is consumed.
- Blacking out - not being able to remember chunks of time.

## **De-addiction Centers**

In 1988, de addiction facilities were authorized by the Ministry of Health and Family Welfare, Government of India, taking into account this fact (Manickam, 1994). There were 18 facilities in 1988, and there are now 121 centers. In Kerala, there was only one center in 1988, but by 1998, there were 20. Each institution has 15 beds with additional space for three people who are relapsing.

## **Treatment Models**

Each centre has developed treatment packages for themselves.

TTK Model, Chennai, South India (Cherian, 1986)

TTK hospital Chennai, (Madras) had done pioneering work in de addiction in the country. This is a private centre, started as six bedded centre and now has facilities for about 45 patients.

TTK Hospital offers a comprehensive in-patient treatment programme. It also includes the involvement of the family of the addict. The treatment programme includes detoxification, intensive psychological therapy, and follow-up. Detoxification is for a period of 7 to 10 days. After detoxification, the patient undergoes an intensive 3–5-week, in-patient therapeutic programme at the hospital. Apart from individual counseling, the treatment package includes lectures, group and family therapy, dietary counseling, relaxation techniques and recreation.

This center has also developed a day care center for alcoholics (Cherian, 1986). In addition, it started camps for the detoxification and care of persons with alcohol dependence in the sub-urban villages of Tamil Nadu. (Murthy, 1992).

## **Detoxification**

When they stop drinking alcohol, the majority of patients exhibit noticeable withdrawal symptoms at the time of admission. In these situations, the right drugs are administered to treat the withdrawal symptoms. The drugs are taken off gradually over a period of time, which is typically ten to fifteen days, depending on the amount of drinking and the length of abstinence. The patient and their loved ones often stop participating in the therapy program after the withdrawal symptoms are under control. Detoxification is not "the" treatment for alcoholism, and at this point, the patient

and their loved ones need to recognize that its purpose is to get someone ready to start the healing process.

The different modalities of the package include the following therapies

**Individual psychotherapy.** Each patient gets around ten sessions of individual psychotherapy.

**Family Therapy** is provided depending on the need of each individual client.

### **Group therapy**

Although group therapy is a successful way for counseling and supporting those who are dependent on alcohol, it was not possible to offer it to everyone who was hospitalized. Fewer than five patients are frequently admitted for a dependence problem in the 35-bed psychiatric facility. However, if there are enough patients, the group can work by include individuals who are outpatients and are currently recovering. Although group therapy is quite beneficial for those who are recuperating, it was ineffective in the Vellore case because the majority of patients came from outlying areas of the country.

### **Occupational Therapy**

The patient, along with their partner or other family member, visit the occupational therapy department while they are hospitalized. The alcoholic requires a simplified atmosphere on the first day of recovery.

### **Drug Therapy**

Disulfiram (Esperol) is given at the end of the hospital stay. The topic of starting disulfiram therapy is discussed after a thorough examination of the patient's physical condition and liver functions. An initial dose of 500 mg of Disulfiram per day for two days is delivered following the patient, spouse, and/or relative completing a signed consent form for the drug's delivery. If there are no negative effects from the initial dose, it is decreased to 250 mg daily and kept at that level for one to two years. Follow-up care

### **Research Methodology**

#### **TITLE**

**“An Analysis of The Effectiveness of Social Work Counselors In De-Addiction Center ”**

### **Statement of the Problem**

Alcoholism has been described as one of the major, impairing social and mental health issues that people experience, with grave ramifications for families. Research studies highlighting family attitudes, behavior, and coping as one of the primary factors in addiction treatment and recovery led to the paradigm change in alcohol dependency from an individual to family focus. Since alcohol dependence considerably increases the burden of alcohol dependence syndrome, it is crucial to look at how the family responds and its own coping mechanisms to deal with the challenges brought on by the alcohol-dependent individual.

### **Aim**

The main aim of the study is social work counselor's efficacy in a de-addiction center.

### **Objectives**

- To study the socio-economic condition of the respondents
- To find out the role of the social worker in de-addiction centers.
- To evaluate the quality of life of those with alcohol addiction
- To find out the aftercare treatment in counseling.
- To offer suitable suggestions and recommendations .

### **Operational Definition**

#### **Alcoholics**

When a person's drinking interferes with one or all areas of his life occupation, family, finance, and inter-personal relationship, physical and mental health and in spite of this he continuous to drink, then he is an alcoholic. An alcoholic continues to drink because of physical and psychological dependence.

#### **Counselling**

There is a big difference between a professional counsellor and a person who uses some counselling skills as part of their role, for example their role as a friend or colleague. A professional



counsellor is a highly trained individual who is able to use a different range of counselling approaches with their clients.

### **Research Design**

The researcher will adopt Descriptive research design for the study, because the study aims at describing the **social work counsellor's efficacy in a de-addiction centre.**

### **Pilot Study**

The pilot study will be conducted by the researcher to know whether the research will be done in the agency. This pilot study will be useful to understand the feasibility of conducting the study.

### **Universe**

This study is based on primary data collection from persons dependent on alcohol in, JESUIT Ministry at Nagercoil, Kanyakumari District, Tamil Nadu. There are a total of 200 respondents under treatment in the years 2020–2021, and they are living sober lives.

### **Inclusion And Exclusion Criteria**

#### **Inclusion**

- The respondents must be diagnosed as alcoholic as per criteria of DSM IV.
- The respondent must be finished the treatment.

#### **Exclusion**

- The respondents admitted for detoxification
- The respondents with co-morbid symptoms
- The respondent who are not attending second time treatment.

### **Sampling**

The researcher will collect data from the persons dependent on alcohol which are coming under the treatment provided at MSJE centre. 100 respondents will be taken as samples by using Simple Random sampling method. The researcher intends to collect samples from the de-addiction centre in this study.

### **Tools for Data Collection**

The researcher uses the following tools for data collection

- Socio demographic profile
- Scale of Quality of life

### **Socio demographic profile**

Self-employing semi structure interview schedule will use to know about the socio economic and demographic condition's variables such as Age, Sex, Community, Education, Religion, Income, Family type, Domicile, Occupation etc.

### **WHO Quality of Life - BREF (WHOQOL-BREF)**

The World Health Organization Quality of Life (WHOQOL) project was initiated in 1991. The aim was to develop an international cross-culturally comparable quality of life assessment instrument. It assesses the individual's perceptions in the context of their culture and value systems, and their personal goals, standards and concerns. The WHOQOL instruments were developed collaboratively in a number of centers worldwide, and have been widely field-tested.

### **Method of Data Collection**

The required information for the study will be collected by using the Interview schedule.

### **Data Analysis and Interpretation**

After the completion of data collection from the field were edited and coded and the data were feed in the computer. The data will use SPSS software and the appropriate statistical techniques namely percentage analysis will be used.

### **Findings**

The major findings of the study are as follows;

- The majority of 78% the respondents belongs to the age between 20-30 years.
- The majority of 76% the respondents are primary school level.
- Nearby 67% of the respondents are married
- 40% of the respondents are following joint family system.

- 89% of the respondents are self employees.
- 56% of the respondent's family income is sufficient for their needs.
- 78% of the respondents never compare the present status with previous experience.
- 89% of the respondents getting physically tired in the present job as well as in their previous job.
- 86% of the respondents fulfill their needs through family members.
- 79% of the respondents are being cared by the family members during the time of illness.
- 87% have said that counselling has influenced the treatment at the treatment centre.
- 89% have said that the counsellor (social worker) has helped them very much to stop drinking.
- 72% have said that their relationship with their family members was satisfied after the treatment.
- 20% of the respondents belong to the low level of Quality of life.
- 44% of the respondents belong to the Moderate level of Quality of life.
- 36% of the respondents belong to the High level of Quality of life

### **Suggestions**

- To alert young, adults and children about the alcohol & drug awareness.
- To promote school social worker.
- The de-addiction centers must employ the social workers as Counselors
- To educate them & to accept that the addiction is a serious problem this requires professional help.
- To promote Effective positive changes towards enhancing the quality of life of Alcohol dependents. (Group Therapy)
- To promote regular Follow-up action.
- The center has take Efforts to contact patients who do not maintain follow-up.

## **Conclusion**

After trying an alcohol for the first time, a person may react in several different ways. Some people don't like the experience and never to use the drug again. Some people enjoy the experience, but they decide never to use the alcohol again. Some people might not like the experience but try the alcohol again to again. The alcohol dependents participated in group therapy to promote the psychological wellbeing. All these indicated that group therapy is effective in improving the psychological wellbeing of the alcohol dependents. Hence group therapy should be conducted for alcohol dependents in order to promote psychological wellbeing through the effort of Social work Counsellors as an Effectiveness of this study.

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