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International Conference on Sustainable Solutions in Engineering and Technology (SSET-2024)

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Track 1: Sustainable Infrastructure and Earth Sciences

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Chairman's Message

It is my distinct honor and privilege to welcome you to the International Conference on Sustainable Solutions in Engineering and Technology, hosted by Basaveshwar Engineering College. This prestigious event brings together thought leaders, researchers, and practitioners from around the globe to explore innovative solutions that address the critical challenges of sustainability in engineering and technology.

Our Sangha is deeply committed to fostering an environment of academic excellence and innovation. We believe that the interdisciplinary exchange of knowledge and ideas at this conference will lead to meaningful collaborations and impactful solutions. The topics covered here, ranging from renewable energy to sustainable infrastructure, are crucial for building a resilient and sustainable world.

The themes and discussions of this conference are more pertinent than ever as we face the dual imperatives of advancing technology and preserving our environment. I am confident that the insights and solutions that emerge from this conference will make significant contributions to our shared mission of sustainability.

I extend my heartfelt thanks to all the keynote speakers and participants for making this event successful. I congratulate the organizers for their hard work and dedication.

Dr. Veeranna C. Charantimath
Chairman,
B. V. V. Sangha, Bagalkote

Secretary's Message

As we navigate the complexities of modern development, it is imperative that we integrate sustainable practices into every facet of our technological advancements. This conference provides a vital platform for researchers, practitioners, and innovators to share their insights, discoveries, and strategies for creating sustainable solutions that will shape our future.

At Basaveshwar Engineering College, we are deeply committed to fostering an environment of academic excellence and innovation. Our goal is to drive forward the boundaries of knowledge and practice in ways that are sustainable and beneficial for society as a whole. This conference is a testament to our dedication to these principles and our belief in the power of collaborative effort.

Shri. Mahesh Athani
Hon. Secretary
B. V. V. Sangha, Bagalkote

Technical Director's Message

I am particularly excited about the innovative solutions and cutting-edge research that will be presented during this conference. The intersection of engineering and sustainability presents unique challenges and opportunities, and it is through gatherings like this that we can share knowledge, inspire innovation, and collaborate on projects that will have a profound impact on our world.

Our commitment to sustainability is not just a goal but a guiding principle that influences all aspects of our work. This conference is an ideal platform to explore new ideas, methodologies, and technologies that can lead to sustainable growth and development. The diverse array of topics and the expertise of our participants promise a rich and enlightening experience for all.

I extend my heartfelt thanks to all the participants, keynote speakers, and organizing committee members for their dedication and hard work in making this conference a reality. Your contributions are invaluable to the success of this event and to the advancement of sustainable engineering and technology.

Dr. R. N. Herkal
Director of Technical Institutes
B. V. V. Sangha, Bagalkote

Principal's Message

Dear Collegues & Researchers

I feel happy to organize International Conference titled "Sustainable Solutions in Engineering and Technology" in Basaveshwar Engineering College, Bagalkote. This prestigious event, promises to be a landmark occasion, bringing together leading experts, researchers, and innovators from around the globe.

Focus of this conference will be on exploring cutting-edge approaches and technologies that address the pressing challenges of sustainability in engineering and technology. With a diverse array of topics ranging from renewable energy solutions and sustainable materials to smart infrastructure and green manufacturing, we aim to foster collaboration and inspire breakthrough ideas. Researchers from all disciplines gather here to explore the multidisciplinary approaches in designing and implementing systems that meet present needs without compromising the needs of future generations.

Our institution is honored to be the venue for this significant event and is committed to providing an enriching experience for all participants. We are confident that the key notes from experts, presentations from researchers will lead to valuable insights and partnerships that will drive forward the agenda of sustainable development.

I extend my deepest gratitude to Management for their continued support. I thank all the Keynote speakers, participants and orgnaising committee members for their continued support and engagement in this crucial event.

Dr. Veena Soraganvi
Principal
BEC, Bagalkote

Dean (R & D)'s Message

Dear Esteemed Colleagues and Participants,

It is with great pleasure and pride that I welcome you to the International Conference on Sustainable Solutions in Engineering and Technology. This conference is a testament to our collective commitment to advancing research and innovation in ways that are both technologically forward-thinking and environmentally sustainable.

Our institution has long been at the forefront of fostering research that addresses global challenges. This conference serves as a crucial platform for sharing knowledge, exchanging ideas, and forging collaborations that can lead to sustainable advancements. The contributions from our distinguished speakers and participants are essential for driving forward the agenda of sustainable development in engineering and technology.

I extend my deepest appreciation to all the researchers, practitioners, and organizers who have worked tirelessly to make this conference a success. Your dedication and expertise is the cornerstone of this event, and your contributions are instrumental in shaping a sustainable future.

Let us seize this opportunity to collaborate, innovate, and inspire one another as we work towards sustainable solutions that will benefit not only our generation but those to come.

Dr. Mahabaleshwar S. K.
Dean (R & D) and ICT
BEC, Bagalkote

CONTENT

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INTERNATIONAL JOURNAL OF RESEARCH AND ANALYSIS IN SCIENCE AND ENGINEERING

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Track 1:

Sustainable Infrastructure and Earth Sciences

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INTERNATIONAL JOURNAL OF RESEARCH AND ANALYSIS IN SCIENCE AND ENGINEERING

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1. A Study on Geotechnical and Agricultural Properties of Sediment Deposited in TB Dam

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ABSTRACT

*This study investigates the geotechnical and agricultural properties of sediment deposited in the Tungabhadra Dam basin. Comprehensive sampling and laboratory analysis were conducted to determine grain size distribution, Atterberg limits, specific gravity, compaction characteristics, and shear strength parameters of the sediments. Additionally, the sediment's nutrient content, pH, organic matter, and cation exchange capacity were evaluated to assess its suitability for agricultural use. Results indicated a predominance of fine-grained particles, with significant variations in plasticity and shear strength across different sediment layers. The sediments exhibited low to moderate plasticity, with liquid limits ranging from 30% to 50%. Shear strength tests revealed reduced stability under saturated conditions. The sediments also exhibited favorable nutrient content and organic matter levels, suggesting potential for agricultural application. The sediment deposited in the Tungabhadra Dam basin can be repurposed for various construction activities, including highway construction and brick manufacturing. This electronic document is a "live" template and already defines the components of your paper [title, text, heads, etc.] in its style sheet. *CRITICAL: Do Not Use Symbols, Special Characters, Footnotes, or Mathin Paper Titleor Abstract. (Abstract)*

KEYWORDS:

MDD, OMC, CI, CBR, UCS

I. Introduction:

Earthy matter, fine soil carried by moving or running water and gets deposited as sediment in the basin of dam (reservoir) known as siltation. Siltation is a major problem because it reduces the water storing capacity of a particular reservoir, so it means important how perfectly we can make use of silt in present days situation Silt can be made as a foundation material by knowing the geotechnical properties of silt in the site considered. By collecting the silt deposited in Tungabhadra dam site and experimental investigation depict the overall physical behavior of the silt.

The geotechnical characterization forms a major comprehensive study aimed at defining the input parameters for suitability as foundation material. Soil investigation is carried out at a proposed dam site across Tungabhadra River near Hospet, Ballari district in Karnataka. India depends to a large extent on dams to store water from surface flow, to be used for irrigation, domestic supply, industrial supply and ground water recharge.

Most of constructed and proposed dam in the country are of earthen and gravity type because certain geological features and economy favors that kind of dam. Tungabhadra dam is a major part of water supply, electricity generation and irrigation project serving farmland in Hyderabad Karnataka region and Rayalaseema region of Andhra Pradesh.

The laboratory investigation included the measurements of the geotechnical properties of soil such as grain size analysis, Atterberg's limits, specific gravity and other properties. The experiment is conducted according to IS codes, laboratory data were analyzed and then utilized to describe and evaluate engineering characteristics of the soil.

II. Objectives of the present study:

The purpose of the report is to present the site conditions and methodology and results of geotechnical task of the study.

1. Characterize Sediment Composition and Plasticity:
2. Evaluate Shear Strength and Compaction Properties:
3. Assess the nutrient content (N, P, K), pH, organic matter
4. Evaluate the potential of using the sediment in Agricultural & construction projects such as highway subgrades, embankments, and brick manufacturing

III. Methodology:

It includes Identified and selected multiple sampling locations within the Tungabhadra Dam basin to obtain representative sediment samples. Store and transport the samples in sealed containers to prevent moisture loss and contamination. In Laboratory different test like, Grain Size Distribution, liquid limit (LL), plastic limit (PL), and calculate the plasticity index (PI).

Specific Gravity, Compaction Properties, Permeability, unconfined compressive strength test and California Bearing ratio test were conducted.

IV. Results & Discussion:

The properties of soil were determined by as per the IS code standards and the results were tabulated in the table 1. and table no 2. The geotechnical properties of the sediment suggest that it can be effectively used in construction applications such as subgrades and embankment fills.

However, its moderate plasticity and shear strength under saturated conditions necessitate stabilization measures. The sediment's favorable nutrient content, neutral pH, and moderate organic matter make it suitable for agricultural use. It can be used to enhance soil fertility in nearby agricultural lands, potentially reducing the need for chemical fertilizers.

Table no. 1 Geotechnical properties of Sediments of TB Dam

Properties	Values	Test carried out as per IS Code
Specific gravity, G	2.45	IS2720part III/Sec-1,1980
Atterberg Limits; Liquid limit, w_L (%) Plastic limit, w_P (%) Plasticity index, I_P(%)	48 22.4 25.6	IS 9256-1979 IS2720PartV,1985
Compaction characteristics; Maximum dry density, $\gamma_{dmax(g/cm^3)}$ Optimum moisture content, W_{OMC}(%)	1.63 22.4	IS2720partVII,1983
Grain size distribution; Silt & Clay(%)	60.53	IS2720part IV,1985
Unconfined compressive strength(kN/m^2)	102.29	IS2720partX,1991
Soil classification	CI	IS Soil classification
CBR (%)	7.78	IS2720partXVI
Coefficient of permeability k_t (cm/sec)	$1.005x10^{-4}$	IS2720-PART17-1986

Table no. 2 Agricultural properties of Sediments of TB Dam

No	Parameters	Protocol	Unit	Result	Permissible range	Use
1	pH	IS:2720 Part-26		6.94	It is neither acidic or alkaline.	Good for crops
2	Moisture	IS:2720 Part -18		5.12	<240kg/ha - > 480kg/ha	Transpiration
3	Conductivity	IS:14767	mS/cm	0.399	0.01-1 mS/m	Safe for agriculture
4	Available Nitrogen N	IS:14684	Kg/ha	340.6	< 10mg/kg &>50mg/kg	Faster growth

No	Parameters	Protocol	Unit	Result	Permissible range	Use
5	Available Potassium as K	IS:9497	Kg/ha	485.6	<110kg/ha &>280kg/ha	Plant growth
6	Available Phosphorous as P	MSVAL/ SOP/S-06	Kg/ha	19.6	<11.0kg/ha &>22kg/ha.	Reproduction and cell division
7	Organic matter	ISO 14235:1998:		2.5	2%- 4 %	improving water infiltration

Fig 1 TB DAM CATCHMENT

Fig 2 SAMPLE COLLECTION

Table 1 presents the geotechnical properties of sediments from the Tungabhadra Dam:

1. Specific gravity: The sediment has a specific gravity of 2.45, which is slightly lower than typical soil values (usually 2.60-2.80). This could indicate the presence of organic matter or lighter minerals.
2. Atterberg Limits: The liquid limit (48%) and plastic limit (22.4%) result in a plasticity index of 25.6%. This suggests the soil has moderate plasticity and is classified as CI (clay of intermediate plasticity).
3. Compaction characteristics: The maximum dry density of 1.63 g/cm³ and optimum moisture content of 22.4% indicate that the soil can be compacted to a reasonably dense state, but requires a significant amount of water to achieve this.
4. Grain size distribution: With 60.53% silt and clay, the sediment is predominantly fine-grained, which aligns with its classification as CI.
5. Unconfined compressive strength: At 102.29 kN/m², the sediment shows moderate strength, which could be suitable for some construction applications but may require improvement for others.
6. CBR value: The California Bearing Ratio of 7.78% suggests moderate strength for subgrade applications, but may need enhancement for use in road construction.
7. Permeability: The coefficient of permeability (1.005 x 10^{-4} cm/sec) indicates low permeability, typical of clayey soils.

Table 2 presents the agricultural properties of the sediments:

1. pH: At 6.94, the sediment is nearly neutral, which is generally favorable for most crops.
2. Moisture content: 5.12% is within an acceptable range for agricultural use.
3. Conductivity: At 0.399 mS/cm, it's within the safe range for agriculture.
4. Available Nitrogen: 340.6 kg/ha is a high value, indicating good fertility.
5. Available Potassium: 485.6 kg/ha is also high, suggesting good nutrient content.
6. Available Phosphorous: 19.6 kg/ha is within the medium range, supporting plant growth.
7. Organic matter: At 2.5%, it's within the ideal range (2-4%) for improving water infiltration and soil structure.

V. Conclusion:

Based on the present study, the following conclusions are drawn.

1. The soil is classified as Silty clay of medium plasticity (CI)
2. The geotechnical properties of soil are as specific gravity is 2.45, liquid limit 48%, plastic limit 22.4%, MDD 1.63 g/cc, OMC 22.4 %, shear strength 102.29 kN/m2, coefficient of permeability 1.005x10-4 cm/s.
3. The sediment has favorable nutrient contents
4. Neutral to slightly alkaline pH (6.5-7.5) and
5. The sediment can enhance soil fertility in agricultural lands, potentially reducing the need for chemical fertilizers and supporting sustainable agricultural practices.
6. The study highlights the potential of the Tungabhadra Dam basin sediment for dual applications, promoting sustainable management and utilization practices that enhance both geotechnical and agricultural outcomes

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2. Application of Trenchless Technology in Urban Areas

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ABSTRACT

Trenchless technology is an innovative method for constructing, repairing, and maintaining subterranean infrastructure in cities. The present study delves into the diverse uses of trenchless techniques, highlighting its importance in mitigating surface disturbance, reducing project durations, and decreasing expenses.

Important methods such pipe bursting, cured-in-place pipe (CIPP) lining, micro tunneling, and horizontal directional drilling (HDD) are covered in detail, along with their benefits and particular applications. Using case studies and performance analysis, the research illustrates the efficacy of trenchless technology in urban environments when conventional open-cut technologies are unfeasible or disruptive.

The results highlight trenchless solutions' potential to promote sustainable urban infrastructure development and guarantee little environmental impact. The ideas in the paper's conclusion address incorporating trenchless technology into urban frameworks for planning and policy to meet the rising demand for sustainable and effective infrastructure management

KEYWORDS:

Trenchless technology, subterranean infrastructure, surface disturbance, sustainable development, infrastructure management.

I. INTRODUCTION:

India is a developing country. Infrastructure development is a major factor in the development. Nearly 40% to 50% funds are reserved for infrastructure developments. For any major change or any new development at any place, the first step is that the place should be easily approachable. Trenchless technology adoption in cities has important social and environmental ramifications. Benefits of trenchless construction include lower carbon footprints (1), less disruption to traffic and business, and shorter construction times (2) (3). On the other hand, societal unrest and environmental risks are examples of secondary expenses associated with traditional construction processes (1). Sustainable methods have been suggested to lessen these effects, such as electrifying trenchless machinery to increase productivity and sustainability (4). In addition, adopting non-destructive technologies for underground network installations can support the overall aims of urban sustainability by reducing social costs and environmental impacts in metropolitan areas (5). It is possible to effectively mitigate the negative effects of trenchless technology adoption in urban settings by giving priority to sustainable practices and creative solutions.

II. OBJECTIVES:

Numerous issues arise from poorly maintained pipeline infrastructure, including:

i. Water loss via leaks in couplings and pipelines
ii. Sewer line leaks have the potential to contaminate groundwater and cause health issues.
iii. A burst pipe may cause an interruption in the water supply.
iv. A water or sewage line may choke.

Most of the earliest subterranean utility facilities are located in close proximity to the surface. Most frequently, services that are added later are incorporated into or located beneath the original installations. Traffic, business, and other services are inevitably disrupted when construction and repair work is done from the surface.

The local ecology is negatively impacted by this interruption in terms of noise, air quality, and other pollutants, as well as local vegetation and structures. The locals' quality of life is then impacted by this. In order to secure public support, more environmentally friendly technologies and methods are needed for the delivery and upkeep of safe and effective utility services. Trenchless technology—also called "no dig"—is a quickly developing technical method that does away with the necessity for surface excavation. In addition to minimizing environmental harm, trenchless technology lowers the cost of subterranean construction. Stated differently, trenchless technology offers cleaning, rehabilitation, and utility inspection services at a reasonable cost. This research is undertaken with following primary aims:

1. To document the current practices and application of trenchless technology.
2. Knowledge about the application area of various trenchless techniques
3. Study of cost estimation of trenchless projects.

III. SCOPE AND CONCEPT:

"No dig" is exactly what it sounds like. There is no digging up of roads to replace utility pipes. When there is a need for pipe rehabilitation in the middle of a busy intersection, trenchless technology allows the repair of the pipe without any excavation on the entire road. Not only does it eliminate the traffic problems but it also saves money as repairs of these roads are not needed. In traditional practice (open trench method) the focus always is on direct cost associated with the work which is mentioned on the paper but what about the hidden i.e. on direct cost? Which is much larger? The research involves attempts at the calculations of these indirect costs associated with the open trench method and then the evaluation of these two methods according to the demand of the situation. When new technologies and methods are considered as alternative construction methods there is usually hesitation and resistance in accepting new technology mainly due to unknown cost parameters.

IV. METHODOLOGY:

The tasks that are carried out to compile the data are utilized to divide this research as:

a) Literature review: To compile data on the various trenchless technology techniques, a literature review was conducted. The literature study presents the main techniques for trenchless construction and restoration and looks at the justification for trenchless technology. Reviews provide an understanding of the advantages of trenchless methods over conventional techniques, as well as the viability of typical methods based on soil conditions, pipe diameter, lengths, and materials.
b) Survey questionnaire: To ascertain the actual issues that the general public has with the road network, primarily as a result of excavation for utility construction, a questionnaire has been designed. Focusing on the core is necessary in the Kolhapur region. There is a need to concentrate on the core problems related to the excavation and finally try to convert this information gained in terms of cost. The format of the questionnaire is a very simple and objective type for the common man to understand. The information obtained should give a clear idea about their problems and their expectations.
c) Interview: A program of personal (one – on – one interview), indirect (telephonic) interviewing trenchless practitioners was conducted to gain additional insights in to experiences in this field, focusing mainly on the practices in Maharashtra (Poona region), documenting procedure, success and failures, interviewing personnel, the project intends to provide information on the different trenchless methods and document current construction practices used in Maharashtra.

V. LITERATURE REVIEW:

John Mathew (6) had presented a paper on "Utility Construction Methods Evaluation Tool (U-COMET) in March 2006. The research papers developed a U-COMET tool which is useful to make decisions on how to accomplish the installation or repair of a buried pipe in

an urban environment involving tangible and intangible parameters. The paper outlines the development of comprehensive, yet straightforward and easy to use interactive software for the evaluation of alternative construction methods that can be employed in the installation or replacements of buried pipes. Based on the specific characteristics of the problem facing the decision-maker, the software performs a preliminary screening, eliminating technologies unlikely to meet the project's requirements. U-COMET is a fully computerized algorithm for the evaluation of competing methods capable of installing, repairing or replacing buried pipes and utilities. It is a helpful tool for assisting an engineer or a contractor in selecting an optimal construction method for a particular installation. Outlooks in France regarding how are taken into account the social costs in the works of installation or rehabilitation of networks presented in July 2007 by Christian LEGAZ (7) highlighted the importance of social cost in every project. He also defines what is meant by social cost, what factor should be taken into account to calculate it and how it will affect the total cost of trenchless technology. He has done the classification of the discomfort under different heads with their respective percentage. Lastly, he concluded that in the near future, no project will be designed and budgeted without taking into account the social and environmental aspects, for the neighbors and all the citizens and users. The global cost, including these social costs, will be soon considered as the unique method for awarding contracts, and not the direct cost of the work. Grant Whittle (8) presented a paper on Application of Trenchless Technology for transportation projects on 13 Feb. 2007. He threw light on the advantages of trenchless over traditional methods with respect to rural communities, weather conditions, community disruptions, topographical site conditions, access to site live load conditions, and ultimately the environmental aspects. He also did the risk analysis of trenchless over traditional method. Seyed Behnam Hshemi (9) presented thesis on construction cost of underground infrastructure renewal :(A comparison of traditional open cut and pipe crusting technology) on December 2008 has developed model of simple regression; multiple regression to compare the cost between open cut method and pipe bursting method by studying the various parameters related to the project like pipe length, dia. Of pipe, soil conditions etc. The total cost of the particular project by using the above stated method for open-cut method and for pipe bursting method is calculated and then compared. He has taken five to six studies which shows that the trenchless methods are more beneficial than the open cut method. William M. Conway (10) presents the thesis Investigation on Trenchless Technologies and their Interaction with Native Soils (IOWA). In 2008, he studied the relation and effects of various trenchless methods on the adjacent structures, behavior of soil and on road pavements. He concluded that "The projects observed by the research team were successful overall, trenchless technologies appear to be effective methods for utility pipe installation in areas where open cut is undesirable. The experience level of the contractor is very important however and it is also important to conduct soil testing in areas of uncertain subsurface conditions. The technological improvement and growing experience will make the trenchless technique more popular. Andrew Lu (11) presented a paper on "Threat of sewer lines when using trenchless technology in October 2010. He gives the idea what will happen in cross bores situation so to go for any trenchless methods it is good to have layout plan of the existing utility networks and if not available, it should be prepared first by using camera and pipe detector etc., so it suggests practices for operators in taking a collaborative approach with other stakeholders, sewer authorities, plumbers, property owners and managers etc. Prof. Niranjan Swarup (12) presented a paper on "Evaluating Time and Cost Saving Effects of Trenchless Application" in 17th Asia Construct Conference and No Dig Show 2011.

He put forward a breakdown structure of both trenchless and open cut methods to calculate its time period and cost related to it. He tried to avoid the interdependent activities to reduce the cost due to delays. He also highlighted the impacts of various nuisances over stakeholders. Ultimately, he relates the total cost of the project with time and gives importance to timely completion of the project by using trenchless technology. S, W, Jaw (13) says that day by day it has become difficult to locate these infrastructures from the bottom up because they are invisible. The research suggests a non-excavation technique that uses digital image processing to obtain as-built data about subterranean utilities. Real model simulations and a selected test site were used for the experimental investigations. By enabling better urban planning, securing as-built information about subterranean utilities helps improve municipal sustainability. This research also shows that, with the right processing, ground penetrating radar (GPR) backscatter can provide unique signatures that help detect different kinds of subterranean utilities without the need for excavation. In addition to offering helpful information for city planning, the remarkable association between the corresponding subterranean utilities and GPR backscatter reflections highlights the enormous potential of GPR backscatter in exposing specific "feature information" of underground objects. Eeva-Sofia, Säynäjoki., Jukka, Heinonen., Seppo, Junnila. (14) states that According to their study, land use planners are unable to exploit urban planning's full potential to influence environmental sustainability on their own. Efforts to decrease individual automobile usage and building heating energy consumption by increasing urban density could result in scenarios where the alternative land-use patterns that can encourage sustainable lifestyles and lessen the overall environmental impact of all consumption are disregarded. To create better futures in the form of sustainable communities, deliberate collaboration, high and shared environmental goals, criticism of prioritizing short-term economic concerns over long-term environmental issues, and improved quantification of environmental sustainability through consumption-based approach to the environmental evaluation of land use are all necessary. In 2016, Mohamed, Salah., Soliman, Abu, Samra., Ossama, Hosny (15) stated that, when it comes to surface development and growing complexity, installing, renewing, and repairing subsurface infrastructure continues to be one of the most difficult projects across the globe. Furthermore, the requirement for a minimal disturbance to the surface is what makes it much more challenging for specialists and contractors to keep. Because of this, trenchless technology has proven to be a cost-effective option for many contractors and specialists, particularly in metropolitan locations, as it ensures lower restoration costs, a smaller social and environmental impact, and higher precision in a shorter amount of time than open cut and cover methods. The paper focuses on the range of trenchless techniques, which was essential to provide a DSS that chooses the best building technique for the project. Characteristics and environmental factors. An AHP engine was used in the creation of the suggested model, which included a wide range of parameters to enable precise construction approach options. After being technically approved by the current AHP-DSS, more work is needed to integrate a cost estimation module that considers the cost as a crucial factor in selecting the construction technique. The paper by Elwira, Tomczak., Aleksandra, Zielińska (16), had discussed the case study of Poland’s sewer network constructed in the early 1900s, which had been losing its water tightness and flow capacity. Rehabilitation efforts are carried out to restore these qualities. The trenchless method allows sewers to reclaim their initial capacity without negatively impacting the urban environment. A new internal leak proof layer is added to the sewer that is undergoing rehabilitation. This layer can stop both sewage leaks and groundwater infiltration, both of which can contaminate the surrounding area. This paper focuses on comparison between conventional open-cut trench excavation and trenchless technologies.

Two methods of trenchless rehabilitation were examined in the study: one that used cured-in-place pipe (CIPP) lining and the other that used GRP panels. Sewer flow rates and velocities before and after repair Also, selected economic and environmental aspects of sewer rehabilitation methods were examined. Junshan, Liu., Scott, Kramer., Guillermo, Provencio (17), said that new technologies and managerial techniques must constantly be incorporated into the operations of the North American construction industry. Acceptance of new techniques and technology typically happens relatively slowly for a variety of reasons. Sometimes people view the risk of using a new or untested technology or procedure as being overly elevated. With the least amount of disturbance to the surface, trenchless procedures enable the construction, enlargement, maintenance, and inspection of the majority of subterranean infrastructure systems. Trenchless technologies provide a range of tools, including closed-circuit television, robots, micro tunneling, and cured in-place lining. The key to choosing amongst these strategies is understanding what products are on the market that can satisfy the unique requirements of each owner. Being aware of the benefits and drawbacks of the trenchless. In 2020, Majed, Alinizzi., Husnain, Haider., Meshal, Almoshaogeh., Fawaz, Alharbi., S., M., Alogla., Gamal, A., Al-Saadi (18) stated that users of urban highways frequently experience difficulties as a result of subterranean infrastructure building and maintenance. Social costs (vehicle operating and traffic delay costs) are often significant at work zone construction areas (WZCA) in conventional open-cut construction. Additionally, municipalities incur extra expenses as a result of early upkeep of detours, i.e., non-work zone construction areas (NWZCA). Furthermore, the combination of work zone and non-work zone locations may have substantial socioeconomic and environmental effects. Trenchless construction reduces agency costs by avoiding early maintenance at NWZCA, in addition to causing the least amount of disruption to the current socio environmental context and saving money for users. Previous research has mostly concentrated on the societal costs related to WZCA. The study has produced a paradigm for evaluating sustainability that takes agency and user costs into account at both the work zone as well as the non-work zone. Based on the three facets of sustainability, the framework assesses several traffic detoured scenarios (for open-cut construction) and trenchless technology possibilities. The relationship between public expectations for large-scale pipeline construction projects in urban areas and the agency's sustainability objectives has been taken into account through the application of the Fuzzy Quality Function Deployment (Fuzzy QFD) method. The framework manages uncertainty pertaining to limited data and imprecise expert opinion for subjective evaluation criteria in an efficient manner. The proposed framework was applied to the case of a storm sewer construction project in the Qassim Region of Saudi Arabia in order to assess its practicality. The open-cut scenario with 50% of the traffic diverted to NWCA was deemed to be the most environmentally friendly construction option, followed by trenchless technology. The suggested approach is also being looked for to improve the way that decisions on the feasibility of trenchless technologies are made, both in Saudi Arabia and internationally. Zhihong, Xia (19) discussed the study and implementation of non-excavation large-diameter pipe-pulling construction technique in upgrading and rebuilding pipelines in high-water-level sandy areas are discussed in the article, with reference to the Xiangyang Yuliangzhou project. This innovation significantly alters the conventional excavation and road techniques, lessening the influence of the construction site on the surrounding environment. It supports national goals for environmental preservation, energy efficiency, and a low-carbon "ecological civilization" by ensuring the pipeline network operates steadily and reliably, conserving resources, and preventing secondary environmental damage. Numerous parties have acknowledged this method. It provides technical

specifications and solution data for comparable projects in the pipeline network renovation industry, guarantees the financial and safety elements of project construction, shortens the construction period, and greatly improves the efficiency and outcomes.

Therefore, current research suggests that trenchless techniques—also known as "green" techniques-are the most cost-effective when taking the project's life cycle into account.

VI. TRENCHLESS TECHNOLOGY METHODS:

Trenchless construction methods (TCM) are used for installation of new pipelines and conduits. All methods of installing new utility systems below ground without direct installation into open trench. Some methods can be used to replace, rehabilitate, upgrade or renovate where a new design life is given to existing pipeline systems. These renewal methods can also be used to replace and enlarge existing pipelines. These construction methods and Rehabilitation methods are represented in the given chart

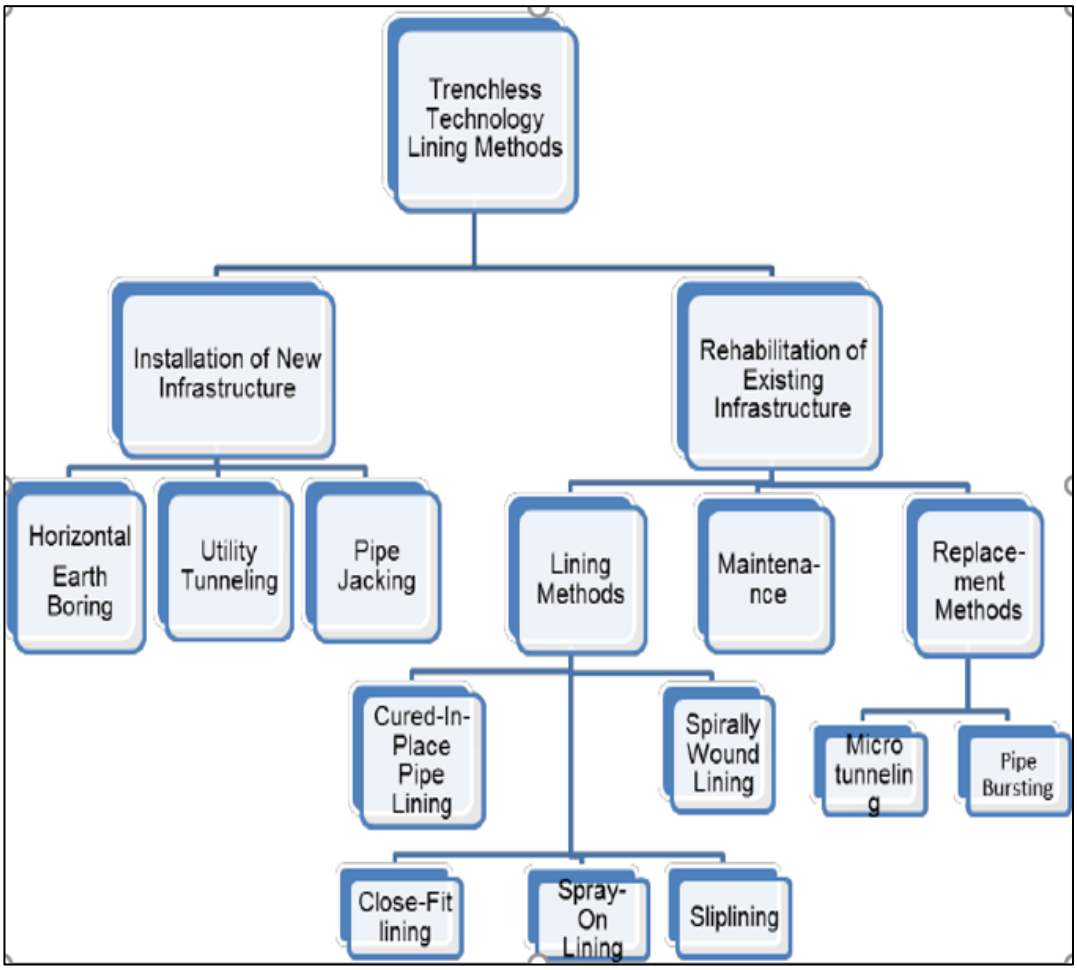

Fig. 1. Classification of Trenchless Technology Methods

VII. Result and Discussion:

A. Comparison of traditional and trenchless techniques:

Trenchless technology is defined as techniques for underground pipeline and utility construction and replacement, renewal, repair or inspection, with minimum or no excavation from the ground surface. Whereas open cut involves digging a trench along the proposed pipeline route, placing the pipe in the trench on a suitable bedding material and then backfilling. Trenchless technology reduces social or indirect cost resulting from the opening up of streets and highways to install or maintain underground utility services is debatable. Such costs fall to society at large and, in particular, the traveling public (whether foot or on wheels) who may suffer delays, disruption or even injury by such works

TABLE I. COMPARISON OF OPEN TRENCH AND TRENCHLESS METHOD

Sr. No.	Open excavation	Trenchless method
1	Large excavations	Only small starting and exit pits
2	Damaging valuable surfaces	Reduces road / pavement damage
3	Increased soil transportation to waste dumps	Reduced transport costs
4	Needs much shoring equipment noise annoyance	Reduced need for shoring equipment's reduced noise annoyance
5	Extensive traffic disturbance – detours	Avoid disturbance to traffic
6	Long duration on the construction site	Reduced duration of the construction
7	Productivity less	More productivity
8	Negative impact on the environment	Reduced the impact on the environment
9	Sometimes groundwater lowering is required	Can apply underground.
10	Increased danger of damaging neighbouring buildings and plants	Reduced danger to operation
11	Dust pollution	Green technique

B. Areas of Application:

Additionally, the selection of technology and site evaluation are key factors in increasing the effectiveness of this technique. The knowledge of the ground's characteristics and the current services network is critical to the success of subterranean construction techniques. When a site study report serves as the basis for the project design, the same holds true for trenchless techniques. Understanding the state of existing services and the ground in which they are placed or to be installed before work begins considerably improves the chances of success for any underground utility project, regardless of the construction style employed. This is especially true for trenchless projects when a site inspection report serves as the basis for project design. In open-cut projects, "the plan" typically entails problem-solving

as it arises, and the trench itself is frequently "the investigation." Currently, there is a. Numerous empirical studies have demonstrated that project management based on this approach may result in unforeseen modifications to materials and support services, delays, and in rare cases, accidents. Without a sufficient project strategy, it is difficult to foresee and reduce the environmental impact. The cost of most underground projects often increases in direct proportion to the depth of the work below the surface, according to conventional wisdom. Making any new installation as shallow as feasible and any access to an existing service as quick and straightforward as possible has therefore been the primary focus. Experience has demonstrated that there is little correlation between cost and depth for trenchless projects.

The access points that are now available can be utilized for work on the current service, and Work can be scheduled to minimize interruptions. Additionally, trenchless solutions have been developed to remotely repair damaged systems without requiring physical access. Furthermore, methods for strengthening services against ground movement brought on by earthquakes and land development exist. The kind of ground and the water table's depth can affect the technology and procedure that are selected for new projects.

Trenchless technologies enable project planners to install new services in regions where open-cut methods were previously impractical by taking advantage of the best ground conditions, regardless of depth.

Services could be placed, for instance, beneath the shear plane in locations vulnerable to land slippage or far from services can be built beneath permafrost in extremely cold climates, beneath areas of cultural or environmental significance, and beneath rivers and lakes, which historically have served as natural barriers to open-cut methods. Additionally, services can be installed beneath water channels that are susceptible to flash flooding and erosion. Greater depths for pipe installation and drilling enable for longer pipe runs with short slopes, which eliminates the need for sumps and pumping stations and simplifies designs. This makes it easier to place pipes beneath crowded subterranean spaces that are near the surface in towns and cities. As a result, trenchless technology has expanded the possibilities for any type of underground labor needed to sustain human communities. Whereas earlier research was restricted to the depth that by using safe open-cut techniques, depth is no longer a constraint. If services are already in place, they can be renovated, and if new services are needed, they can be built underneath the current infrastructure. There are definite environmental benefits to being able to "renew" and optimize subterranean systems rather than building new ones.

C. Cost Analysis:

The cost-effective construction of the pipeline project requires a clear understanding of all the cost factors associated with the specific conditions of the project. The designer must include all the cost items in the project budget. These cost categories include –Planning and engineering costs (Preconstruction cost), Direct cost, Indirect cost, social cost, Post construction cost (Operation and maintenance cost) Life cycle costs have traditionally been calculated only by considering the –Preconstruction, Construction and, Post construction cost.

TABLE II. LIFE CYCLE COST

Preconstruction	Construction	Post construction
Conceptual planning, risk and impact analysis	Direct construction cost (Labor, material and equipment)	Operation
Land acquisition	Indirect (overhead) construction costs	Maintenance
Surveying and documentation of existing and site condition	Inspection and testing cost	Depreciation
Easements	Social costs	Loss of revenue due to emergency repairs
Permits	----------	----------
Design fees and preparation of contract drawings	----------	----------

A trenchless technique may provide a realignment advantage, which may shorten the overall length of the pipeline and thereby reduce the number of manholes and eliminate pump stations, which would significantly reduce the life cycle cost of the project. If the same project is evaluated by open cut and trenchless methods, the various factors associated with the cost will have different impact on each of the method such as:

1) Cost factors for preconstruction cost:

TABLE III. PRE-CONSTRUCTION COST FACTORS

Sr. No.	Cost factor	Open cut	Trenchless
1	Field survey work and plan preparation	Major	Minor
2	Engineering and design	Major	Major to minor
3	Legal issues	Major	Major
4	Working area requirements	Major	Minor
5	Subsurface investigation requirement	Major	Major
6	Preparation of bid documents	Major	Minor

2) Cost factors during post construction:

TABLE IV. POST-CONSTRUCTION COST FACTORS

Sr. No.	Cost factor	Open cut	Trenchless
1	Mobilization and demobilization	Major	Minor
2	Shoring and sloping trench walls	Major	Minor
3	Dewatering	Major	Minor
4	Spoil removal	Major	Minor

Sr. No.	Cost factor	Open cut	Trenchless
5	Cost of detour rods	Major	Minor
6	Backfill and compaction	Major	Minor
7	Reinstatement of surface	Major	Minor
8	Construction equipment cost	Major	Minor
9	Labor costs	Major	Minor
10	Pipe material costs	Major	Major to Minor

Dependent on the type and size of the project. The construction equipment's costs are usually higher for open cut projects e.g. in a trench less pipeline renewal project, the equipment costs are minor, however, if the same project were to be constructed by on open cut method, the use of heavy trucks and excavators could be necessary and the equipment costs could be significant in open cut projects, the cost of fuel is significantly more than trench less projects.

The pipe used for pipe jacking and micro tunneling must have enough bearing capacity to take the jacking loads that are usually higher than the long-term dead and live loads exerted on the pipe. As a result, with pipe jacking and micro tunneling operations, pipe material is more expensive than open cut but a better quality and product is achieved additionally because of the arching effect of soil, the soil and traffic loads on the pipes installed with open-cut projects.

Studies have shown that owing in the cost of double handling of soil and required reinstatement of the surface for open cut projects, these costs can add up to 70 percent of the total cost of an open cut project. These reinstatement costs are usually minimal for TT installation.

3) Indirect Costs:

The indirect or overhead costs of the construction basically include all the costs that are not directly related or applied to the actual constructions. These costs are normally fixed and spread out over the entire project e.g. indirect costs include head office and job overhead costs such as taxes, temporary utilities, field supervision, traffic control and insurance. Indirect costs are usually calculated after direct costs are estimated and are most often added as a percentage of the direct costs.

The determination of indirect costs requires considerable construction knowledge and includes the greatest variation in construction cost estimating and can be approximately 20 percent of the direct cost of a utility project.

However, the indirect costs are dependent on the duration of the projects and will increase as duration of the projects and will increase as duration of the project increases. As trench less construction methods usually involve higher productivity and reduced waste, the duration of these projects is normally less than open cut projects. Trench less methods, therefore, will have less indirect costs than open – cut projects.

TABLE V. INDIRECT COST FACTORS

Sr. No.	Cost factor	Open cut	Trenchless
1	Head office costs	Major	Minor
2	Field office costs	Major	Minor
3	Field supervision cost	Major	Minor
4	Cost of temporary facilities	Major	Minor

4) Social Costs:

The social costs of construction include inconvenience to the general public and damage to the environment and existing structures. Social costs are becoming more important as the public awareness grows and the need to conserve and protect our environment and equality of life are more understood.

These needs have resulted in identification and evaluation of social costs of utility and pipeline installations. Social costs can be a major element in calculating the total lifecycle cost of a project, which to a large extent, is a function of the method of installation adopted using trenchless methods can significantly reduce social costs for open cut methods.

These cost comparisons for different construction methods need to be performed during the design stage of a project and only applicable methods with minimum overall and social cost should be advertised for contractors bid. As the contractors do not include costs into their bids, as a general use. The choice of construction method should not be left to the contractor.

The cost of open - cut construction include- Vehicular traffic disruption, Road and pavement damage, Damage to adjacent utilities, Damage to adjacent structures, Noise and vibration, Heavy construction and air pollution, Pedestrian safety, Business and trade loss, Damage to detour roads, Site and public safety, Citizen complaints, Environmental impacts.

The effect of social cost in increasing the total cost of a project is not very well understood. Some cities charge a utility-cut fee to recover some of the costs involved in the construction of utility work such as the cost of cutting and the cost of reinstating the pavement. Studies have shown that the traditional open cut method, although considered reliable, is a time consuming and inefficient method of pipe installation and renewal.

The cost and time associated with the traditional approach exceeds the estimated or bid amount due to the addition of various social and environmental costs involved, if unaccounted for in the project budget, some of these costs may show up during road maintenance by public agencies such as municipalities, which in turn, look for tax money from the general public. It is important to estimate the social costs of utility construction for using various methods of pipe installation. Government agencies and design and consulting engineers need to estimate the total life cycle with the lowest social costs. Estimates of social costs are project specific and there is no universal method or model to calculate social costs for all the conditions.

VII. CONCLUSION:

It has been demonstrated that trenchless technology is cost-effective in some situations, such as deep cutting, extended lengths, challenging terrain, and railroad crossings.

In residential regions with high population density and shallow work depths, it is also an economical option. Conventional project cost estimates sometimes overlook social expenses, which can have a big influence on the community. When comparing open-cut versus trenchless technologies, societal costs should be taken into account in high-density areas or environmentally sensitive zones. Particularly for lengthy projects, trenchless technology lessens stress, visual and environmental disturbance, and community effect. For projects to be completed on schedule, efficient project management with few and well-coordinated operations is essential. Trenchless technology also helps to cut down on activity dependencies and delays. ***"Saving the cost is itself the process of minimizing the total cost of the project."***

VIII. ACKNOWLEDGMENT:

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3. Dairy industry Effluent treatment by removal of COD by Electrocoagulation method using Aluminum and Graphite Electrodes

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ABSTRACT

The present research work focuses on the dairy effluent treatment by adopting the electrocoagulation methodby using Graphite and Aluminum electrodes. The effect of operational parameters such as pH, applied voltage and electrolysis time were studied extensively at optimum conditions. The experiment was conducted in batch process and process variables such as removal efficiency of COD. The overall removal efficiency are 68.1% at optimum operating conditions (40 min, 20V and pH 7) was obtained. It was found in the experiment that the optimum parameters the energy consumption was about0.00701 kwh/kg COD.

KEYWORDS:

Dairy wastewater, Aluminum, Graphite, COD, Electrocoagulation

1. Introduction:

If we consider, amongst the industry, in particularly dairy industry, huge amount of effluent ranging from 0.2L to 10L of waste per litre of processed milk [1]. Generally, these effluents are discharged in to rivers or reservoirs without any treatment resulting in eutrophication due to phosphorus and nitrogen compounds present in the effluent.

This yields poor water quality by consumption of dissolved oxygen and damages to aquatic life [2]. In addition to this, wastewater contains trace amount of fats and oils can cause the formation of surface films and can lead to environmental degradation when discharged in to aquatic environment. This is most essential to treat the effluents. The purpose of recycling the water to the environment to avoid the contamination [3].

The present-day dairy industries face the problems that it generates significant quantity of wastewater which contains trace amount of fat, casein and inorganic salts. These contribute high amount of BOD, COD, oil and grease which are more than discharge limits as per Central Pollution Control Board (CPCB) standards. When discharged on land wastewater will affect the soil quality and soil structure and part of wastewater can also leach to underlying groundwater and affects its original quality. As dairy products consumption increased, as the problem is more serious, when it concerns wastewater discharge without treatment from dairy or milk processing industry [4].

There are several technologies have been adopted to treat dairy waste effluent. Dairy wastewater is treated by physicochemical and biological methods to nullify the pollutants from dairy wastewater. One of the clinical methods is biological treatment which is widely used in earlier days. Dairy wastewater is generally treated using biological methods such as activated sludge process [5], Up Flow Anaerobic Sludge Blanket (UASB) reactor [6], Rotating biological contractor [7] reverse osmosis membrane [8] and anaerobic sequencing batch reactor [9]. Other than this, chemical treatments could include a secondary pollution and removal process not much effective in biological methods [10].

As the demand increases in milk and milk products, this led to study growth in the production of milk per head of cattle [11]. The wastewater generates from cleaning and washing in plants. Dairy wastewater is generally measure in terms of BOD and COD concentrations. In recent years EC treatment have been adopted slowly investigated in environmental applications, in particularly for treating water/wastewater. Amongst these methods, the most effective one of these processes is electrocoagulation (EC) which has achieved much attention due to its advantages as: (a) simple, (b)economic and (c) highly efficient, has been regarded as a potential approach [12].

Electrocoagulation (EC) is a multistep complicated process involved many chemical and physical phenomena that use consumable electrodes to supply ions in to the wastewater stream. In an EC process the coagulating ions are produced ‘in situ’ and it involves three successive stages: (1) formation of coagulants by electrolytic oxidation of the ‘sacrificial electrode’, (2) destabilization of the contaminants, particulate suspension, and breaking of emulsion and (3) aggregation of the destabilized phases to form flocks [13].

The EC method is adopted widely in treatment of different effluents like potato chips processing wastes [14], textile wastewater [15], tannery wastewater [16], slaughterhouse wastewater [17], electroplating wastewater [18] and laundry wastewater [19]. Present study, author adopted the EC method to investigates application of electrocoagulation technique in treating dairy effluents. Here author adopted the method of aluminum and graphite parallel arrangement, for the treatment of real dairy wastewater. In order to assess the influence of various operational factors, such as pH, applied cell voltage, and electrolysis time, on the removal of COD from wastewater have been conducted.

2. Materials and methods:

2.1 Effluent Analysis:

The analysis of the dairy waste effluent was measured at pH, Color and COD.

2.2 To calculate the removal efficiency after the EC treatment was carried out using the given equation (1).

Removal efficiency (%) = $\frac{I-F}{I}$ X 100…. (1)

where I denote prior to the wastewater treatment and F denotes after treatment.

The EC tests were conducted in batch process carried out in the reactor. The reactor of 150 x 100 x 100 mmsize was used.

Acrylic was used for fabricating the reactor with a maximum capacity of 1500mL, but the reactor up to 67% of total capacity was used i.e. up to 1005 mL only used in view of safety and accuracy due to safety and accurate results.

The sample of completing 1000ml was taken. One aluminium plate of size 100 x 100 x 1 mm, 100 x 100 x 1 mm of Titanium plate and 100x100x10 mm of Graphite plates were used.

The spacing between the electrodes was one cm. A DC power source (0 to 30 V and 0 to 2 A) was connected to the electrodes.

For homogeneous mixed solution, a magnetic stirrer at 180 RPM was use. After each experiment the electrodes were washed and cleaned by HCl solution.

2.4 Specific Energy Consumption Study:

Specific electrical energy consumption is defined as the amount of electrical energy consumed per unit mass of pollutant removed.

In general, energy consumption is important factor considering for any treatment of wastewater using Aluminum and Graphite electrode. The energy consumption calculated for optimum removal efficiency of COD given in (2).

$$SEEC = \frac{I\int_0^t v dt}{(X_0 - X_t)V} = \frac{Ivt}{(X_0 - X_t)V} \quad \text{.....} \quad (2)$$

Where, I is current (A), v is average cell voltage, t is electrolysis duration (hour), X0 is initial COD concentration in mg/L, Xt is final COD concentration in mg/L and V is volume of sample in litres[21].Figure 1 shows the experimental setup that was used to analyze the sample.

3. Results and discussion:

3.1 General:

The variation in the average values for the physical and chemical characteristics of the dairy effluent has been studied. After collection of the sample, without pretreating as such samples were considered for analysis. The samples were collected and analyzed for various analytical techniques like pH, turbidity, COD, BOD and color. The obtained values are tabulated in table 1.

Table – I: Average characteristics of dairy wastewater

Sl. No.	Characteristics	Value
1	pH	9
2	BOD	967.68 mg/L
3	COD	3000 mg/L
4	Turbidity	255 NTU
5	Color	Whitish

3.1 Batch Electrocoagulation using Aluminium-Graphite:

3.1.1 Effect of Different pH and voltage on COD removal at pH 9.

Graphite and aluminum (Al) and electrodes were used in batch electrocoagulation to treat effluent from the dairy and removal of COD.

In continuation of our effluent treatment, the crucial game changing parameter like pH was varied and studied extensively. Since, the pH plays vital role in influencing the EC process. The pH of the effluent was adjusted for pH5, pH7 and originally it was pH 9. The change occurred in the value of CODhave been studied. The characterizations of dairy effluent in its original form are discussed below. The Electrocoagulation run with actual pH 9.0, the removal efficiency increases with increasing the voltage from 5 to 20V. Increase in voltage result in increase in the current density. Higher the supply of voltage leads to higher generation of metal ions to enhance the coagulation process obtained sludge precipitates in greater amount at the bottom of the reactor, this result in the removal of pollutants [22]. In the first phase of decreasing pollution features, or the “reactive stage” during which the removal yield for the parameters such as CODincrease with the voltage. This can be explained by the fact that Al+3productions resulting from the anode dissolution, increases with voltage according to Faraday’s law (Eq. 3) [23]. Secondly, called here “stationary phase” is reached after 40 min of treatment during this course, it has been observed that there is increased concentration of aluminum in the reactor but there is no further variation in the wastewater concentration. Indeed, the suspended and dissolved organic matters were not eliminated in either way of the higher aluminum concentration deposited by longer periods of Al anode dissolution.At this optimum time (40 min) and at constant voltage of 20 V, the COD, with the values of 53%. The effect of applied voltage on COD is shown in figure 1,

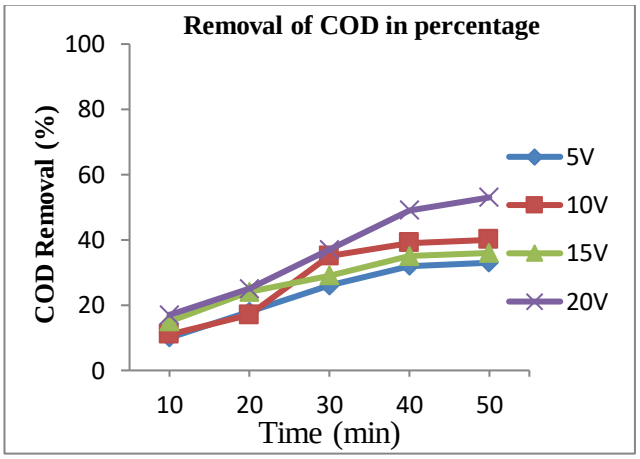

Fig 1.COD removal with ET at different voltages (pH=9)

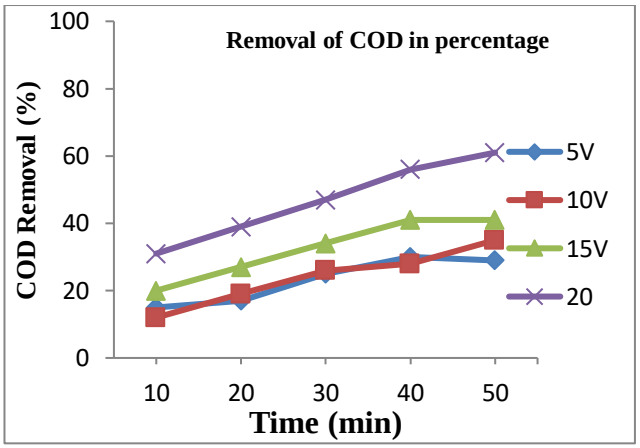

Fig.2. COD removal with ET at different voltages (pH=5)

3.1.2 Influence of Varying Voltage and Time on COD Reduction at pH 5:

As electrolysis time extends as % of COD decrement value has been increased. The percentage COD removal value was found up to 61% at 50th minute. After 50th minutes the COD values remain unchanged. The applied voltage 5 and 10V removal efficiency will follows the same trend up to 40 minutes this implies that generation of metal ions are very less for coagulation, which precipitates in lesser removal efficiency even higher the voltage applied (10V). The maximum value of removal efficiency was found at pH 5 was 61% which is highest among the pH value. The obtained results are shown in figure2.

3.1.3. Effect of Varying Voltage and Time on COD Removal at pH 7:

During EC measurement the pH 7 and the results of pH 5 were found to be better for COD reduction as illustrated in figure 4. To determine the effectiveness of COD removal, the COD values were evaluated at various voltages.

The voltage varied from 5, 10, 15 up to 20V with 10 min interval till 50 minutes. 68.1% of COD has been removed at 20V and found highest amount. All the measured samples are at 7.0 for 50 minutes. Here the voltage and ET increases, % removal of COD also increased. The obtained results are shown in figure 3.

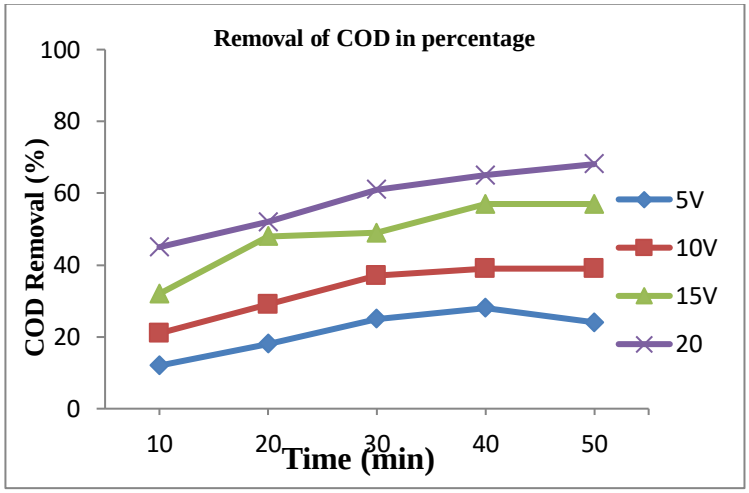

Fig. 3 COD removal with ET at different voltages (pH=7)

3.2. Specific Electrical Energy Consumption (SEEC) Study:

The specific electrical energy consumption study has been carried out by using equation 2.

The optimum energy consumption for Aluminum-Graphite at pH 7 with applied voltage 20V, was 0.00701 kwh/kg COD.

Table – 2: Specific Electrical Energy Consumption

Sl. No.	pH Value	Voltage	SEEC in kwh / kg COD
1	9.0	20	0.00891
2	5.0	20	0.00789
3	7.0	20	0.00701

Conclusion:

The present work attempted to investigate the electrocoagulation process using aluminum and graphite electrode for the treatment of dairy wastewater. Electrocoagulation is found to be an acceptable method for the treatment of dairy wastewater, according to the experimental observation. The treatment efficiency was found to be a function of pH, applied voltage and electrolysis time on the COD. The optimal operational parameters are determined at 20V, 50 minutesand pH 7.0 respectively. The highest COD removal observed at optimum condition was 68.1%.

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4. Delineation of Ground Water Recharge Zones in Hirehalla Sub Watershed Using Geographical Information Systems

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ABSTRACT

Ground water recharge is useful for mprovement of ground water augmentation. This is necessary in the regions where ground water storage or exploration is at critical level, wide variations or uncertainty in rainfall and east availability of surface water resources.

For ground water recharge, artificially, to be done, suitable recharge zones are to be identified in he study area or in the region of interest, followed by suitable recharge structure construction in the identified zones.

Further, here should be a means for quantification of recharge of ground water artificially. Conventional methods to identify favourable zones for ground water recharge, are costlier, have limited applicability and consume more ime, as geomorphology, geology, water resources availability, slope aspects of the region are to be studied extensively and spatially.

Further, spatial comparison is to be made, to analyze the ground water recharge variation trend. Hence, in such cases, GIS and Remote sensing techniques can be used to find spatial variability in recharge zones and to find favorable recharge zones.

Through remote sensing satellites mages are available, other collateral data and Geomorphology layers are integrated in GIS. In his paper, an attempt is made to illustrate the use of GIS and RS for identification of favorable ground water recharge zones.

KEYWORDS:

Remote Sensing, Geographical Information Systems (GIS), Ground water Recharge

Introduction:

Ground water is a valuable water resource, which will satisfy the water demand for irrigation and domestic purposes, especially during summer season, since during summer season the rainfall is scarce, more evaporation results in drying of surface water bodies. Such a valuable water resource is gradually depleting due to over utilization. So, now, conservation of this resource is necessary and important which is possible by ground water recharge, i,e the procedure of refilling water to the ground water table. But natural recharge is not sufficient enough to replenish the ground water draft, so, artificial recharge method has to be adopted, but artificial recharge is effective, only, if proper recharge structures are erected in regions with higher recharge rates. These regions can be delineated within economical limits using remote sensing and Geographical Information Systems (GIS) approaches. In the current paper, such a work has been presented.

I.P. Senanayake et.al, 2014, has used remote sensing and GIS methods, to delineate recharge zones in Ambalantota, Srilanka. The sites delineated were verified by indirect methods, and were found as feasible sites for recharge of Ground Water table.

Ismail Chenini et-al, 2007, has used GIS and Remote sensing techniques to delineate feasible ground water recharge sites in Ethiopia, South Africa. Here, the author, has conducted geophysical tests also and further, merged in GIS and determined the annual recharge

KrishnaMurthy et-al, 2000, has discussed about advantage of using GIS and RS techniques in to delineate feasible ground water recharge sites.

Basavaraj Hutti et-al, 2011, has used GIS and RS techniques to delineate ground water potential zones in Ghataprbha sub-basin. Here, the author, also has calculated the average annual ground water recharge to ground water table.

Objectives:

1. Delineation of ground water recharge sites in the study area.
2. Validation of ground water recharges sites identified by indirect methods.
3. Proposal for location of ground water recharge structure

Study Area:

The Study area is a sub watershed (CODE: 4D5D4) lies in Ghataprabha Sub Basin Belagavi district of Karnataka state surrounded by Raibagh, Chiccodi, Gokak and Hukkeri taluks. The geographic location of the study area is in between 74.5 degrees East, 16.4 degrees North to 75 degrees East 16.33 degrees North. The Size of the study area is 460 sqkms, consists of6 mini water sheds (4D5D4K, 4D5D4J, H, G, D, F), 37microwater sheds, and 75 villages with about 0.75 lakhs population throughout the entire sub water shed. Annual rainfall of the study area ranges from 320 mm to 661 mm. Loamy and clayey soils are dominant in the study area.

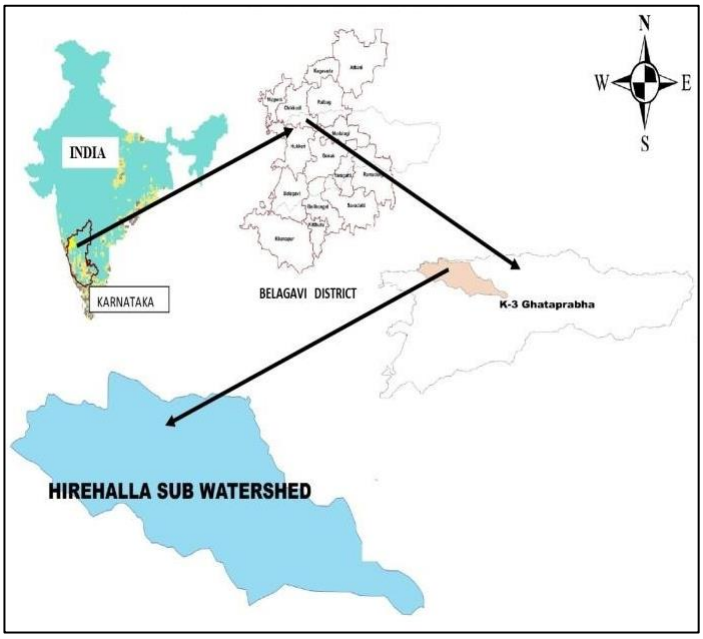

Figure-1- Key Map of Study Area

Land Use Land Cover of Study Area:

Majority area of the study region, is covered under crop land and there are about 1472 bore wells in the study area. Out of the total geographical extent of study area, about 65% is covered under cultivation (crop land) , and 20% with water bodies and plantations, the remaining 15% of the area is covered under human settlements, according to 2020 year LU/LC statistics of GOK.

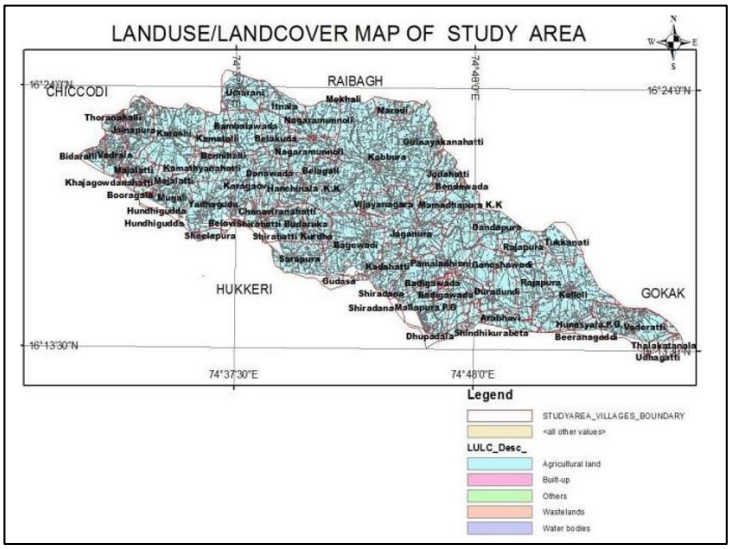

Figure-2- LU/LC Map of Study Area

Slope: 50% geographical area of the study region, falls under flat slope (0-3%), 20 % under very gentle slope (3-5%), 20% under moderate slope (5-8%) and 10% under steep slope (8% to 15%), the flat, slope, gentle and very gentle slopes are present at distance upto15km away from the stream and major drain of the study area, Hirehalla, slope % will play prominent role in Ground water potential, Ground water recharge, site selection for water harvesting structure.

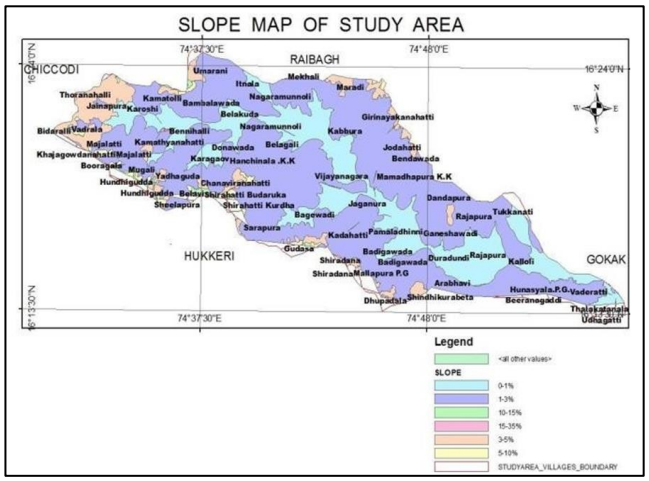

Figure-3- Slope Map of Study Area

Geomorphology: This indicates the terrain and land form profile of any region. The regions with pedi plain and plateu and canal command areas have got good ground water potential and recharge potential. Lineaments form fractured form of the region, (since lineaments are also a type of fractures), but on other part, structural hills and pediments have low ground water potential and recharge potential. Around 300 Km2 area is covered under plateau and 50 Km2 area is covered canal command.

Methodology:

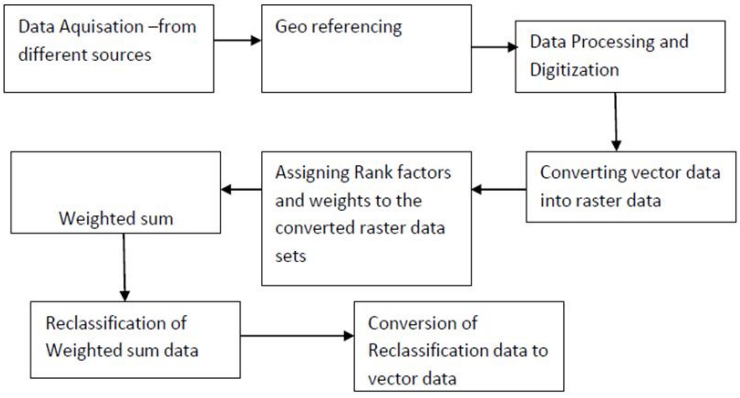

Figure-4- Methodology Flow Chart

Table-1- weights of Different Parameters in Weighted Overlay Method

Sr. No.	Parameter	Weighted Factors	Rank
1	**Slope**	**0.212**	
i	Flat (0%)		4
ii	Gentle slope (0%-3%)		3
iii	Moderate slope (3%-8%)		2
iv	Steep slope (8%>)		1
2	**Lineament**	**0.170**	
i	Lineament Density- 1.84km/sqkm		4
ii	Lineament Density- 1.5-1.84 km/sqkm		3
iii	Lineament Density- 1.2-1.5 km/sqkm		2
iv	Lineament Density- 1.0-1.2 km/sqkm		1
3	**Geomorphology**	**0.200**	
i	Canal Command Area		4
ii	Pediment /pediplain		3
iii	Plateau/dissected		2
iv	Structural hills		1
4	**Soil**	**0.125**	
i	Sandy soil		4
ii	Loamy skeletol		3
iii	Clayey soil		2
iv	Very fine soil		1

Data acquisition stage involves collection of thematic layers such as soil, slope, LU/LC , drainage and administrative boundaries in the shape file format (from KSRSAC) and topo sheets from SOI on 1:50,000, water shed boundaries from SLUSI,.

The topo sheets and SLUSLI maps are geo referenced with respect to WGS -84 datum, UTM 43N projection with GCS coordinate system. In the data processing stage, all shape files were converted to raster data in ARC GIS 10.8 software, these raster data features were assigned with ranks, according to the suitability for recharge site.

Higher rank indicates higher suitability. Weighted factors were assigned to each layer, according to Saaty scale of importance and their influence on ground water recharge, higher weightage indicates higher influence.

Using ranks and weights, CSI is calculated and based on CSI value, suitability status is decided.

Now, Composite suitability Index =CSI= ∑Rank Factors X Weight Factors, CSI value ranges from 1 (poor) to 3.5 (good)

Result and Discussions:

Very Good Recharge Zone area =3.5 sqkm. Good recharge zones area=155 sqkm, Moderate recharge zones area = 186.03 sqkm, Poor recharge zones area=35 sqkm (Obtained from ARCGIS 10.8 version software). Average recharge % is 15% of rainfall (**According to Ground water recharge Assessment Paper Values, Published by Nagraj Patil and Purundara.B.K**), average rainfall =661mm, average recharge depth=0.15 X 661 mm = 100 mm, so, total volume of recharge = 3.5X 106 X 0.1 = 350000 cubic .meters = 0.35 MCM, good recharge zones area=155 sqkm=155 X 106 X 0.1 = 15.5 MCM, very good recharge zones 0.35 MCM, for moderate recharge zone, recharge volume = 18.6 MCM.

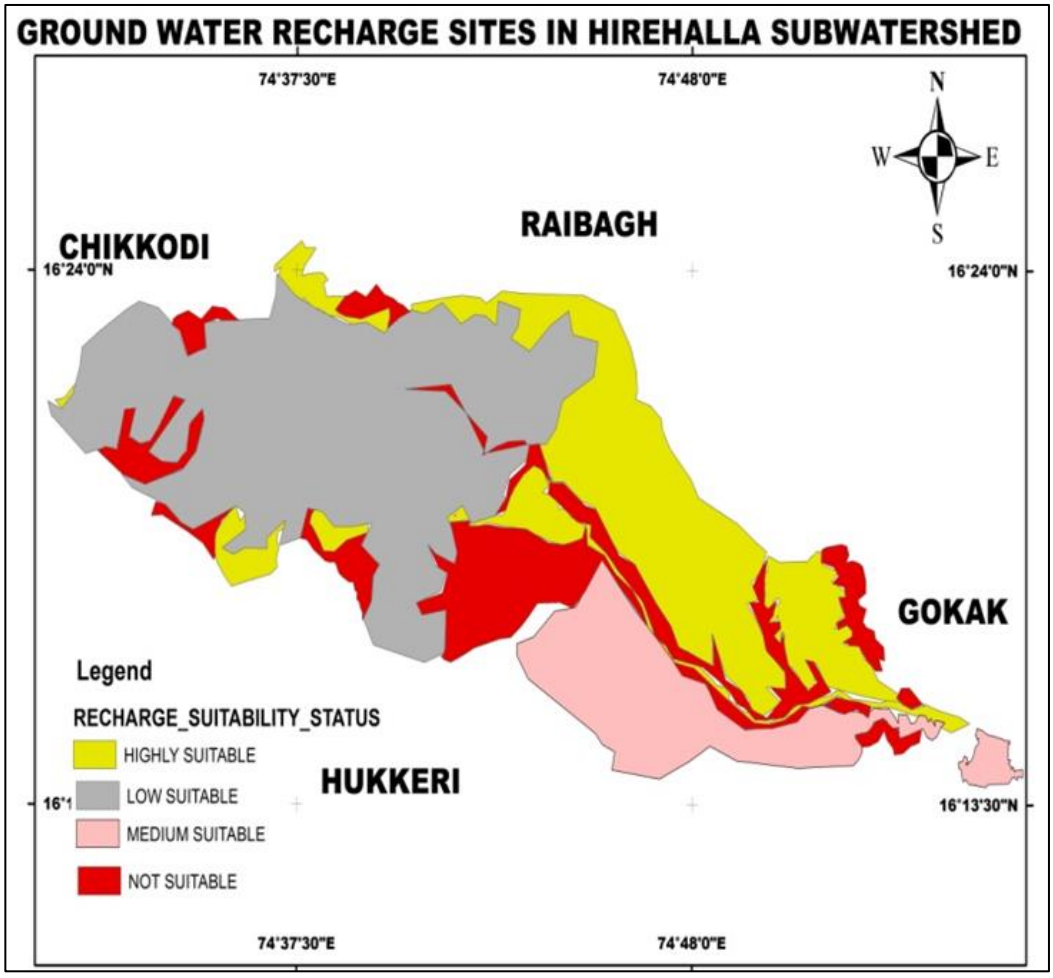

Figure-5- Ground Water Recharges Sites in Study Area

Indirect methods such as finding lineament length, counting the number of open wells or bore wells, will be helpful in assessing the adequacy of the delineated sites for ground water recharge. In this section, the values of few such methods have been discussed.

Table-2- Parameters Considered for Validation of Recharge Sites Delineated, by Indirect Methods- Good Sites for Ground Water Recharge

A) Lineament Length (KM)	
Lineament Length	40
B) Ground Water Fluctuation:	
Average Ground Water Fluctuation	4M
c) YEILD OF AQUIFER	
Yield of Aquifer (LPS)	4
Number of open wells	780

Table-3- Parameters Considered for Validation of Recharge Sites Delineated, by Indirect Methods- Poor Sites for Ground Water Recharge

A) Lineament Length (KM)	
Lineament Length	10
B) Ground Water Fluctuation:	
Average Fluctuation	1.8M
C) YEILD OF AQUIFER	
Yield of Aquifer (LPS)	1
Number of Open wells	53

In good recharge zones, the lineament length is 40 km. This length is more than, the lineament length (10 Km) in poor recharge zones. Recharge zones are more effective with higher lineament length. Similarly, the average ground water fluctuation in good recharge potential zone is 4 m, but in poor ground water recharge potential zones, it is 1.8 m, good recharge zones have higher ground water fluctuation rate. Also, yield of well in good recharge zone is 4 LPS, but in the wells located in poor ground water recharge zones, the yield of well is 1 LPS. These were the values obtained for different parameters used to assess the correctness of the delineated recharge sites. These observations indicate that, the sites delineated as recharge sites for ground water recharge are adequate.

Finding Appropriate Location for Recharge Structure:

Recharge structure has to be provided in the regions with low recharge levels. Here, focus is given on low recharge area, since here ground water potential is low, fluctuation of ground water levels is low, recharge of ground water level is also low due to

fine soils, lineament length is only 10 KM, but number of open wells=53, so here, the abstraction of ground water is more, so recharge is essential. Here, since, the soil type is almost clayey, injection wells shall be provided in the areas with low recharge.

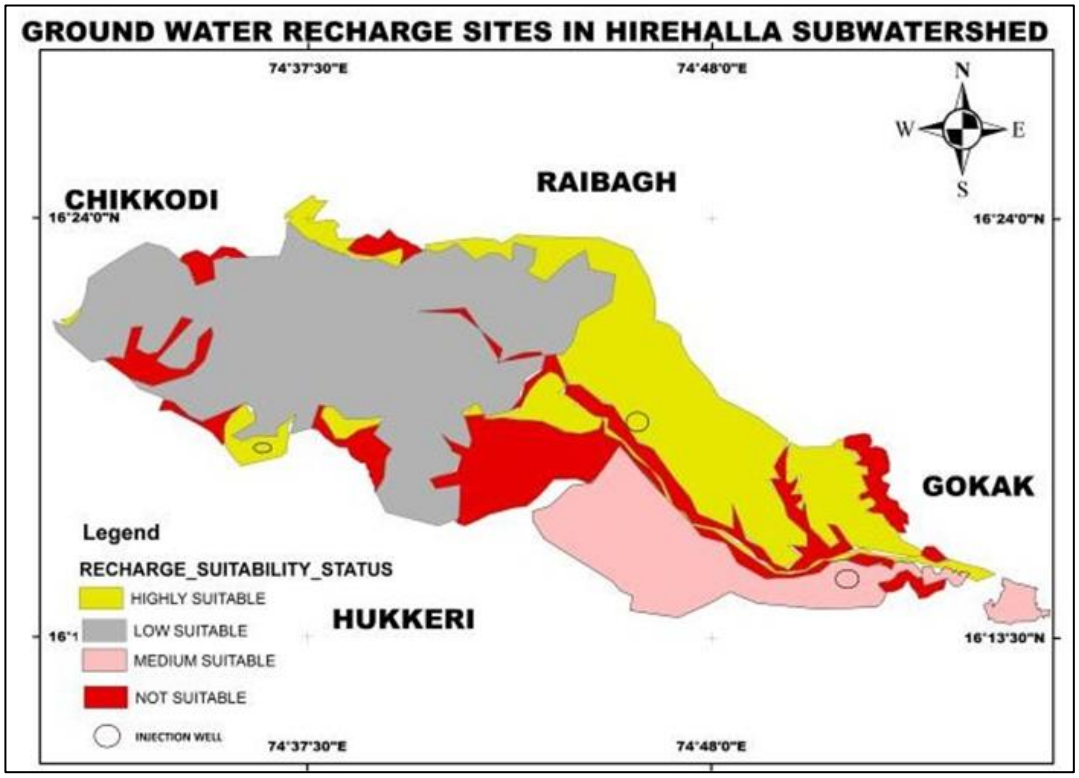

Figure-6- Ground Water Recharges Sites in Study Area with Proposed Injection Well Locations.

Conclusions:

In the present study, GIS is used in identification of Ground water recharge sites, around 40% of the study area, falls in good ground water recharge zones, 8% of the study area falls in poor groundwater zones and 52 % of the study area falls under moderate ground water recharge zones, Focus should be given for poor ground water recharge zones, to improve ground water potential in such zones. The suitable location of recharge is proposed I in the form of check dam and injection wells.

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5. Influence of Quarry Dust and Demolished Soil on Strength Properties Including Compressive Stress-Strain Behavior of Rammed Earth

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ABSTRACT

Rammed earth is monolithic structure formed by compacting the natural soil in progressive layers. It is widely used in the construction industry. Nowadays rammed earth wall construction is fashion to construct the load bearing walls, floors, sub-base material in roadways, airport runways, taxiways, foundations and earthen bund by using natural soil and cement. Cement is used to stabilize the rammed earth structure.

In the present work natural soil is replaced partially by quarry dust and demolished soil to improve the properties compared to the specimen made by natural soil, also to utilize the quarry waste. Natural soil, quarry dust, demolished soil, cement and water are used as ingredients of stabilized rammed earth specimens.

Effort is made to replace the natural soil partially by quarry dust and demolished soil to study the influence on strength properties through an experimental programme. Mechanical properties such as compressive strength, flexural strength, split tensile strength and stress-stain relationships are studied for chosen three densities both in dry and saturated specimens. It is observed that the mechanical properties for three densities (16, 17, 18 kN/m3) considered are improved for specimens prepared by using quarry dust and demolished soil.

KEYWORDS:

natural soil; quarry dust; demolished soil

1. Introduction:

Now a days cement stabilized rammed earth (CSRE) are more popular because, since the last 5 decades cement is used for the stabilizing the soil in Australia and part of the United States of America. The addition of cement in soil significantly improves compressive strength, water-borne deterioration, and general durability and robustness. OPC (Ordinary Portland Cement) is added to the soil in the range of 4 to 12% by mass. The rammed earth wall is composed of several layers of earth. The earth is poured loose in layers of 10–15 cm thick into a metal or timber formwork, which is then rammed with a rammer (manual or pneumatic). After the compaction, each layer thickness is typically 6–10 cm.

The procedure is repeated until completion of the rammed earth wall. Present days Stabilization of rammed earth is most important to improve the physical properties rammed earth. Stabilized rammed earth can be done by adding the cement, otherwise by adding the quarry dust, lime, bitumen and sodium silicate fly ash, etc. For example, stabilizing the rammed earth soil by using the cement is common accepted in Australia. By stabilizing rammed earth improve the durability, strength [14].

Stabilized soil is, in general, a composite material that results from combination and optimization of properties in individual constituent materials. Well-stabilized techniques of soil stabilization are often used to obtain geotechnical materials improved through the addition into soil of such cementing agents as Portland cement, lime, asphalt, etc [2].

Replacement of natural soil, aggregates, and cement with solid industrial by-product is highly desirable. In some cases, a by-product is inferior to traditional earthen materials. Due to its lower cost, however, it makes an attractive alternative if adequate performance can obtain. In other cases, a by-product may have attributes superior to those traditional earthen materials. Often selected materials are added to industrial by-products to generate a material with well-controlled and superior properties [4].

During the manufacture of coarse aggregates, boulders are crushed to aggregates and simultaneously quarry dust will generate as a by-product. Roughly around 200 million tons of quarry dust is produced annually [1]. There's always an issue with the disposal of such a large quantity disposal of quarry dust because of their environmental and health hazards [13]. There's always a scope for finding effective utilization of the quarry dust in the construction and in turn eradicating the possible environmental problem [3].

Natural soil is used for constructing the rammed earth wall, but now a day's cement is used for stabilizing natural soil to improve the properties of rammed earth wall. Use of the natural soil extensively may result shortage in forth coming days hence there is need think about alternative material which can replace partially to construct the rammed earth wall and also improving the strength properties. In present study quarry dust and demolished soil are used as alternative material and also compare the strength properties.

The specimens are prepared by natural soil with cement, this type of soil is known as S1 and also specimens prepared by reconstituted soil (natural soil + quarry dust + demolished soil) with cement known as S2 type of soil

2. Experimental investigation:

2.1 Materials used:

Materials are natural soil, quarry dust, demolished soil and cement discussed below. All the materials are taken in Karnataka in India and their properties are shown in Table 1.

2.1.1 Natural soil:

In this work the natural soil used was collected from village Halkurki land of Bagalkot district in Karnataka, collected at a depth of 60 cm below the ground surface. The natural soil to be used in the present study for evaluating engineering properties will be replaced partially by quarry dust and demolished soil for the construction of rammed earth walls shall be studied.

2.1.2 Quarry dust:

Quarry waste is produced during the process of crushing operations of the boulders. Roughly around 20–25% of the total output is generated as quarry dust. The process of crushing stone consists of blasting, primary crushing, secondary crushing, screening and stockpiling. Around 200 million tons of quarry by-product will be generated every year in India [1]. The quarry dust is collected from Kolahar quarry, Vijaypur District Karnataka. In this work natural soil is partially replaced by quarry waste of 25%.

2.1.3 Demolished soil:

Demolished soil is collected from the buildings demolished during UKP Project at Bagalkot (Karnataka). In this present study demolished soil is used to replace the 25% amount of natural soil and also to preserve the environment.

2.1.4 Reconstituted soil:

Reconstituted soil is a mixture of the natural soil quarry dust, demolished soil and cement. The clay content for rammed earth walls is 5% to 20% by mass [14].

By adding quarry dust and demolished soil in the natural soil the clay content decreases 13.5% to 10% which is in the range mentioned above. By replacing natural soil with both the quarry dust and demolished soil the natural soil can be saved and also environment is preserved by reusing the demolished materials. The proportion of thereconstituted soil chosen for the present study is based on the work of [15-16] and also the criterion of the reconstituted soil meets the requirements mentioned in the Table 1and the proportion is given in Table 2.

2.1.5 Cement:

Type of cement used shall be 43 grade Ordinary Portland Cement conforming to IS:12269 (2009) code is used to prepare the rammed earth samples [5].

2.1.6 Water: Potable water shall be used for preparing rammed earth samples.

2.2 Test conducted in laboratory:

2.2.1 Particle size analysis:

Particle size analysis were determined in accordance with the Indian standard methods - IS: 2720 (Part 4) –1985[8]. Clay and silt content and partial size are found through this test for both type of soil (S1 and S2).

Table 1: Properties of Natural soil, Quarry dust, Demolished soil and Reconstituted soil

Test conducted	Description	Natural soil	Quarry dust	Demolished soil	Reconstituted soil
Particle size analysis	Sand (4.75-0.75mm)	54.00%	67.00%	67.50%	64.00%
	Silt (0.75-0.002)	32.50%	30.25%	23.50%	26.00%
	Clay(<0.002mm)	13.50%	2.75%	9.00%	10.00%
Atterberg limits	Plastic limit (%)	28.48	15.15	26.80	19.50
	Liquid limit (%)	32.50	28.15	36.65	28.75
	Plasticity Index (%)	4.02	13.00	9.85	9.25
Specific Gravity	-	2.6	2.875	2.45	2.75
Compaction properties with cement	MDD (kN/m^3)	18	-	-	18.45
	OMC (%)	17.20	-	-	15.00
pH	-	8.15	9.90	7.50	9.00

Table 2: Details of mix proportion for reconstituted soil

Natural Soil:	Quarry dust:	Demolished soil:	Cement:	Water
1.0	0.5	0.5	0.2	0.33

2.2.2 Atterberg limits:

The Atterberg consistency limits were determined in accordance with the Indian standard methods - IS: 2720(Part V) 1985 [9]. The soil was sieved through 425micron.Soilis retained through that sieve. The soils, then, oven dried for 24 hours before the test. The test carried out for both type of soil (S1 and S2)

2.2.3 Compaction test:

Compaction test is conducted to determine the optimum moisture content (OMC) and dry density relationship as per IS 2720 (1980). In this present study dry density find out by light compaction only. This test carried out for both soils i.e. natural soil and reconstituted soil [10].

2.2.4 Specific gravity test:

This experiment is carried out by Pycnometer method as per IS 2720 Part III Sec 2 1980 for natural soil, quarry dust, demolished soil [7].

The pH values are found out by Electrometric pH meter by means of an electrode assembly consisting of one glass electrode and one calomel reference electrode with a wet potassium chloride solution. 30 g of the soil sample passing 425 microns was taken in a 100ml beaker with 75ml of distilled water and suspension is stirred for a few seconds and allowed to stand for one hour. The sample is stirred well again before testing following as per IS: 2720 (Part 26) - 1987. Carried out for both type of soil [6]

2.2.6 Compressive strength test:

Compression test was carried for both (S1 and S2) of Cylinder specimens of 150 mm diameter and 300 mm height are used for thepresent study at 16, 17, 18 kN/m3 similarly also for split tensile test and flexural test, to ascertain the compressive strength and stress-strain characteristics. A weighed quantity of partially wet soil-cement mixture for S1 and natural soil, quarry dust, demolished soil and cement mixture for S2 was fed into the mould in 3 layers; each layer was rammed to achieve 100mm thickness. For proper bonding between the 3 layers dents were made using damping rod. For different densities of the specimen the bulk weight of the soil mixture required for 100 mm layer was controlled by resorting weigh batching. Compression test was conducted for both wet condition and dry condition. The dry test was conducted after the oven dried the specimens at 50oC to constant weight and then allowed to cool down at the room temperature. The wet test was conducted after the 28 days curing specimens are air dried for 14 days, then specimens are soaking in water for attended the constant weight. The experimental setup is shown in the Fig 1.The mass and the dimensions of the specimens were recorded prior to the testing. The specimens were mounted in the displacement-controlled servo hydraulic testing machine for testing. The specimens were tested at the displacement rate of 3 microns per second. Moisture content of the wet specimens was monitored by oven drying samples at 110oC for 24 hours after failing.

2.2.7 Split tensile strength test:

The specimens prepared as per explained in compressive test. Split tensile test was carried for both (S1 and S2) of Cylinder specimens of 150 mm diameter and 300 mm height are used for the present study. Cylindrical specimen is mounted in to a displacement-controlled testing machine after recording mass and dimensions. The experimental set up as shown in the Fig 2.

The line load was applied through 10 mm square bar of 300 mm length mounted on diametrically opposite positions along the length of the cylinder. Using the failure load split tensile strength was determined by formula. Split tensile test was also conducted for the wet specimens by soaking the oven dried samples for 48 hours prior to the test. The specimens were tested at the displacement rate of 1.67 microns per second. Moisture content was determined by drying the samples from the failed specimens immediately after the test in an oven for 24 hours at 110oC.

2.2.8 Flexural strength test:

Beam specimens of 75 mm width 75 mm height and 300 mm length [11] are used for in this study. A weighed quantity of partially wet soil-cement mixture for S1 type of specimens and Natural soil, quarry dust, demolished soil and cement mixture for S2 type of specimens was fed into the mould in 3 layers, each layer was rammed to achieve 25 mm thickness. For proper bonding between the 3 layers dents were made using damping rod. For different densities of the specimen the bulk weight of the soil mixture required for 25 mm layer was controlled by resorting weigh batching. Curing is done similar to cylindrical specimen. S1 and S2 specimens were tested for dry as well as in wet conditions.

The dry test was conducted after the oven dried the specimens at 50oC to constant weight and then allowed to cool down at the room temperature. The wet test was conducted after the 28 days curing specimens are air dried for 14 days, then specimens are soaking in water for attended the constant weight.The experimental setup is shown in the Fig 3. The test specimens were placed on steel plates spaced at distance 3 times the depth of the beam turning the beam with original top and bottom surfaces as moulded perpendicular to the testing machine. Load applying block assembly was placed on the surface at the third points between the supports. The specimens were tested at the displacement rate of 1.67 microns per second. Moisture content of the specimens was determined by drying the samples from failed specimens in an oven for 24 hours at 110oC.

3. Results and discussion:

S1 and S2 type soil specimens tested under two extreme conditions of dry and wet state [15-16]. The compressive strength including compressive stress-strain behavior, split tensile strength and flexural strength are discussed below.

3.1 Compressive strength, split tensile strength and flexural strength of rammed earth specimens:

Table 3gives the details of dry density, compressive strength, and strain value. Table 4 gives details of split tensile strength and ratio of spilt tensile strength to compressive strength and Table 5 flexural strength, maximum deflection at peak load. The aim is to maintain the dry densities of specimen at 16, 17 and 18 kN/m3. However, the dry densities of the specimens tested were in the narrow range of 16.09-16.16 kN/m3, 17.11-17.2 kN/m3 and 18.1-18.32 kN/m3 for S1 type of specimens and for S2 type of specimens 16.1-16.24 kN/m3, 17.21-17.46 kN/m3 and 18.08-18.35 kN/m3. Three samples were tested in each case. The results recorded are average of three tests for each parameter measured.

Fig 1: Compressive strength test setup.

Fig 2: Split tensile strength test setup.

Fig 3: Flexural strength test setup.

Rammed earth specimen fails in shear for compression as they are monolithic. Beams fractured in the pure bending zone of the specimen which lies in between two loading points of the test setup. Fig 4 and Fig 5 shows the typical failure pattern of compression and split tensile tests for cylinders respectively.Fig 6shows the failure pattern of flexural tests for beam.

3.1.1 Compressive strength of rammed earth specimens (fc):

At 16 kN/m3 density the compressive strength of S1 type is 1.67 MPa and 0.71 MPa for dry and wet cases respectively, similarly for S2 type is 2.51 MPa and 1.26 MPa for dry and wet cases respectively. Whereas for 17 kN/m3 density the strengths of S1 type are 2.93 MPa and 0.91 MPa for dry and wet cases respectively and that of S2 type are 4.75 MPa and 1.96 MPa for dry and wet cases respectively. At 18 kN/m3 density the compressive strength of S1 type is 4.14 MPa and 1.88 MPa for dry and wet cases respectively, similarly for S2 type is 5.28 MPa and 2.70 MPa for dry and wet cases respectively. These results show that the wet strength of S1 type of specimen is about 46% of dry strength and for S2 specimen type it is about 51% of dry strength. The results clearly indicate the influence of density and moisture content on strength of S1 and S2 type of soil specimens. The S1 and S2 type of specimens when wet lose the strength by half of dry specimen. This can be attributed to the presence of clay minerals in the mix, which soften upon soaking in water. Investigations show a wet to dry strength ratio of 0.3-0.5 and 0.4-0.6 for S1 and S2 type of specimens respectively and moisture content of both (S1 and S2) specimens shown in Fig 7.

At the highest density of the specimens the dry strength is 4.14 MPa and 5.28 MPa for S1 and S2 type respectively. The dry compressive strength for S2 type is increased by 28% of strength of S1 type of specimen. Similarly, the wet strength is 1.88 MPa and 2.70 MPa for S1 and S2 type respectively. The wet compressive strength for S2 type is increased by 43% of strength of S1 type of specimen, for the highest densities and further densities increment is shown in Fig 12. These results indicate that the strength is increased by adding quarry dust and demolished soil. This is because the quarry dust added is having rough texture which increases the friction between the soil particle that aids in the increasing the strength of the specimen, the demolished soil fills the voids present which in turn distributes the load properly there by contributing in the increasing the strength of the soil.

3.1.2 Split tensile strength of rammed earth specimens (ft):

The split tensile strength of S1 type of specimen for wet case is 0.06, 0.1 and 0.15 MPa respectively for 16, 17 and 18 kN/m3 specimens and for S2 type of specimen it is 0.12, 0.15 and 0.22 MPa respectively for 16, 17 and 18 kN/m3. Similarly, the dry strength is 0.09, 0.16 and 0.22MPa for 16, 17 and 18 kN/m3 density specimens respectively for S1 type of specimen and 0.15, 0.25 and 0.31 MPa for 16, 17 and 18 kN/m3 density specimens respectively for S2 type of soil. Like compressive strength, split tensile strength is sensitive to density and moisture content of specimen during testing. Split tensile strength in wet state is about 68% and 71% of strength in dry state for S1 and S2 type respectively. Considering the highest density (18 kN/m3) of S1 and S2 specimens the tensile strength is increased by 41% and 47% for dry and wet conditions respectively and also shown in Fig 13 with other two (16 and 17 kN/m3) densities.

3.1.3 Flexural strength of rammed earth specimens (R):

The flexural strength of S1 type of specimen for wet case is 0.337, 0.444 and 0.730 MPa respectively for 16, 17 and 18 kN/m3density specimens and for S2 type are 0.444, 0.515 and 0.694 MPa respectively for 16, 17 and 18 kN/m3. Similarly, the dry strength is 0.512, 0.584 and 0.798 MPa for 16, 17 and 18 kN/m3 density specimens respectively for S1 type of specimen and 0.548, 0.655 and 1.083 MPa for 16, 17 and 18 kN/m3 density specimens respectively for S2 type. Flexural strength is sensitive to density and moisture content of specimen during testing. At the highest density of the specimens the dry strength is 0.798 MPa and 1.083 MPa for S1 and S2 type respectively. The dry flexural strength for S2 type is increased by 36% of strength of S1 type of specimen. Similarly, the wet strength is 0.659MPa and 0.730MPa for S1 and S2 type respectively. The wet flexural strength for S2 type is increased by 11% of strength of S1 type of specimen. Beams fractured in

Fig 4: Typical failure pattern of cylinder specimen tested under compression.

Fig 5: Typical failure pattern of cylinder specimen tested under split tension test.

Fig 6: Typical failure pattern of beam specimen tested under flexural load.

the pure bending zone of the specimen which lies in between two loading points of the test setup and failure was sudden as rammed earth is brittle material. At the highest density of the specimens the deflections are 0.324 mm and 0.545 mm for S1 and S2 type respectively in dry condition. Similarly, in wet state the deflections are 0.154 mm and 0.177 mm for S1 and S2 type respectively. For the highest densities and further densities increment is shown in Fig 14. The results show that the deflection is increased by 68% and 15% in dry and wet state respectively.

3.2 Stress-strain characteristics of rammed earth specimens:

Stress-strain relationships for both dry and wet conditions using three different densities were generated. Fig8 and Fig 9shows the stress-strain relationships for S1 and S2specimens. Table 3gives the ultimate and peak strain values.

The stress-strain curves show a linearly varying portion initially then reaching a peak value followed by fine drooping portion. The following observations can be made from the stress-strain plots and the results are given in Table 3.

3.2.1 Strain at ultimate strength of rammed earth specimens (∈c):

At 16 kN/m3 density the strain at ultimate strength of S1 type is 0.0319 and 0.0132 for dry and wet cases respectively and 0.0248 and 0.0161 for dry and wet cases respectively for S2 type of specimen. At 17 kN/m3 density the strain at ultimate strength of S1 type is 0.0254 and 0.0223 for dry and wet cases respectively and is 0.0406 and 0.0272 for dry and wet cases respectively for S2 type of specimen. Whereas for 18 kN/m3 density the values are 0.04021 and 0.026 for dry and wet cases respectively for S1 type of specimen and 0.0573 and 0.0307 for dry and wet cases respectively for S2 type of specimen. These results show that the strain at ultimate strength of wet S1 type of specimen are about 41% 88% and 64% of dry specimen respectively for densities of 16, 17 and 18 kN/m3. Similarly, the strain at ultimate strength of wet S2 type of specimen are about 65% ,67% and 53% of dry specimen respectively for densities of 16, 17 and 18 kN/m3. At the highest density (18 kN/m3) of the specimens the strain values are 0.0402 and 0.0573 for S1 and S2 type respectively in dry condition. Similarly, in wet state the strain values are 0.0260 and 0.0307 for S1 and S2 type

respectively. The results show that the strain is increased by 43% and 19% in dry and wet state respectively for S2 type of specimen. At the middle density (17 kN/m3) of the specimens the strain values are 0.0254 and 0.0406 for S1 and S2 type respectively in dry condition. Similarly, in wet state the strain values are 0.0223 and 0.0272 for S1 and S2 type respectively.

The results show that the strain is increased by 60% and 24% in dry and wet state respectively for S2 type of specimen.At the lower density (16 kN/m3) of the specimens the strain values are 0.0191 and 0.0248 for S1 and S2 type respectively in dry condition. Similarly, in wet state the strain values are 0.0132 and 0.0161 for S1 and S2 type respectively. The results show that strain is increased by 30% and 22% in dry and wet state respectively for S2 type of specimen.

3.2.2 Strain at failure of rammed earth of soil specimens ($\in f$):

At 16 kN/m3 density the strain at failure of S1 type of soil is 0.03371 and 0.01451 for dry and wet cases respectively and 0.02776 and 0.027312 for dry and wet cases respectively for S2 type of specimen. At 17 kN/m3 density the strain at failure of S1 type of specimen is 0.0281 and 0.024 for dry and wet cases respectively and is 0.04258 and 0.03084 for dry and wet cases respectively for S2 type of specimen.

Whereas for 18 kN/m3 density the values are 0.04121 and 0.027 for dry and wet cases respectively for S1 type of soil and 0.05813 and 0.0334 for dry and wet cases respectively for S2 type of specimen.

These results show that the strain at failure of wet specimen is about 43%, 85% and 66% of dry specimen for 16, 17 kN/m3 and 18 kN/m3 densities respectively for S1 type. Similarly, the strain at failure of wet specimen are about 98%, 72% and 58% of dry specimen for 16, 17 and 18 kN/m3 densities respectively for S2 type.

The results of strain values indicate higher straining capacity in dry condition. This can be attributed to the fact that in wet state the clay softens and loses the ability to absorb energy during straining process.

3.3 Deflection at peak load of rammed earth specimens:

Fig 10and Fig 11 shows the load-deflection curves for S1 and S2 specimens. Table 5 gives the flexural strength and deflection at maximum loads. The load-deflection curves show a reaching a peak value followed by fine drooping portion. The following observations can be made from the load-deflection plots and the results are given in Table 5.

At 16 kN/m3 density the deflection of S1 type is 0.224 mm and 0.118 mm for dry and wet cases respectively and is 0.447 mm and 0.225 mm for dry and wet cases respectively for S2 type of specimen. At 17 kN/m3 density the deflection of S1 type is 0.251 mm and 0.147 mm for dry and wet cases respectively and is 0.305 mm and 0.198 mm for dry and wet cases respectively for S2 type of specimen. For 18 kN/m3 density the deflections are 0.324 mm and 0.154 mm for dry and wet cases respectively for S1 type of specimen and 0.545 mm and 0.177 mm for dry and wet cases respectively for S2 type of specimen. These results

show that the deflection at maximum load of wet S1 type of specimen are about 52%, 59% and 48% of dry specimen respectively for densities of 16, 17 and 18 kN/m3. Similarly, the deflection at maximum load of wet S2 type of specimen are about 50%, 65% and 33% of dry specimen respectively for densities of 16, 17 and 18 kN/m3. At the highest density (18 kN/m3) of the specimens the strain values are 0.324 and 0.545 for S1 and S2 type respectively in dry condition. Similarly, in wet state the strain values are 0.154 and 0.178 for S1 and S2 type respectively. The results show that the strain is increased by 68% and 16% in dry and wet state respectively for S2 type.

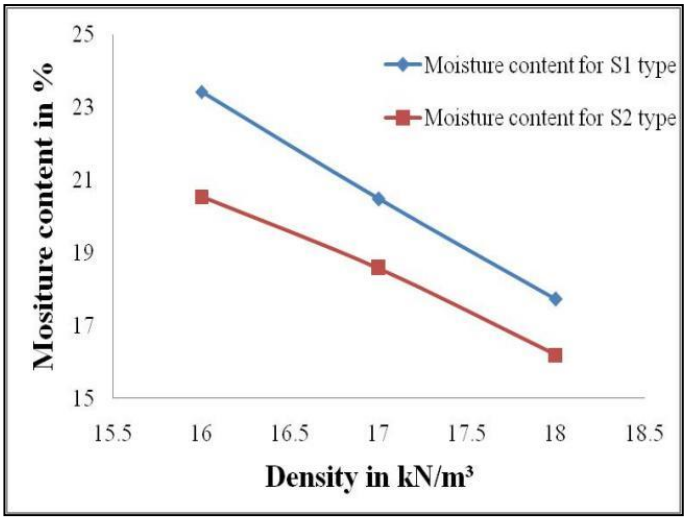

Fig 7: Moisture content curve for variations densities

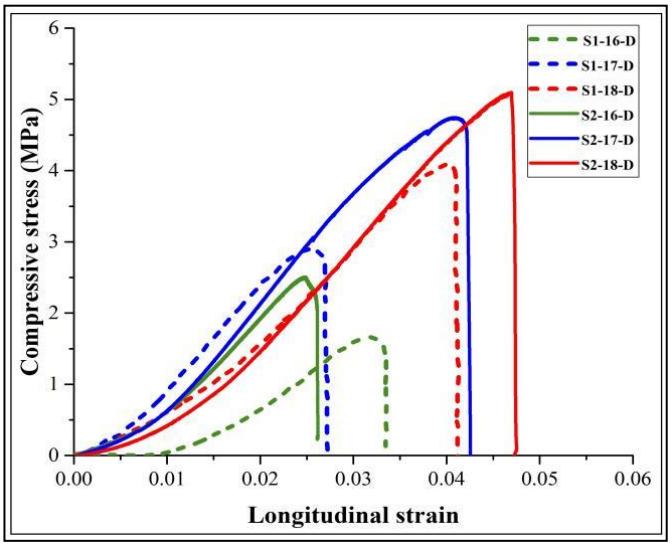

Fig 8: Stress-strain relationship for S1 and S2 type under compression in dry (D) only

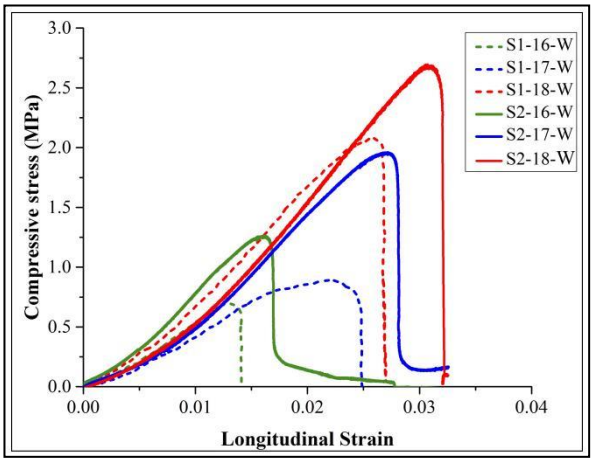

Fig 9: Stress-strain relationship for S1 and S2 under compression in wet (W) only

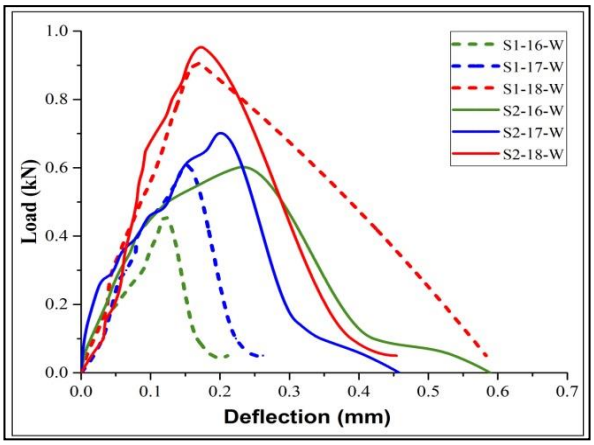

Fig 10: Load-deflection curves for S1 and S2 under flexure in wet (W) state.

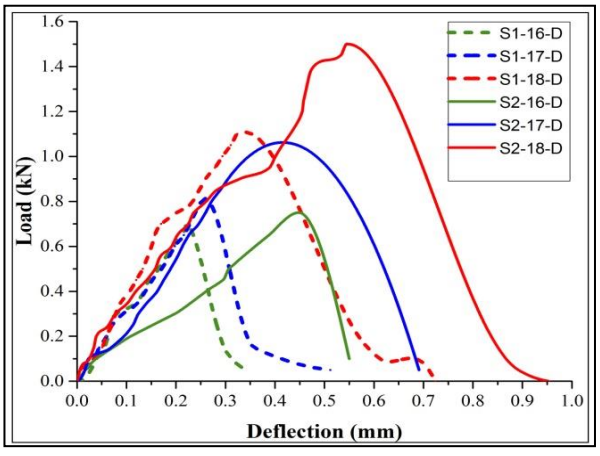

Fig 11: Load-deflection curves for S1 under flexure in dry (D) and wet (W) state

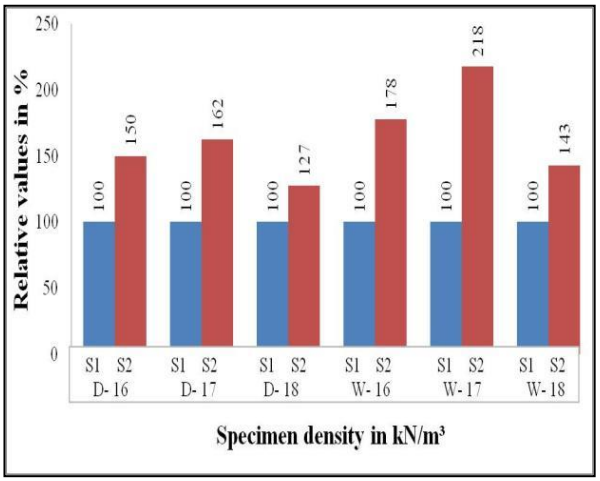

Figure 12: Comparison of properties in dry (D) and wet (W) state between S1 and S2 specimens in compressive strength.

Table 3: Compressive strength and stress-strain characteristics of S1 and S2 specimens in dry and wet.

Sr. No.	Specimen Designation	Specimen condition at the time of testing	Dry density achieved γ_d (kN/m^3)	Compressive strength f_c (N/mm^2)	Strain at ultimate strength ϵ_c	Strain at failure ϵ_f
1.	S1-16-D	Dry	16.09–16.16	1.672	0.0319	0.0337
2.	S1-16-W	Wet		0.711	0.0132	0.0145
3.	S1-17-D	Dry	17.11–17.20	2.926	0.0254	0.0281
4.	S1-17-W	Wet		0.91	0.0223	0.024
5.	S1-18-D	Dry	18.10–18.32	4.144	0.0402	0.0412
6.	S1-18-W	Wet		1.885	0.026	0.027
7.	S2-16-D	Dry	16.15–16.24	2.509	0.0248	0.0277
8.	S2-16-W	Wet		1.264	0.0161	0.0273
9.	S2-17-D	Dry	17.21–17.4	4.745	0.0407	0.0426
10.	S2-17-W	Wet		1.96	0.0272	0.3084
11.	S2-18-D	Dry	18.08–18.35	5.276	0.0573	0.0581
12.	S2-18-W	Wet		2.696	0.0307	0.0334

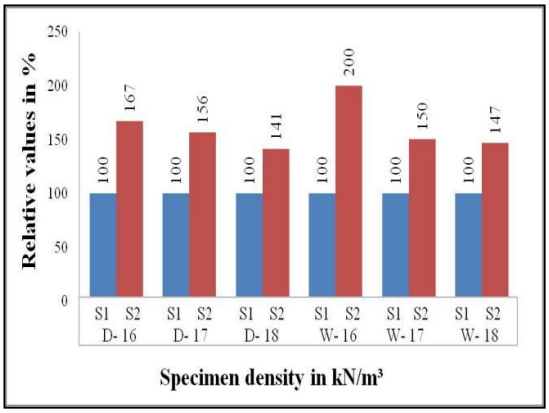

Fig 13: Comparison of properties in dry (D) and wet (W) state between S1 and S2 specimens in split tensile strength.

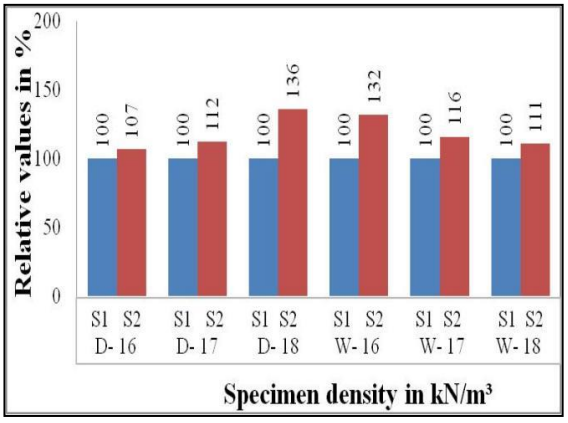

Fig 14: Comparison of properties in dry (D) and wet (W) state between S1 and S2 specimens in flexural strength

Table 4: Tensile strength properties of S1 and S2 in dry and wet state

Sr. No.	Specimen Designation	Compressive strength	Split tensile strength	Split tensile strength to compressive strength ratio
		f_c (N/mm^2)	f_t (N/mm^2)	f_t / f_c
1.	S1-16-D	1.672	0.09	0.05
2.	S1-16-W	0.711	0.06	0.08
3.	S1-17-D	2.926	0.16	0.06
4.	S1-17-W	0.91	0.1	0.11
5.	S1-18-D	4.144	0.22	0.05
6.	S1-18-W	1.885	0.15	0.08

Sr. No.	Specimen Designation	Compressive strength	Split tensile strength	Split tensile strength to compressive strength ratio
7.	S2-16-D	2.509	0.15	0.06
8.	S2-16-W	1.264	0.12	0.10
9.	S2-17-D	4.745	0.25	0.05
10.	S2-17-W	1.96	0.15	0.08
11.	S2-18-D	5.276	0.31	0.06
12.	S2-18-W	2.696	0.22	0.08

Table 5: Flexure strength properties of S1 and S2 in dry and wet state

Sr. No.	Specimen Designation	Modulus of rupture (N/mm^2)	Central Deflection at peak load (mm)
1	S1-16-D	0.512	0.224
2	S1-16-W	0.337	0.118
3	S1-17-D	0.584	0.251
4	S1-17-W	0.444	0.147
5	S1-18-D	0.798	0.324
6	S1-18-W	0.659	0.154
7	S2-16-D	0.548	0.447
8	S2-16-W	0.444	0.225
9	S2-17-D	0.655	0.305
10	S2-17-W	0.515	0.198
11	S2-18-D	1.083	0.545
12	S2-18-W	0.73	0.177

Conclusions:

In the present work partial replacement of natural soil by quarry dust and demolished soil, improve the properties compared to the specimen made by natural soil.

- With increasing density of the soil, the compressive strength increases in dry and saturated state for both type of specimens. The strength is sensitive to the moisture content of the specimens.

- Partial replacement of sand by quarry dust and demolished soil shows the improvement in engineering properties such as compressive strength, split tensile strength and flexural strength.
- For S2 type of specimen, the amount of water absorbed is lesser then S1 type of soil is 12.3%, 9.3% and 8.6% for 16, 17 and 18 kN/m3 respectively.For S2 type specimen the quarry dust with rough surface texture, sharp edge and angular particles shall improve the strength due to the better interlocking. Demolished soil added could act as filler material.
- Strain at ultimate strength is higher in dry condition when compared with the values in saturated condition for both type of specimens (S1 and S2).
- For dry specimen the values of strain at failure are higher than those of saturated specimen.
- For higher density dry compressive strength of S2 type of specimen is 27% more than the S1 specimen.
- The compressive strength of S1 specimen 43% lesser than the S2 specimen in saturated state at higher density.
- Split tensile strength in saturated state is about 68% and 71% of strength in dry state for S1 and S2 specimens respectively.
- At higher density of S1 and S2 specimens of split tensile strength is increased by 41% and 47% dry and saturated condition respectively.
- Flexural strength of S2 specimen is 36% more as compared to S1 specimen in drystate, similarly in saturate state 11% higher, at higher density.
- Strain at ultimate strength is higher 43% and 19% in S2 specimen when compared with S1 specimen, dry and saturated condition respectively.
- In flexural strength test, the centre load point deflection for S2 specimen is 68% higher than the S1 specimen tested in dry state.
- In flexural strength test, the centre load point deflection for S2 specimen is 23% higher than the S1 specimen tested in saturated state.

Future scope:

Durability study has to be made.

Evaluation of shear parameters.

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6. Parametric Assessment of Soil Nailing on Deep Excavation

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ABSTRACT

Soil nail walls have proven particularly effective for applications such as roadway cut excavations, road widening under existing bridges, rehabilitation of existing retaining structures, and both temporary and permanent excavations in urban areas. Soil nailing is a soil stabilization technique which is used as a remedial measure in order to treat the unstable natural or artificial soil slopes this study investigates the effectiveness of soil nailing for stabilizing deep excavations under static loading using a parametric approach. Numerical models were developed in the finite element software PLAXIS 2D to analyze the factor of safety of deep excavation with soil nails. The research will evaluate the impact of various parameters on the stability of the excavation, including slope angle, nail length and number of nails. The expected outcomes include identifying optimal soil nailing configurations that maximize the factor of safety and minimize slope deformation. This research aims to provide valuable insights for engineers designing deep excavations with soil nail reinforcement.

KEYWORDS:

Soil Nailing, Deep Excavation, Slope Stability, Parametric Analysis, Plaxis 2D.

I. Introduction:

Soil nailing is a geotechnical engineering technique that reinforces soil slopes, excavations, or retaining walls. It involves installing slender steel bars, known as nails, into the soil mass (Pujevic&Vukicevic, 2014).

These nails enhance stability by transferring tensile forces through friction with the surrounding soil and by resisting shear and bending stresses. Additionally, a facing structure, such as shotcrete, is often applied to the soil mass to provide support, limit deformation, and anchor the nails (Ramteke & Sahu, 2046). A soil-nailed slope consists of three main elements: the soil, steel reinforcement bars (nails), and the facing. The composite interactions of these elements determine the deformations and stability behavior of a soil

nailing system. The shear and tensile strengths of the reinforcing elements increase the overall shear strength and self-supportability of the in-situ soil. The facing in a soil nailing system serves to maintain the local stability of the ground between the nails and prevent soil displacement (Liu et al., 2017; Pujevic & Vukicevic, 2014; Song & Song, 2014). The facing should be flexible enough to withstand ground displacement during excavation.

Soil nailing is a geotechnical engineering technique that reinforces soil slopes, excavations, and retaining walls using steel rods anchored into the ground. This method shares similarities with the New Austrian Tunneling Method, which employs steel reinforcement in rock followed by concrete application. (Kulczykowski et al., 2017; Ramteke & Sahu, 2046; Song & Song, 2014; Triveni & Kommu, 2023) (1964), a system for underground rock excavations, gave rise to soil nailing.

This technique involves applying reinforced shotcrete after passive steel reinforcement has been incorporated into the rock Soil nailing was first employed in 1972 to stabilize an eighteen-meter-high sandy slope during a railway expansion project near Versailles, France.

Subsequently, Germany initiated research into this technique, with the University of Karlsruhe and Bauer Construction Company collaborating on a research program from 1975 to 1981.

Fig 1: Soil Nailing

Experimental, mathematical, and numerical analyses collectively support soil nailing's efficacy in stabilizing slopes, highlighting 15° inclination as optimal for enhancing stability and safety (Jayanandan & Chandrakaran, n.d.; Kulczykowski et al., 2017; Simulation of Soil Nail Structures Using PLAXIS 2D, n.d.; Triveni&Kommu, 2023) [1].

Soil nail characteristics such as length, spacing, and orientation affect the stability of slopes under different surcharge loads. Longer nails reduced lateral slope movement and footing settlements, with variations in these properties showing nonlinear effects on horizontal pressure along the slope face [2].

The length of the nails significantly influences system behavior, with longer nails yielding higher safety factors [4].

A. TYPES OF SOIL NAILING:

Soil nailing is a ground reinforcement technique involving the installation of steel bars into the soil to stabilize slopes and walls (Kulczykowski et al., 2017; Pujevic&Vukicevic, 2014). There are several primary methods:

- Grouted Nail: In this method, holes are drilled into the soil, followed by the insertion of steel bars. Cement grout is then injected to fill the hole and secure the nail. This approach offers excellent corrosion protection.
- **Driven Nail:** Driven nails are mechanically installed directly into the soil during excavation. While this method is rapid, it provides limited corrosion resistance and is often used for temporary stabilization.
- **Self-Drilling Soil Nail:** Hollow bars are driven into the ground while simultaneously injecting grout. This combines the speed of driven nails with improved corrosion protection compared to the traditional driven method.
- **Jet-Grouted Soil Nail:** High-pressure water jets are used to create a hole in the ground, which is then filled with grout and a steel bar. This technique offers good corrosion protection due to the encasement of the nail in grout.
- **Launched Soil Nail:** Steel bars are fired into the soil at high-speed using compressed air. This method is extremely fast but has limitations in controlling the depth of penetration.

B. APPLICATION OF SOIL NAILING:

- Roadway cuts
- Increasing road width while preserving existing bridge foundations.
- Tunnel portals
- Rehabilitation of existing retaining structures. (Kulczykowski et al., 2017)
- Hybrid soil nail systems

II. OBJECTIVES:

1. To study the effect of variation in design parameters of soil on stability of reinforced soil slopes.
2. Reference problem:
   Manjularani et, al. (2016) “seismic analysis of soil nail performance in deep excavation” taken for validation study.

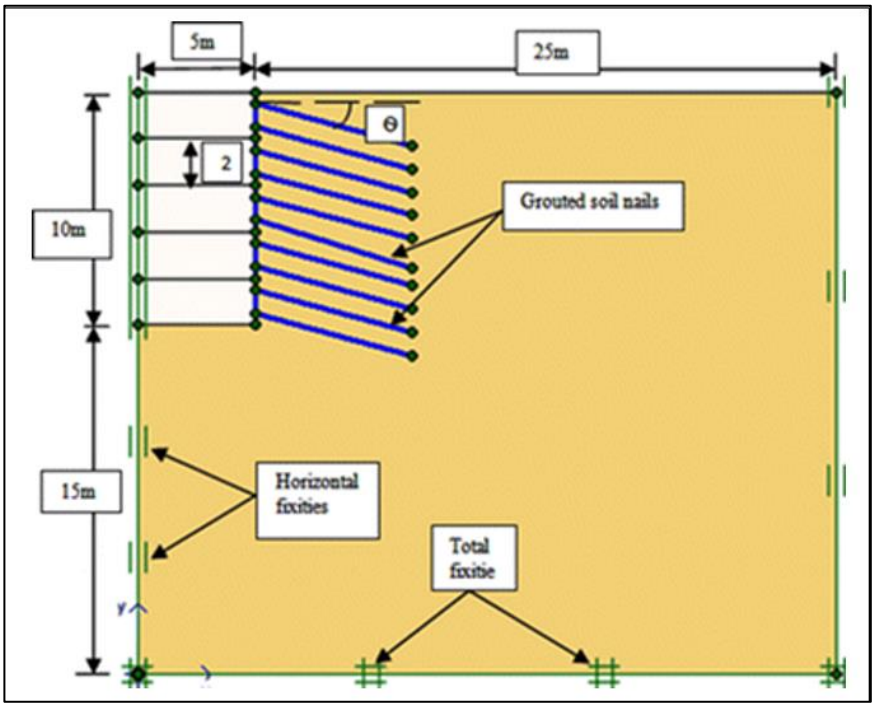

Fig 2: Numerically simulated soil nailing model

III. DESIGN OF SOIL NAILING (FHWA (2003):

1. Determining the Axial (EA) and Bending Stiffness (EI) of Grouted Nails (Pujevic &Vukicevic, 2014; Ramteke & Sahu, 2046):

$$E_{eq} = E_n\left(\frac{A_n}{A}\right) + \left(\frac{A_g}{A}\right) \qquad (1)$$

Where,

$$E_g = Young's\ modulus\ of\ grout$$

$$E_n = Young's\ modulus\ of\ nail$$

$$E_{eq} = Equivalent\ stiffness\ of\ the\ grouted\ soil\ nail\ system$$

$$A_n = c/s\ area\ of\ rc\ bar$$

$$A_g = c/s\ area\ of\ grout\ cover$$

$$A = c/s\ area\ of\ grouted\ soil\ nail$$

$$\boldsymbol{A = \frac{\pi}{4} D^2} \quad \boldsymbol{, A = \frac{\pi}{4} d^2} \quad \boldsymbol{,} \quad \boldsymbol{A_g = A - A_n}$$

Axial stiffness,

$$EA\left(\frac{kN}{m}\right) = \frac{E_{eq}}{S_h}\left(\frac{\pi}{4}D^2\right) \qquad (2)$$

Bending stiffness,

$$EI\left(\frac{kNm^2}{m}\right) = \frac{E_{eq}}{S_h}\left(\frac{\pi}{64}D^4\right) \qquad (3)$$

Where, $D = Diameter\ of\ drill\ hole$

$d = Diameter\ of\ nail$

2. Ultimate bond strength:

$$q_u \pi d = Q_u(kPa)$$

3. Maximum axial force T_{max}:

$$T_{max}(kN) = K_a(q_s + \gamma H)S_h S_v$$

$$K_a = \frac{1 - Sin\theta}{1 + Sin\theta}$$

4. Minimum length of nail (m):

$$L = \frac{(H - S_v)cos\theta}{\sin(\theta + 1)} + \frac{2T}{\pi d q_u}$$

$$Or$$

$$L = 0.6\,H$$

5. lobal Factor of Safety (〖FS〗_(G))):

$$FS_G = \frac{T_{eq}\cos(\theta - i) + [(W + Q_T)] + T_{eq}\sin(\theta - i)\,tan\theta}{[W + Q_T]sin\theta}$$

Where,

- Allowable axial force carrying capacity

$$T_{eq}(\frac{kN}{m})=\frac{1}{S_h}\sum_1^n(Tall)_j$$

- Weight of failure wedge

$$\mathrm{W}(kNm) = 0.5\gamma H^2 cot\theta$$

- Total surcharge load

$$\mathrm{Q_T} = \mathrm{q_s H cot\theta}$$

IV. NUMERICAL MODELING:

A. Software use for analysis: PLAXIS 2D V20 is a commercially available finite element code used for conducting deformation and stability analyses of a wide range of geotechnical problems (Jayanandan& Chandrakaran, n.d.; Ramteke & Sahu, 2046; Simulation of Soil Nail Structures Using PLAXIS 2D, n.d.). From excavations and embankments to foundations, tunnels, mines, and reservoir geomechanics, engineers can employ PLAXIS to evaluate and manage geotechnical risks.

B. Soil Properties and modelling:

Table 1. Soil properties

Parameters	***Values***
Vertical dimension of the wall	10m
Nail type	Grouted
Material model	Mohr -Coulomb
Cohesion (C)	4kpa
Friction angle (θ)	31.5°
Unit weight (y)	17kN/m^3
Elastic modules (E)	20Mpa
Poison's ratio (v)	0.3
Dilatancy angle	0º

Table 2. Properties of Grouted Nail and Facing

Parameter	***Grouted nail***	***Facing***
Material type	Elastic	Elastic
Axialstiffness (EA)KN/m	228.70x10^3	4.4x10^6
Bending stiffness (EI) kNm^2/m	4.4x10^6	1466.74
Poisson's ratio (v)	0.15	0.15
Weight (w) KN/m	8.3	8.3

V. RESULTS:

Finite element model is used to conduct analysis of soil nail wall are placed horizontally i.e. at θ=0° at an inclination of at θ=15°

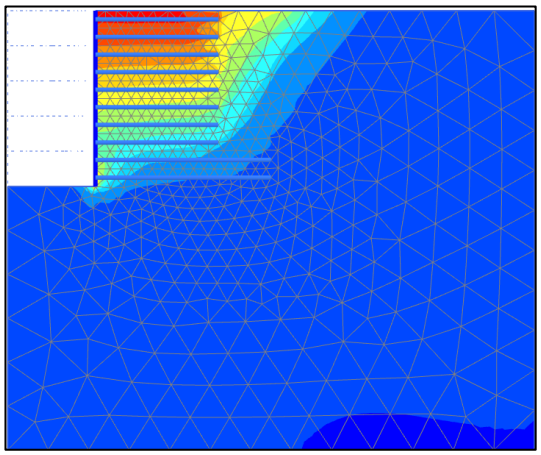

Fig 3: soil nailing model at θ=0°.

Table 3. Global Factor of safety without inclination (I = 0°)

Depth of excavation(m)	Reference problem results	Software results	Manual results
2	3.59	3.32	5.08
4	2.35	2.71	3.09
6	1.84	1.80	2.11
8	1.56	1.50	1.98
10	1.37	1.40	1.24

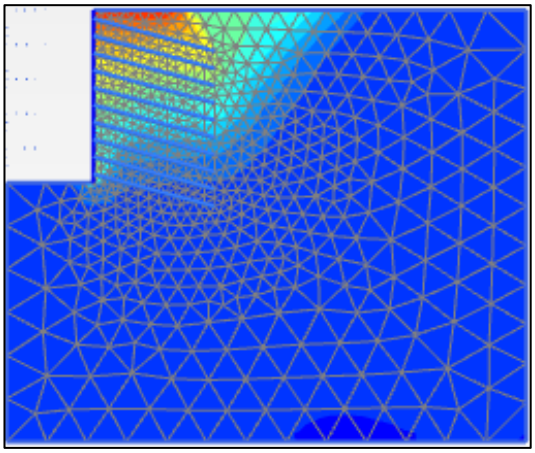

Fig 4. Soil nailing model at θ=15°

Table 4. Global Factor of safety without inclination (I = 15°)

Depth of excavation(m)	Reference problem results	Software results	Manual results
2	4.11	5.01	5.20
4	2.71	2.97	3.29
6	2.12	2.13	2.53
8	1.76	1.78	2.14
10	1.52	1.40	1.30

The variation in factor of safety values between manual, numerical, and reference data for soil nailing likely stems from differing assumptions, methodologies, and complexities considered in each approach. Manual calculations often rely on simplified models and engineering judgment, leading to potential overestimation of factor of safety. Numerical models, while incorporating more complex soil-structure interactions, might underestimate factor of safety due to uncertainties in soil parameters and model limitations. Conversely, reference problem results might represent idealized conditions, potentially deviating from real-world complexities. Soil nailing techniques, when integrated into numerical models, can capture the reinforcement effect more accurately by considering nail geometry, spacing, and load transfer mechanisms. However, manual methods often simplify nail behavior, potentially affecting the calculated factor of safety.

VI. CONCLUSIONS:

From the validation study we can conclude that,

- The length of the nail significantly influences the stability and performance of the soil wall system.
- Increase in nail length will increase the global factor of safety to certain degree.
- Increase in the depth of excavation leads to increases the displacement of soil nail wall.
- The behavior of maximum wall displacement, axial force, shear force, bending moment and factor of safety under both static and seismic condition were studied.

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7. Performance Analysis of Ultra-High-Performance Concrete Using Locally Available Materials

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ABSTRACT

Ultra-High-Performance Concrete (UHPC) is an new age type of steel fiber reinforced concrete that has superior strength and durability properties. The use of local materials is a fundamental step to save materials and along with saving the energy and to reduce the construction cost of concrete. In this study, a effort is made to produce the Ultra-high performance concrete by using the locally available material such as fly ash, silica fume, basalt, fine natural sand available locally. Results indicated a convincing 28-day compressive strength about 103.67 MPa and 96.92 MPa were achieved which is about 70.88% and 70.90% more than the normal concrete compression strength with replacement steel fibers resulted in the highest strength.

KEYWORDS:

UHPC, Steel fibers, Silica fume, Compression and flexure strength.

I. INTRODUCTION

Ultra-high-performance concrete (UHPC) is a modern construction material that has been developed recently around the world. This new type of concrete creates innovation in construction of building with the advanced material properties and technologies, which enabled the efforts of the human challenge for constructing the tall (buildings) and long span structures like roofs and bridges of the structural systems. Because of this type of concrete developed on composite material, which has enhanced mechanical properties, excellent durability, and relatively high toughness [2].

So, this kind of concrete needs for variety of research to cover all applicable usage and affordable materials. The definition of UHPC has been revolving over the past many years. Based on Federal Highway Administration regulations, UHPC is concrete which produces more than 150MPa compressive strength, with a maximum water-to-cement ratio (w/cm) of 0.25.

Irrespective of the specific definition, it has grater compressive strength, much higher tensile strength as well as better ductility, and good improved durability. Because of these better mechanical and durable properties [2], UHPC has become a most widely used material for accelerated bridge construction and rehabilitation of existing infrastructure to enhance capacity of structural systems.

Further, a cementatious admixture such as silica fume used for a pozzolanic effect that enhances the production of calcium silicate hydrate (C-S-H) and act as a micro filler to improve the impermeability property of the concrete. Finally, steel fibres are included in the UHPC mixture to increase the mechanical properties of the concrete members, especially the ductility. Curing is important actin to develop the effect of the pozzolanic effect of silica fume.

The usage of (UHPC) in structural applications has increased significantly owing to its numerous advantages when compared with conventional normal concrete (NC) and high-performance concrete (HPC). UHPC produces superior properties in terms of compressive strength behaviour's, tensile strength behaviours, and durability property of the concrete. Moreover, UHPC is more efficient in producing smaller and very thin and lighter sections.

II. LITERATURE REVIEW:

A. SHEHAB EL-DIN, SAYED AHMED ET.AL (2016):

In this research, the tests were carried out on a total 42 cubes, 84 cylinders and 21 prisms of UHPC samples to study the effect of steel fibers on the mechanical properties of UHPC such as, compressive strength, modulus of elasticity, poisonous ratio, flexural strength and split tensile strength.

The test results showed that the increase in volume fraction of steel fiber from 0% to 3% for UHPC shows maximum increase in compressive strength by 18.2%, flexural strength by 40% and tensile strength by 66% for higher side of aspect fiber ratio. It is moted that compressive strength increased from 7.7% for (UHPC) with steel fiber addition. It is seen that modulus of elasticity increased from 6.0% for (UHPC) with steel fiber inclusion. Addition of fiber to UHPC improves its ductility and its post-cracking load-carrying capacity also.

B. SAFEER ABBAS ET.AL (2015):

Ultra-high-performance concrete (UHPC) is a modern construction material reinforced with steel fiber which shows superior mechanical and durable properties. In this study, a number of UHPC specimens with varying dosage of steel fiber of length 8mm,12mm and 16mm

with percentages 1%,3%, and 6% were able to produce enhanced compressive, split and flexural strengths. And these specimens were also showing resistance to chloride ion exposures indicating good durability properties under various exposures. As the dosage of steel fiber increases UHPC mixture shows improved durability properties.

C. Ahmed Abd El-Azimet.al (2019):

In this tests author observed that the average compressive strengths of UHPC and NC were 120Mpa and 40Mpa respectively. The main purpose of this study is to find the relation between the behavior of UHPC columns and normal columns under eccentric loads. UHPC has low water to cement ratio and high range water reducing agents to make the workable concrete.

Tensile strength values for UHPC are in the range 7Mpa to11Mpa which has a maximum tensile strength reaching 20Mpa and the tensile capacity is in the range from 8% to 13%. It is observed that by adding UHPC core to the NC column, it increases the specimen load carrying capacity to carry higher loads and increase the ductility.

III. OBJECTIVE OF THE WORK:

1. To develop UHPC by using locally available materials.
2. To determine the compressive strength of UHPC over Nomal concrete using loacally available materials.
3. To study the effect of steel fiber, strengthen of UHPC beams on ultimate load carrying capacity and failure pattern Using locally available materials.
4. To compare UHPC with normal concrete using Micro-steel fibers under flexure.

IV. MATERIALS USED:

1. Cement: Cement confirming to IS 269:2015 is used which satisfies in all basic tests conducted is laboratory shows specific gravity value as 3.15.
2. Fine Aggregate: Fine aggregates can be natural or manufactured. Fine aggregate generally consists of natural sand with most particles passing through a 1.18mm IS-Sieve with specific gravity 2.59, the selection of fine aggregate is also on important factor as it directly affects the strength of concrete with the varying utilization of water.
3. Basalt: Basalt aggregate with a particle size 1.18mm to 5mm are designed by using the particle packing theory and considering optimal powder proportion having specific gravity value 2.69.
4. Steel fibers: Steel fibers are a discontinuous, 3-dimensionally orientated, isotropic reinforcement, Steel fibers with diameter 0.2 mm and length of 13mm with aspect ratio 65 are used shown in fig.1.
5. Silica flume: Silica flume is also referred as micro silica or condensed silica fume available locally in the nearby cement factory is a powdered material used for casting of UHPC which will helps to give more strength.
6. Super plasticizer.: Super plasticizer is liquid material which is used while casting of Ultra High-Performance Concrete which is taken by local trader’s shop. Super plasticizer is material which will helps improve the workability and to binding property of concrete

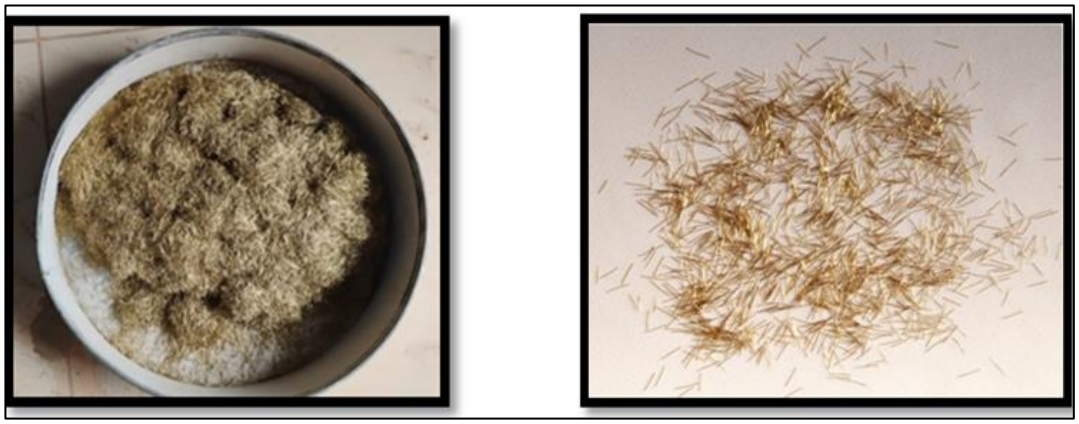

Fig. 1. Steel fiber.

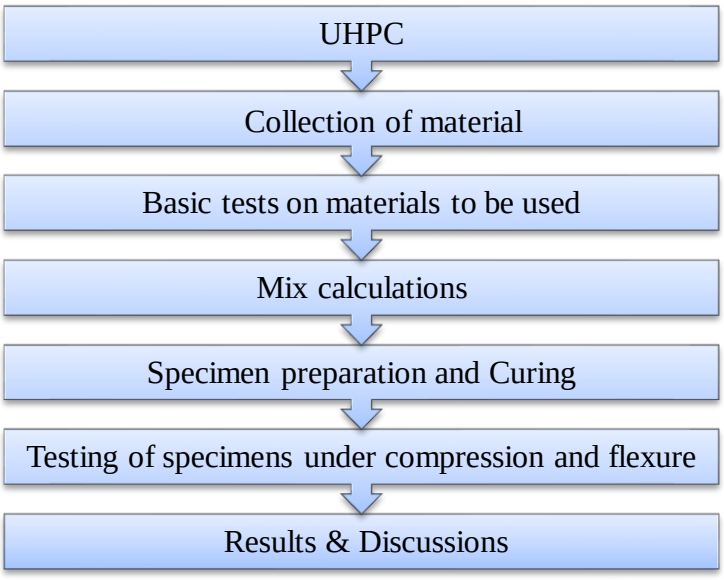

Fig. 2. Methodology

Following flow chart in fig.2 explains the process of work flow to achieve the UHPS using locally available material and to check the mechanical property of UHPC

VI. MIX DESIGN CALCULATIONS:

Mix proportion calculations is carried out by collecting the locally available material by referring the mix calculations obtained by Shehab el-din et.al [1] to achieve the UHPC. Among the varies trials author has achieved the better compressive strength and durability properties for following mix proportion listed in table. 1values which would result in giving maximum compression strength value at lowest water cement ratio about 0.18 [1].

TABLE 1. Mix proportions

Ingredients	(kg/m^3)
Cement	720
Basalt 1.18 – 2.36mm	179
Basalt 2.36 – 5mm	448
Silica fume	215
Sand	384
Steel fibers	156
Water	129.6
Superplasticizer	35.4
w/c ratio	0.18

VII. SPECIMEN PREPARATION AND CURING:

Ultra-high-performance concrete cube specimens of size 75x75x75mm and 100x100x100mm of 3 cubes each are prepared to evaluate the compression strength of concrete cubes under compression along with normal concrete cube specimens of the similar size. As the expected strength is more than the capacity of the CTM machine available in the laboratory smaller sized specimen were prepared to understand the behavior of UHPC. Similarly, to evaluate the flexural behavior of UHPC using locally available specimen of size 500mmx100mmx100mm are cast and kept for 28 days curing in curing tank.

VIII. TESTING OF SPECIMENS UNDER COMPRESSION:

UHPC specimens of size 75x75x75mm and 100x100x100mm of 3 cubes each are subjected to compressive load in CTM to find the failure load. Similarly normal concrete cubes of similar sized specimens are tested and correlated the compressive strength of UHPC and normal concrete values as shown in table 2 and table 3 for 7 days and 28 days strength.

Fig.3 Compression strength test on specimen of size 100mmX100mmX100mm

Fig.4 Compression strength test on specimen of size 75mmX75mmX75mm

Fig.5 Flexural strength test on specimen of size 100x100x500mm

IX. TESTING OF SPECIMENS UNDER FLEXURE:

In order to understand the flexural behavior of UHPC specimens with 100x100x500mm are subjected to two-point loading frame as shown in fig.5 and load at failure is recorded to study the behaviour of UHPC under flexure.

X. EXPERIMENTAL RESULTS:

A. Compression Strength of concrete:

Table 2 shows the 7 days compression strength test results of specimens cured for 7days for both UHPC and Normal concrete.

TABLE 2. 7 days compression strength for both UHPC and Normal concrete

COMPRESSIVE TEST RESULT OF CUBES ON 7 DAYS					
Mould size	Samples	Peak Load (KN)	Compressive Strength of UHPC (N/mm^2)	Average compressive strength(N/mm^2)	Compressive Strength of Normal concrete (N/mm^2)
75mm	1.	315.36	56.06	54.29	16.2
	2.	298.40	53.04		17.38
	3.	302.62	53.79		16.18
100mm	1.	652.83	65.28	63.98	20.1
	2.	643.52	64.35		19.68
	3.	621.31	62.31		18.56
150mm	1.	Excepted outcome will be 143.9 N/mm^2 for 150x150x 150mm (Due to available of 2000N capacity of CTM machine in our college specimen size 150x150x150mm is excluded)			

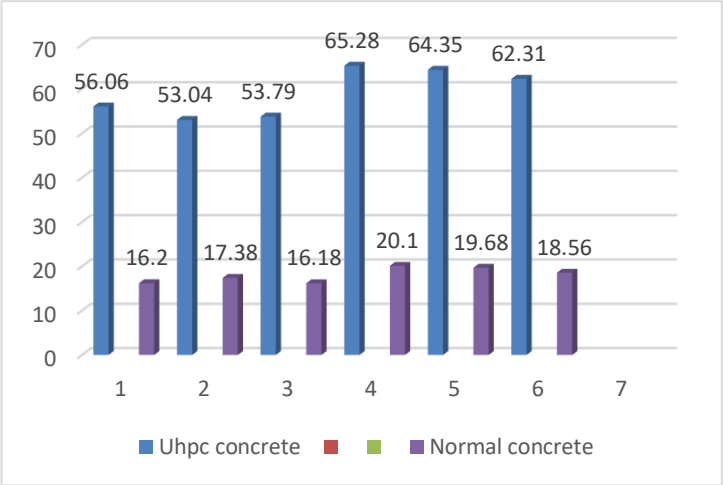

Fig.5 Comparison of Compressive strength of NC vs UHPC for 7 days curing

TABLE 3. 7 days compression strength for both UHPC and Normal concrete

COMPRESSIVE TEST RESULT OF CUBES ON 7 DAYS					
Mould size	**Samples**	**Peak Load (KN)**	**Compressive Strenght of UHPC (N/mm^2)**	**Average Compression of UHPC strength(N/mm^2)**	**Compressive Strenght of normal concrete (N/mm^2)**
75mm	1.	553.6	56.06	96.92	27.3
	2.	545.3	53.04		28.2
	3.	536.8	53.79		27.5

COMPRESSIVE TEST RESULT OF CUBES ON 7 DAYS					
Mould size	**Samples**	**Peak Load (KN)**	**Compressive Strenght of UHPC (N/mm^2)**	**Average Compression of UHPC strength(N/mm^2)**	**Compressive Strenght of normal concrete (N/mm^2)**
100mm	1.	1045.7	65.28	103.67	29.45
	2.	1052.3	64.35		30.18
	3.	1013.6	62.31		30.07
150mm	1.	Excepted outcome will be 233.25 N/mm^2 for 150mmX150mm 150mm (Due to available of 2000N capacity of CTM machine in our college specimen size 150mmX150mmX150mm is excluded)			

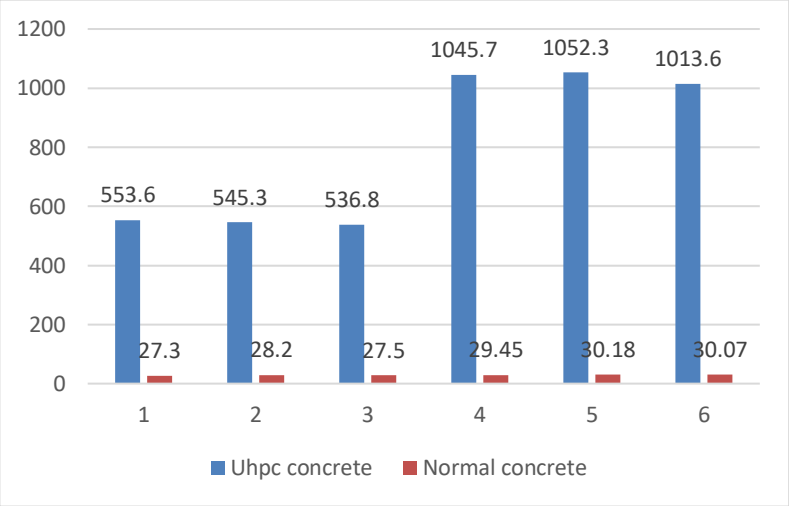

Fig.6 Comparision of Compressive strength of NC vs UHPC for 28 days curing

B. Flexural strength of concrete:

TABLE 4. Flexural strength of UHPC beam specimens

Curing period	Samples	Avg.Peak Load (kN)	Avg. Flexural Strength (kN/mm^2)
07	3	21.92	8.33
28	3	48.6	18.47

XI. Test Results and Discussion:

A. Compressing strength:

with concrete cubes of UHPC it is found that there is 70% of increase in compressive strength for cube of size 75x75mm and cube size of 100x100mm for 7 days of curing by using locally available material Similarly, for 28days compressive strength increased by 72% for both 75x75mm and 100x100mm cubes by using locally available material.

B. Flexural Strength:

The flexural strength of UHPC concrete shows 8.33 kN/mm2 for 7days of curing and 18.47kN/mm2 for 28days of curing for UHPC concrete.

Failure pattern indicates the addition of fibers to UHPC improves its ductility and its post-cracking load-carrying capacity.

XII. Conclusions:

- When steel fibers are incorporated into UHPC, they have improved the material's ductility and durability. The steel fibers helped us to control cracking, increased flexural strength and enhanced the overall performance of the concrete.
- Regardless of the silica fume content and the types of sand, the compressive strength increases as the binder content increases.
- The use of steel fibers in UHPC can also lead to reduced maintenance costs and longer service life of structures. Overall, the outcome of using steel fibers in UHPC is a stronger, more durable, and high-performance concrete material.

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8. Performance of Low-Density Foamed Concrete (LDFC) Integrated with Industrial and Agricultural Nano Wastes for Sustainable Development

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ABSTRACT

This study examines the integration of industrial and agricultural Nano wastes into Low-Density Foamed Concrete (LDFC) to improve its mechanical properties and sustainability. LDFC is known for its lightweight and thermal insulation benefits, but its lower strength limits its application in construction. To overcome this, Nano-sized industrial by-products like fly ash and silica fume, along with agricultural residues such as rice husk ash, were incorporated into the LDFC matrix. The results demonstrated significant improvements across all evaluated properties, particularly with silica fume making the modified LDFC a more viable and eco-friendly option for construction. This study contributes to sustainable development by promoting the use of Nano waste materials, reducing environmental impact, and enhancing the performance of LDFC in various construction applications.

KEYWORDS:

Sustainable concrete, fly ash, GGBS, silica fume, recycled concrete aggregate, plastic waste etc.

I. INTRODUCTION

The construction industry is under increasing pressure to adopt sustainable practices due to the growing concerns over environmental degradation and the depletion of natural resources. One innovative approach to achieving sustainability is the utilization of low-density foamed concrete (LDFC) integrated with Nano-scale wastes derived from industrial and agricultural sources. Foamed concrete, characterized by its lightweight nature and high thermal insulation properties, offers a promising solution for various construction applications.

By incorporating Nano wastes, which are by-products of industrial and agricultural processes, into LDFC, it is possible to enhance its performance characteristics while also addressing waste management issues. This study explores the performance of low-density foamed concrete enhanced with industrial and agriculturalNano wastes, focusing on its potential for sustainable development.

Literature Review:

LDFC is a type of lightweight concrete that incorporates a foaming agent to create a porous structure. According to Jones and McCarthy (2005), LDFC has been widely recognized for its excellent thermal insulation properties and its potential to reduce the overall weight of structures, leading to lower construction costs and reduced load on foundations. However, its mechanical strength often falls short compared to conventional concrete, which limits its broader application in structural elements. Industrial by-products like fly ash and silica fume have long been used as supplementary cementitious materials to enhance concrete properties.

Research by Chindaprasirt et al. (2007) demonstrates that fly ash can significantly improve the workability and durability of concrete while reducing its environmental footprint. Silica fume, with its ultra-fine particles, is known to enhance the compressive strength and impermeability of concrete, as reported by Detwiler and Mehta (1989).

The incorporation of these Nano-scale industrial wastes into LDFC could potentially offset its inherent weaknesses, such as lower strength and higher porosity. Agricultural wastes, particularly those rich in silica, like rice husk ash (RHA), have shown promise as concrete additives. A study by Ganesan, Rajagopal, and Thangavel (2008) highlights that RHA can improve the mechanical properties and durability of concrete due to its high silica content, which contributes to the pozzolanic reaction within the cement matrix. Nano-cellulose, derived from plant fibers, has also garnered attention for its ability to improve the tensile strength and toughness of composite materials, including concrete, as evidenced by research from Saba et al. (2016).

The concept of sustainable development in construction emphasizes reducing environmental impacts while maintaining economic viability and social responsibility. Incorporating industrial and agricultural wastes into construction materials aligns with the principles of sustainability by promoting waste valorisation, reducing the consumption of natural resources, and lowering greenhouse gas emissions. According to Pacheco-Torgal et al. (2011), sustainable construction practices, such as the use of recycled materials and waste products, are critical for the long-term health of the planet and the construction industry.

This study aims to fill this gap by investigating the performance of LDFC when enhanced with Nano-scale industrial and agricultural wastes.

The focus will be on assessing improvements in physical, mechanical, and durability properties, thereby providing insights into the potential of this innovative material for sustainable construction.

The main objectives of this study are:

1. To evaluate the physical properties of LDFC integrated with industrial and agricultural Nano wastes.
2. To assess the mechanical performance of the modified LDFC, including compressive, flexural, and tensile strengths.
3. To analyse the durability aspects of the enhanced LDFC, such as freeze-thaw resistance, chemical resistance, and thermal conductivity.

Materials Used:

The Following materials were used

1. **Cement:** Ordinary Portland Cement (OPC) is used as the primary binder in the foamed concrete. It is selected for its wide availability and established performance in concrete applications.
2. **Foaming Agent:** A synthetic foaming agent is used to generate the foam required to produce the low-density structure of the concrete. The foaming agent is chosen based on its ability to create stable and uniform bubbles.
3. **Nano Wastes:**
   Industrial Nano Wastes: Fly ash and silica fume, obtained as by-products from thermal power plants and silicon metal production, respectively. These materials are known for their pozzolanic properties and ability to improve concrete strength and durability.

Figure 1. Industrial Nano Waste Fly Ash and Silica Fume

Agricultural Nano Wastes: Rice husk ash derived from rice milling and agricultural residues. These wastes are rich in silica offering potential benefits for concrete performance.

Figure 2. Agricultural Nano WasteRice Husk Ash (RHA)

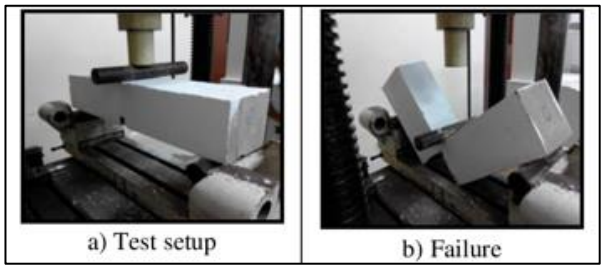
4. **Aggregates:** Fine aggregates (sand) are used in small quantities to provide additional strength and stability to the foamed concrete matrix.
5. **Water:** Potable water is used for mixing and curing the concrete. The water-to-cement ratio is carefully controlled to achieve the desired workability and strength.
6. **Admixtures:** Chemical admixtures, such as superplasticizers, are added to enhance the workability and performance of the foamed concrete mix.

Experimental work:

Here are some mechanical properties evaluated the performance of low-density foamed concrete (LDFC) integrated with industrial and agricultural Nano wastes:

a) Compressive Strength
b) Flexural Strength
c) Tensile Strength
d) Modulus of Elasticity
e) Impact Resistance

Figure 3 Failure of LDFC Cube



Test Results: The Various Mechanical Properties of Modified LDFC are tabulated in the Table Below

Table: Test results

Mix ID	M1	M2	M3	M4	M5	M6	M7
Nano Waste Type	None (Control)	Fly Ash	Fly Ash	Silica Fume	Silica Fume	Rice Husk Ash	Rice Husk Ash
Nano Waste %	0	5	10	5	10	5	10
Compressive Strength (MPa)	10.5	12	13.2	14.5	16	11.8	12.9
Tensile Strength (MPa)	1.5	1.7	1.9	2.1	2.3	1.6	1.8
Flexural Strength (MPa)	2.1	2.4	2.7	3	3.3	2.3	2.6
Modulus of Elasticity (GPa)	10.2	10.8	11.1	11.5	12	10.5	10.9
Impact Resistance (J)	3.5	3.8	4.1	4.4	4.7	3.6	3.9

Compressive Strength:

The figure 4illustrates the Compressive Strength characteristics of modified LDFC Cubes and results are discussed

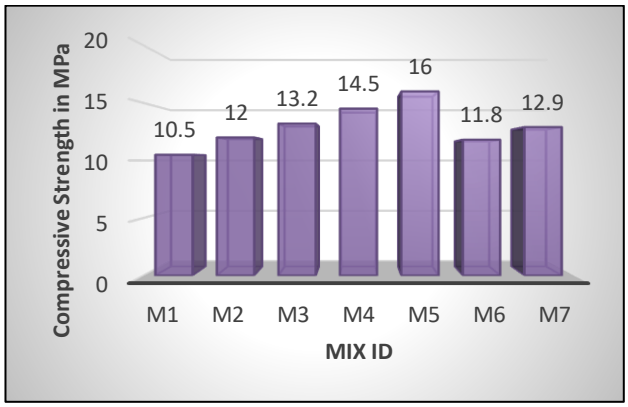


Figure 4 Test Results of Compressive Strength

Control (M1): The compressive strength of the control sample (without Nano wastes) is 10.5 MPa.

Fly Ash (M2, M3): Adding 5% fly ash (M2) improves the compressive strength to 12.0 MPa, while 10% fly ash (M3) further increases it to 13.2 MPa. This demonstrates that fly ash enhances the compressive strength by filling voids and contributing to the pozzolanic reaction.

Silica Fume (M4, M5): With 5% silica fume (M4), the compressive strength rises to 14.5 MPa, and with 10% silica fume (M5), it reaches 16.0 MPa. Silica fume's fine particles and high pozzolanic activity significantly improve the compressive strength.

Rice Husk Ash (M6, M7): Incorporating 5% rice husk ash (M6) yields a compressive strength of 11.8 MPa, and 10% rice husk ash (M7) increases it to 12.9 MPa. The high silica content in rice husk ash contributes to this improvement.

Tensile Strength:

The figure 5 illustrates the Tensile Strength characteristics of modified LDFC Cylinders and results are discussed

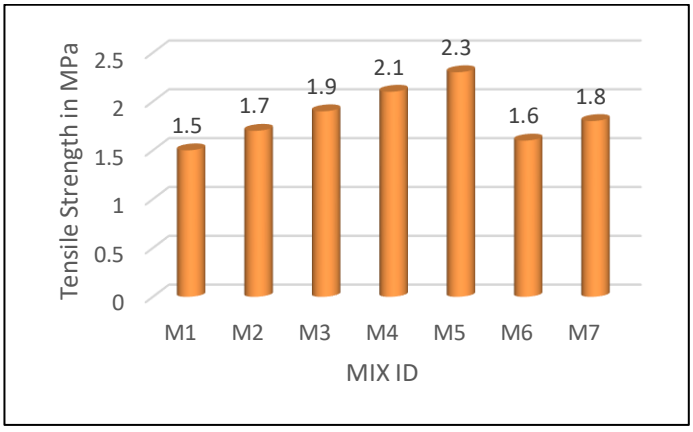


Figure 5 Test Results of Tensile Strength

- Control (M1): The tensile strength of the control sample is 1.5 MPa.
- Fly Ash (M2, M3): With 5% fly ash (M2), the tensile strength increases to 1.7 MPa, and with 10% fly ash (M3), it reaches 1.9 MPa. Fly ash improves the tensile properties by refining the pore structure.
- Silica Fume (M4, M5): Adding 5% silica fume (M4) enhances the tensile strength to 2.1 MPa, and 10% silica fume (M5) further improves it to 2.3 MPa. Silica fume's fine particles and pozzolanic reaction strengthen the tensile properties.
- Rice Husk Ash (M6, M7): The addition of 5% rice husk ash (M6) results in a tensile strength of 1.6 MPa, and 10% rice husk ash (M7) increases it to 1.8 MPa. The silica content in rice husk ash contributes to the improved tensile strength.

Flexural Strength:

The figure 6 illustrates the Flexural Strength characteristics of modified LDFC and results are discussed

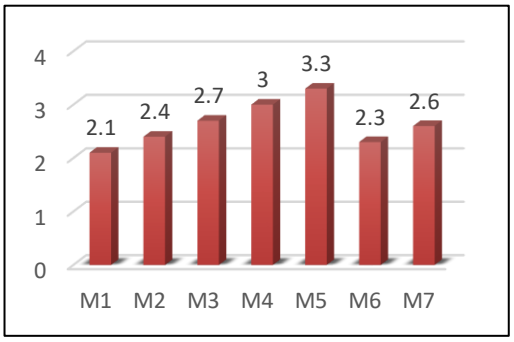


Figure6 Test Results of Flexural Strength

- Control (M1): The flexural strength of the control sample is 2.1 MPa.
- Fly Ash (M2, M3): The addition of 5% fly ash (M2) increases the flexural strength to 2.4 MPa, while 10% fly ash (M3) raises it to 2.7 MPa. This indicates that fly ash contributes to improved bending resistance.
- Silica Fume (M4, M5): With 5% silica fume (M4), the flexural strength improves to 3.0 MPa, and with 10% silica fume (M5), it reaches 3.3 MPa. Silica fume significantly enhances flexural strength due to its high fineness and pozzolanic properties.
- Rice Husk Ash (M6, M7): Adding 5% rice husk ash (M6) increases the flexural strength to 2.3 MPa, and 10% rice husk ash (M7) to 2.6 MPa. The silica in rice husk ash improves the flexural performance.

Modulus of Elasticity:

The figure 5 illustrates the Modulus of Elasticity of modified LDFC and results are discussed.

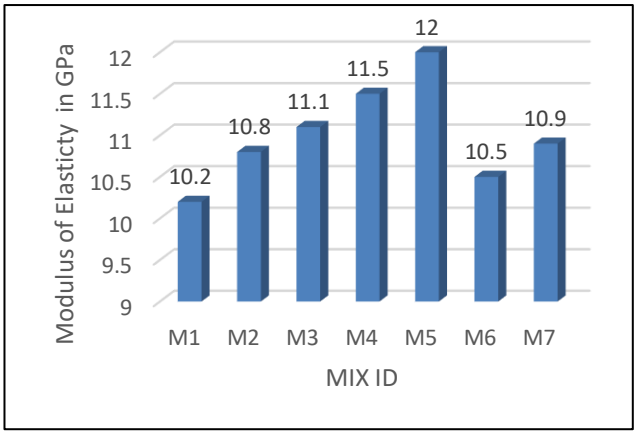


Figure 5 Test Results of Modulus of Elasticity

- Control (M1): The modulus of elasticity for the control sample is 10.2 GPa.
- Fly Ash (M2, M3): Adding 5% fly ash (M2) increases the modulus to 10.8 GPa, while 10% fly ash (M3) raises it to 11.1 GPa. Fly ash contributes to a denser and stiffer concrete matrix.
- Silica Fume (M4, M5): With 5% silica fume (M4), the modulus improves to 11.5 GPa, and with 10% silica fume (M5), it reaches 12.0 GPa. Silica fume enhances the stiffness due to its fine particles and pozzolanic reaction.
- Rice Husk Ash (M6, M7): Incorporating 5% rice husk ash (M6) results in a modulus of 10.5 GPa, and 10% rice husk ash (M7) increases it to 10.9 GPa. The silica in rice husk ash improves the stiffness of the concrete.

Impact Resistance:

The figure 6 illustrates the Impact Resistance of modified LDFC and results are discussed.

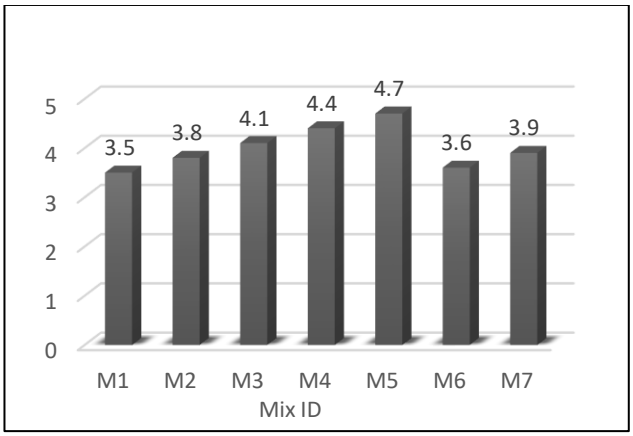


Figure 6 Test Results of Impact Resistance

- Control (M1): The impact resistance of the control sample is 3.5 J.
- Fly Ash (M2, M3): The addition of 5% fly ash (M2) increases the impact resistance to 3.8 J, while 10% fly ash (M3) raises it to 4.1 J. Fly ash enhances the energy absorption capacity of the concrete.
- Silica Fume (M4, M5): Adding 5% silica fume (M4) improves the impact resistance to 4.4 J, and 10% silica fume (M5) further increases it to 4.7 J. Silica fume enhances the toughness and energy absorption capacity of the concrete.
- Rice Husk Ash (M6, M7): Incorporating 5% rice husk ash (M6) results in an impact resistance of 3.6 J, and 10% rice husk ash (M7) increases it to 3.9 J. The silica content in rice husk ash improves the impact resistance.

Overview:

The results indicate that incorporating industrial and agricultural Nano wastes into LDFC significantly enhances its mechanical properties. Fly ash, silica fume, rice husk ash, and Nano-cellulose all contribute to improved compressive, flexural, and tensile strengths, as

well as increased modulus of elasticity and impact resistance. Silica fume show the most substantial improvements across all properties. These enhancements make LDFC a more viable and sustainable option for various construction applications, promoting waste valorisation and reducing the environmental impact of construction activities.

Conclusions:

From the Extensive Experimental work carried out the following outcomes were concluded

Compressive Strength: The use of Nano waste significantly enhances compressive strength. Silica fume at 10% provides the highest increase, reaching 16 MPa compared to the control's 10.5 MPa.

Flexural Strength: Similar to compressive strength, flexural strength improves with Nano waste addition. The highest value is observed for silica fume (3.3 MPa).

Tensile Strength: Tensile strength also increases with the use of Nano waste showing the highest value at 2.3 MPa.

Modulus of Elasticity: There is a moderate increase in the modulus of elasticity with the addition of Nano waste achieving 12 GPa.

Impact Resistance: Impact resistance improves with the addition of Nano waste, with the highest value of 4.7 J.

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9. Wastewater Treatment and Sustainable Bio-Energy Generation Using Microbial Fuel Cell (MFC)

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ABSTRACT

In this paper pilot scale Microbial Fuel Cell (MFC) with two compartments was constructed for the treatment of wastewater and bio-electricity generation. MFC contain two chambers; anode and cathode chamber, which contain carbon and graphite electrode respectively. Both the chambers of MFC were separated by Agar-NaCl salt bridge. Efficiency of performance of a microbial fuel cell (MFC) was optimized as a function of three main factors such as pH was varied from 8-4, Hydraulic Retention Time (HRT) varied from 1 to 5 days and oxygen concentration in range of 0.2 to 1 ml/min. The percentage removal in BOD and COD at 5day retention it showed 71.16% and 72% respectively with generation of electricity of 140mV.

KEYWORDS:

Microbial Fuel Cell (MFC), Wastewater treatment, Bio-electricity, Agar-NaCl salt bridge.

I. INTRODUCTION

Environmental pollution is the high risk problem that world is facing today. A large amount of wastewater is generated globally and treatment of it is still economic burden to government and the industries (Chaudhari and Deshmukh, 2015). Fossil fuels are the main energy sources that are utilized in the energy production and due to demand in large scale;

we will soon ran out of non-renewable energy sources (Nawaz et al., 2022). The technology of MFCs has been proven to be one of the promising and eco-friendly methods in the treatment of wastewater and generation of energy. There is surge in research and advancement in fuel cell technology in recent years. The rapidly growing MFCs technology is illustration of a paradigm shift (Jiseon ,2016). MFCs are bio-electrochemical devices that produce electrical energy organic material degradation. MFC technology uses microbial degradation of organic constituent that are present in wastewater to produce the bio-energy. A typical MFC contain two chambers one is anode chamber and other is cathode chamber. Anode and cathode contain carbon and graphite electrodes respectively. The two chambers of MFC are connected by Agar-NaCl salt bridge. Anode chamber of MFC contain wastewater enriched with MLSS (Mixed Liquor Suspended Solids) and cathode contain aerated water. The micro-organisms that are present in wastewater will oxidizes the organic matter present in wastewater and this microbial degradation of organic constituent produces protons and electrons which are transferred to terminal electrode and electricity produced will be read by connecting electrodes to the multimeter. Thus electricity will be harnessed by placing load between the two chambers of MFC.MFC technology offers dual advantage one is that the electricity produced will be cheap and other is wastewater will be treated effectively. MFCs have proven to be green technology in the wastewater treatment integrated with bio-energy generation (Zhang and Yifeng, 2012).

A. Working principal of MFC:

The MFC is made up of two chambers: cathode and anode chamber. The anode chamber contains microbe-enriched wastewater, and the bacteria transform chemical energy provided by the oxidation of organic/inorganic molecules into ATP through successive processes in which electrons are transported to a terminal electron acceptor to generate an electrical current. Microorganisms present in it will digest organic constituents of wastewater to reduce BOD and COD levels. Microbial breakdown of organic molecules produces electrons and protons. The electrons are subsequently transported to the terminal of anode. The electrons transfer from the anodic chamber to the cathode chamber via the electrical circuit, whereas the protons pass through the electrolyte and then the cationic membrane. Protons and electrons produced get imbibed in the cathode by reducing electron acceptors such as oxygen and acidic permanganate is used. Electricity is harnessed by employing wastewater as substrate in the anode compartment of MFC.

The use of wastewater as a source has a dual advantage; first, the electricity produced is inexpensive, and second, it leads treatment of wastewater (Kifle et al, 2023).

B. Types of MFC:

1. Single Chambered MFC:

Single chamber MFCs are utilized in the wastewater treatment system and energy production in pilot scale with less internal resistance by promoting higher potency and low cost. Single compartment MFCs are composed of one anode compartment and has no defined cathode chamber and PEM; only a porous cathode is present, which allows protons to pass through by preventing the flow of oxygen towards the anode. This design can be employed in batch or continuous mode. Usually carbon electrodes are wielded in anode

chamber; cathode chamber contain either PEM fused with flexible carbon cloth or porous carbon electrodes. Single chamber MFC allows reaction between oxygen and porous cathode electrode. It is employed in air-cathode mode. Single chamber MFCs have several advantages such as enhanced proton diffusion, less internal resistance, high rate of oxygen reduction at cathode, easy to operate and it is cheap. The major drawback is when it is implied at commercial scale such as evaporation, high-rate oxygen diffusion and liquid outflow.

2. Double Chambered MFC:

This type of MFC comprised of two compartments for aerobic and anaerobic conditions respectively. The two chambers of MFCs are connected together by ion exchange membrane which behaves as a selectively permeable barrier and allows the transfer of electron and proton from the anode to the cathode and also prevents the diffusion of ions from cathode to anode chamber of MFC. The anaerobic degradation process takes place in anode chamber of MFC by micro-organisms present in it. These electrons reach the cathode through the external wire, and protons move toward the cathode chamber through the membrane. It requires a constant supply of oxygen in the cathode compartment. The dual chamber MFCs can be utilized in large scale in treatment of wastewater and generate energy. The parameters such as pH, oxygen available, internal resistance, and electron mediators play major role in the enhancement of MFC performance (Roy et al., 2022).

3. Stacked MFC:

MFCs can be stacked either in parallel or series and they play significant role in amplify the power production. The MFCs can be arranged in either a series or parallel configuration. The aim of this is to improve wastewater contaminant removal and electricity output. Both the voltage increase and the treatment time reduction are made possible by the series connection. Conversely, a parallel connection leads to an increase in power density and current. It is also possible to connect the MFCs horizontally or vertically.

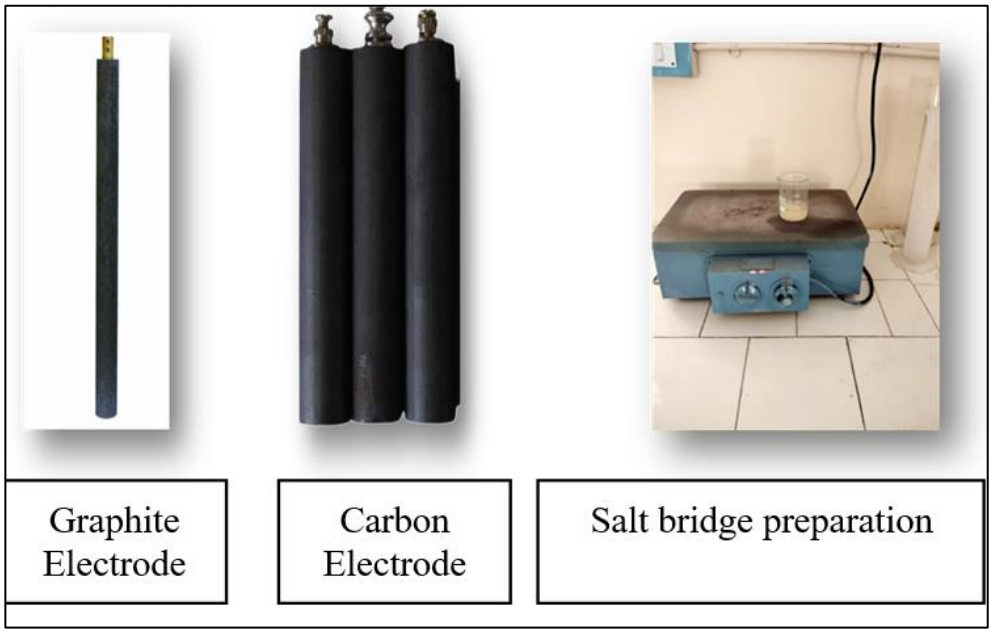
II. MATERIALS AND METHODOLOGY:

A. Sample collection:

Municipal wastewater sample was gathered from Bagalkot region. MLSS for the MFC obtained from sugar industry from the Bagalkote region. Collected sample was stored in refrigerator at 4 0C. Collected sample was brought to laboratory for initial characterization and further treatment process.

B. Materials for MFC:

Microbial fuel cell was fabricated from the locally available materials. Materials for fabrication are collected from the nearby shops. After material collection, fabrication is done and all the fabricated units are assembled in the laboratory. Carbon and graphite electrodes are used at anode and cathode chamber of MFC respectively. The two chambers of MFC are connected by ion exchange membrane of agar and NaCl solution.



C. Methodology:

MFC is constructed to a pilot scale with low-cost electrodes and both electrodes are separated by ion exchange membrane. The reactor design contains two different compartments one is anode chamber and another is cathode chamber connected by a salt bridge which act as selective barrier for migration of ions. The anode chamber contains carbon electrode and cathode chamber contains graphite electrode. One of the containers consists of microbial rich wastewater (addition of MLSS) and another chamber contains aerated water. Anaerobic condition is maintained at anode chamber, which contain wastewater. The cathode chamber is operated under aerobic conditions by continuous supply of oxygen (Kifle et al., (2023), (Shanmuganatham et al., 2023).

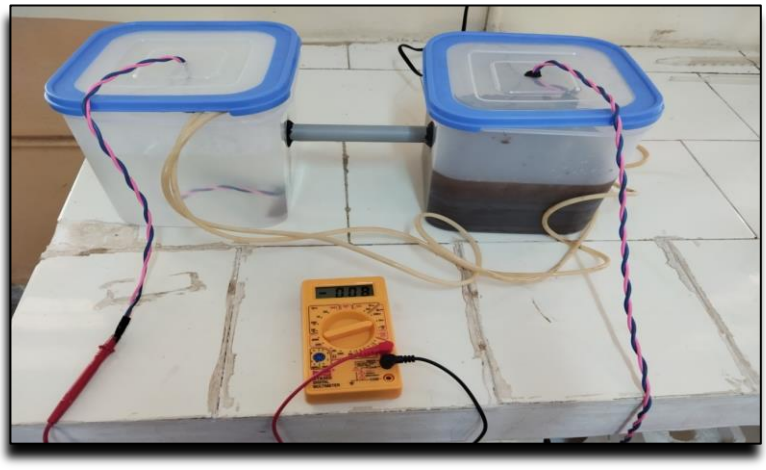


Fig: Experimental setup of MFC

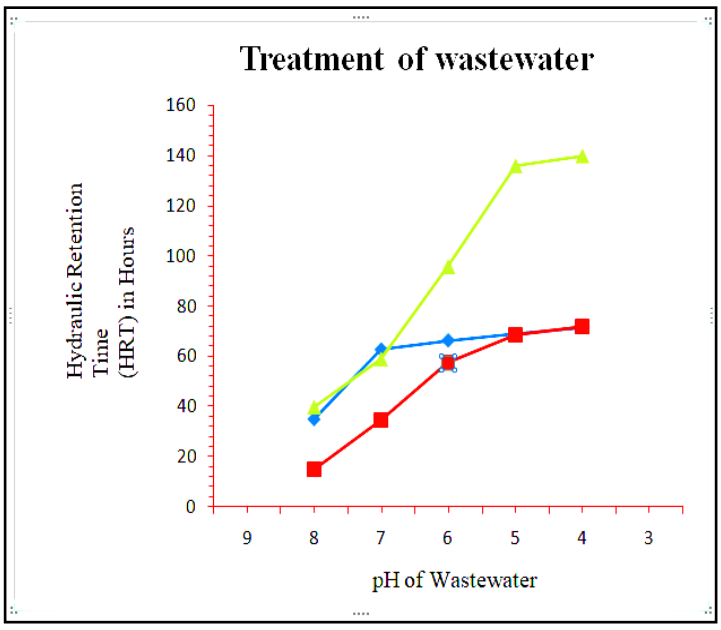
III. RESULTS AND DISCUSSION:

Municipal wastewater Sample gathered was analyzed for initial characterization in the laboratory. Wastewater sample along with MLSS added into anode chambered of MFC. Experiment was carried out in batch mode.

Table: Treatment of Wastewater using MFC

Treatment of Wastewater using MFC				
Sl No.	Hydraulic Retention Time(HRT)	BOD Removal(%)	COD Removal(%)	Electricity(mV)
1				
2	24	35	15.18	40
3	48	62.8	34.82	59
4	72	66.38	57.35	96
5	96	69.11	68.24	136
6	120	71.51	71.76	140

Chart 1: Treatment of wastewater using MFC



CONCLUSION:

In this study, a pilot-scale two-chambered MFC was constructed and evaluated for its performance in wastewater treatment and bio-electricity generation. The two chambers of MFC was connected together by an Agar-NaCl salt bridge, the MFC demonstrated significant efficacy in reducing biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in municipal wastewater.

Through the application we optimized key operational parameters, including pH, Hydraulic Retention Time (HRT), and oxygen concentration. We achieved maximum removal efficiency of BOD and COD with maximum voltage generation.

ACKNOWLEDGEMENT:

I would also like to extend my sincere gratitude to my project guide Dr. Jayalatha N A and co-guide Dr. G.B. Megeri and Dr. B.R. Hiremath HOD, department of Civil Engineering for their invaluable guidance, insightful feedback, and constant encouragement throughout the course of this project.

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10. Sustainable Wastewater Management with Native Plant Reed Beds

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ABSTRACT

This study investigated the use of constructed wetlands for efficient municipal wastewater treatment. Three wetland setups were tested: one with Canna indica, another with Flax lily, and a control without plants. The results demonstrated that Canna indica outperformed Flax lily and the control in removing various wastewater parameters.

The optimum retention period of 9 days achieved significant reductions, including a remarkable 82.87% reduction in COD and 94.4% reduction in nitrogen for the Canna indica setup. Overall, this study highlights the effectiveness of vertical flow constructed wetlands with Canna indica for eco-friendly and sustainable municipal wastewater treatment.

KEYWORDS:

Canna indica, Flax lily, Municipal Wastewater Treatment, Reed Bed System

1. INTRODUCTION

Water, Earth's essence, comprises 1460 teratons; oceans hold 97.5%, aquifers 1.6%, and accessible freshwater only 1%. Urbanization and industry demand environmental protection. Toxic sewage and industrial discharges threaten water, necessitating conservation. A shared commitment is vital to safeguard our dwindling water resources and ensure a sustainable future (Sathyapriya K, 2019). Population growth heightens wastewater reclamation need. UN's 2019 report shows water stress in African countries. Unconventional sources gain importance.

Alarming UN estimates reveal 80-90% of developing nations discharge untreated wastewater into water bodies. Urgent action, proper management, and sustainability are vital for a healthier future (Kataki, 2021). Plants can accumulate heavy metals, aiding water and soil purification, but excessive concentrations harm them.

When managed properly, phytoremediation becomes a sustainable, eco-friendly method to combat heavy metal pollution and safeguard ecosystems, utilizing plants' innate metal-accumulating abilities.

Plants employ diverse metal absorption mechanisms, including root uptake and storage. Root exudates solubilize metals for uptake. Two strategies, avoidance and tolerance, aid in metal detoxification. Avoidance limits uptake, while tolerance involves accumulation and metabolism.

This interplay underscores plants' potential in phytoremediation (Yan & Wang, 2020). Phytoremediation methods: Phytovolatilization,Phytoextraction, Phytostabilization, and Phytofiltration utilize plants for sustainable heavy metal removal, aiding environmental restoration (Marques & Rangel, 2009).Plants use roots to absorb pollutants, aiding microbial growth, soil improvement, and bioremediation.

Root exudates influence vital interactions, emphasizing their role in enhancing soil quality (Ramachandra, 2006). Wastewater treatment employs physical, chemical, and biological methods like filtration and nanotechnology, but challenges like high costs, energy use, and spatial demands persist, necessitating ongoing innovation (Crini&Lichtfouse, 2019).

Constructed wetlands (CWs) mimic natural wetland processes for sustainable wastewater treatment, using vegetation, media, and microorganisms in a controlled setting (Luis Sandoval, 2019).

Reed bed systems offer cost-effective, eco-friendly domestic wastewater treatment. Their historical roots, consistent performance, and indigenous plant choices, like reeds, enhance pollutant removal efficiency (Al-Ajalin, 2020). Reed Bed Systems, or constructed wetlands, use Root Zone Technology for eco-friendly wastewater treatment. Vertical flow reed beds are practical for small-scale sewage treatment (Aditya Bhandakkar, 2021).

2. METHODOLOGY:

A. Materials and sample collection:

Canna Indica and Flax lily (Fig.1) were employed for their local availability, adaptability, and robust root systems in pollution reduction. Canna Indica, found in various regions, is known for quick growth, biomass output, and efficient pollutant removal due to its fast development rate and high-water intake.

Flax lily, or Dianella tasmanica, is herbaceous perennial with glossy green leaves, resembling sedge, often used for groundcover or as an accent plant in Southeast Australia. It can reach 1.5 to 2 feet in height with strap-like leaves up to 3 feet long.

Fig 1. Canna indica (a), Flax lily (b)

Aggregates, like sand, crushed stone, and slag, are used with hydraulic cement to make concrete and mortar, available in coarse and fine forms.

Fig 2: Aggregates of 30, 20 and 10mm passing

2.2 Experimental set-up and method:

Experimentalset-up: Thelab-scale three CW systems were constructed utilizing Plastic container.

Set-up 1: The control (unplanted) constructed wetland (CW) system is constructed in four layers: the bottom layer with 5cm depth of aggregates passing through 30mm sieves, followed by 5cm of aggregates passing through 20mm sieves, 5cm of aggregates passing through 10mm sieves (Fig. 3), and a top layer of 5cm of washed sand.

Set-up 2: The construction of the Canna indica CW system involves four layers: the bottom layer with 5cm depth of aggregates passing through 30mm sieves, followed by 5cm of aggregates passing through 20mm sieves, 5cm of aggregates passing through 10mm sieves, and a top layer of 5cm of washed sand. This system is cultivated with Canna indica plants (Fig. 4).

Set-up 3: The Flax lily CW system is structured with four layers: a 5cm deep bottom layer of aggregates passing through 30mm sieves, followed by a 5cm layer of aggregates passing through 20mm sieves, another 5cm layer with aggregates passing through 10mm sieves, and a top 5cm layer of washed sand. This system is cultivated to yield flax lilies (Fig. 5).

Plastic containers measuring 21cm in height and 30cm in diameter were employed for setting up Reed Bed systems (Set-up 1, 2, and 3). Plants from the University of Horticultural Sciences, Bagalkote, were washed before planting.

A hole at the bottom had a tap for outlet water collection. Raw municipal wastewater was collected from a treatment facility. Initial concentrations were measured, and different retention times (3, 6, and 9 days) were tested.

After retention, water was sampled, and pollutant removal effectiveness was assessed, including COD, BOD, DO, pH, TDS, Chloride, Nitrogen, and Phosphorus.

Fig 3: Experimental set-up 1

Fig 4: Experimental set-up 2

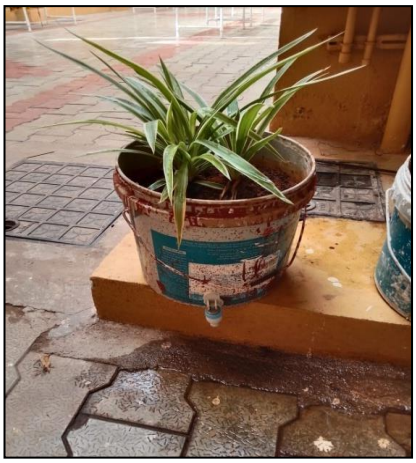

Fig 5: Experimental set-up 3

3. RESULTS AND DISCUSSION:

Removal of Pollutants from waste water using Reed Bed System: Municipal waste water was treated for pollutants removal using unplanted, Canna indica and flax lily and tested for BOD, COD, DO, Chloride, pH, TDS, Nitrogen and Phosphorus with varied retention time.

Table 1: Characteristic of municipal wastewater before treatment

Parameters	**Raw wastewater**
pH	8.6
TDS (ppm)	904
COD (mg/L)	264.67
DO (mg/L)	2.65
BOD (mg/L)	47.6

Parameters	Raw wastewater
Chloride (mg/L)	186.66
Nitrogen (mg/L))	180
Phosphorus (mg/L)	77

3.1 Variation of parameters in constructed:

Wetlands:

Table 2: Variations of parameters with time (days) for control (unplanted)

Parameters	Treatment Periods		
	3rd day	***6th day***	***9th day***
pH	8.6	8.5	8.5
TDS (ppm)	900	899	898
COD (mg/L)	260.2	260.1	259.1
DO (mg/L)	2.8	2.9	2.9
BOD (mg/L)	45.3	45	46
Chloride (mg/L)	180.2	180	179.88
Nitrogen (mg/L)	178	170	169
Phosphorus (mg/L)	71	68	62

Table 3: Variations of parameters with time (days) for Canna indica

Parameters	Treatment Periods		
	3rd day	***6th day***	***9th day***
pH	8.1	7.9	7.4
TDS (mg/L)	805	726	666
COD (mg/L)	242.67	112.2	45.33
DO (mg/L)	2.45	4.2	5.3
BOD (mg/L)	18	14	12
Chloride (mg/L)	154.89	111.2	89.21
Nitrogen (mg/L)	30	20	10
Phosphorus (mg/L)	22	19	14

Table 4: Variations of parameters with time (days) for Flax lily

Parameters	Treatment Periods		
	3rd day	***6th day***	***9th day***
pH	8.4	7.7	7.6
TDS (mg/L)	820	705	699

Parameters	**Treatment Periods**		
	3rd day	***6th day***	***9th day***
COD (mg/L)	248	229	200
DO (mg/L)	2.45	3.63	4.3
BOD (mg/L)	27	21	18
Chloride (mg/L)	179.33	96.35	80.96
Nitrogen	80mg/l	72mg/l	59mg/l
Phosphorus	32mg/l	22mg/l	17mg/l

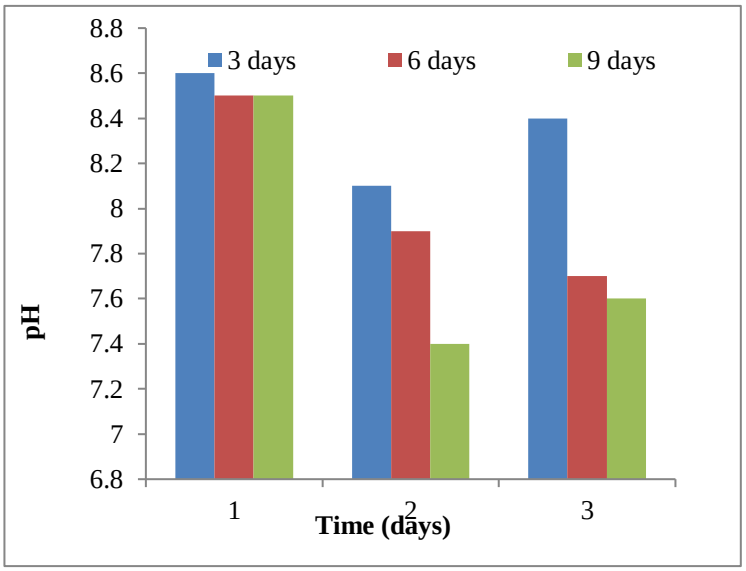

Chart 1: pH removal varies in CW units at different HRT levels

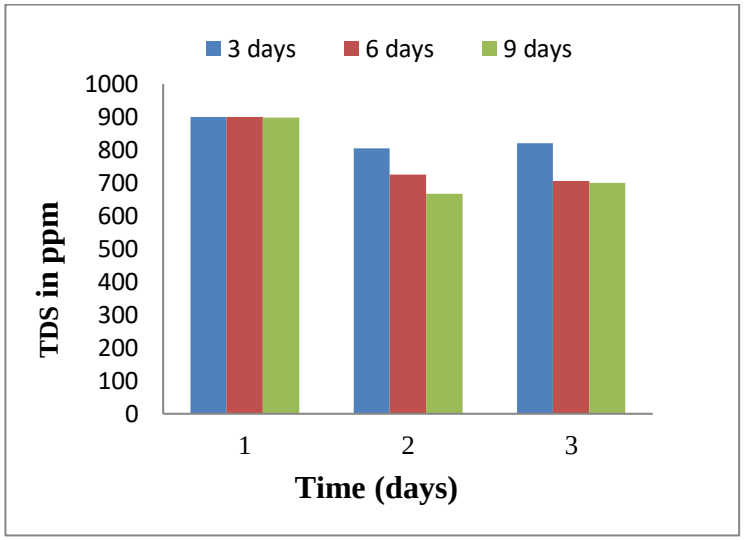

Chart 2: TDS removal varies in CW units at different HRT levels

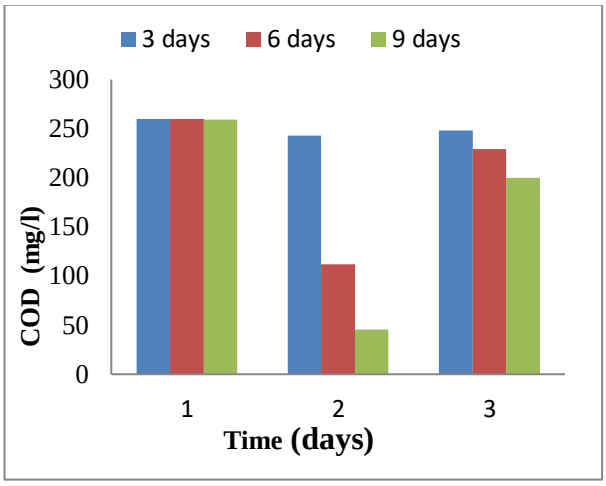

Chart 3: COD removal varies in CW units at different HRT levels

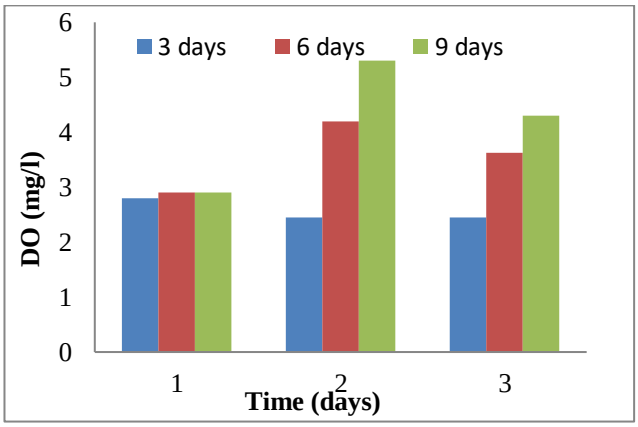

Chart 4: DO removal varies in CW units at different HRT levels

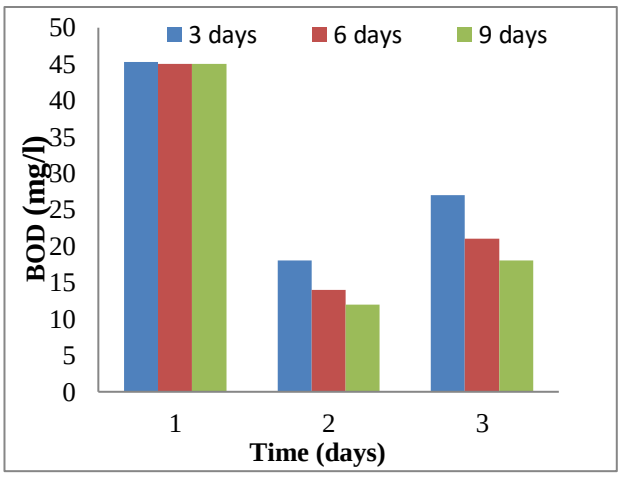

Chart 5: BOD removal varies in CW units at different HRT levels

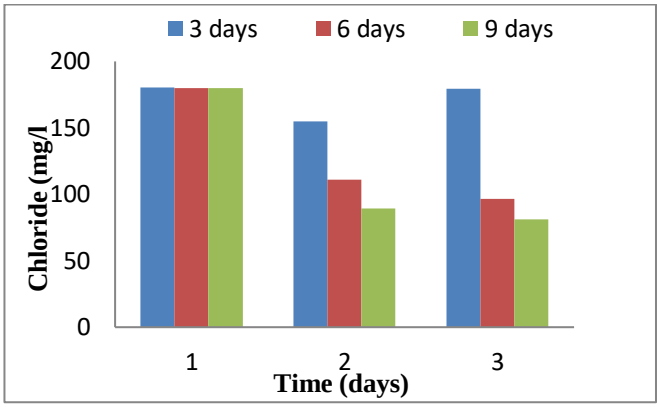

Chart 6: Chloride removal varies in CW units at different HRT levels

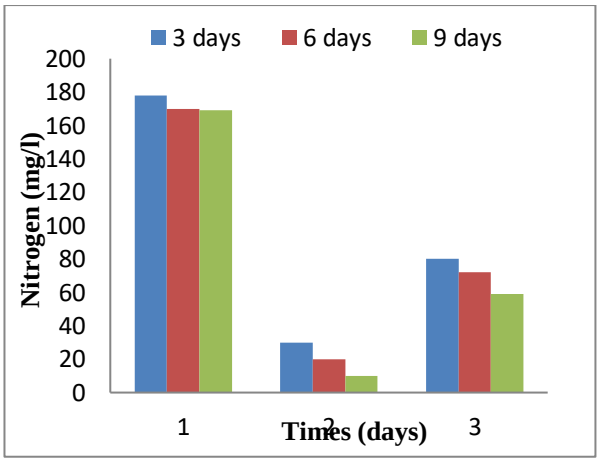

Chart 7: Nitrogen removal varies in CW units at different HRT levels

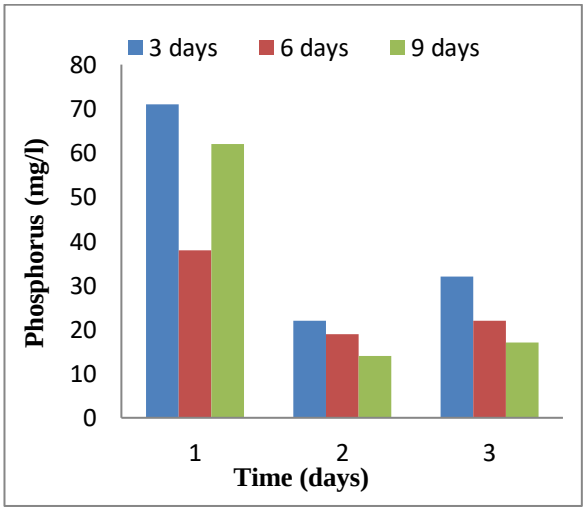

Chart 8: Phosphorus removal varies in CW units at different HRT levels

The results and accompanying charts illustrate significant variations in the removal efficiency of various parameters across different constructed wetland (CW) units with varying Hydraulic Retention Times (HRT). Notably, the second CW unit featuring Canna indica demonstrated the highest removal efficiency. As HRT increased to 9 days, removal percentages also increased. In the control (unplanted) unit, parameters like pH, TDS, COD, DO, BOD, Chloride, Nitrogen, and Phosphorus exhibited reductions of 1%, 9.4%, 2%, 9.4%, 5.5%, 3.6%, 6%, and 19.48%, respectively. Canna indica, on the other hand, achieved substantial reductions of 14%, 26%, 82.87%, 62.26%, 74.78%, 52.21%, 94.4%, and 81.8%, while flax lily resulted in reductions of 11.63%, 22.67%, 24.43%, 50%, 62.18%, 56.62%, 67.72%, and 77.92%, respectively. These reductions are attributed to the presence of bacteria attached to plant roots in the CW units, facilitating effective wastewater treatment.

4. CONCLUSION:

The study revealed significant reductions in various pollutants (pH, TDS, COD, DO, BOD, Chloride, Nitrogen, Phosphorus) from domestic and wastewater samples in three reed beds. However, the control bed displayed notably lower pollutant removal efficiency compared to the other two reed beds.

Canna indica demonstrated significant improvements in water quality parameters over retention periods of 3, 6, and 9 days. The removal efficiencies for pH, TDS, COD, DO, BOD, Chloride, Nitrogen, and Phosphorus increased notably, with percentages reaching 14%, 26%, 82.87%, 62.26%, 74.78%, 52.21%, 94.4%, and 81.8%, respectively. These results highlight the effectiveness of Canna indica in enhancing water quality, showcasing its potential as a natural and sustainable remediation solution for various contaminants over different timeframes. The study shows that plant absorption and assimilation is the main elimination stage in the treatment. Canna indica is a viable plant species for wetland treatment systems developed for tropical climates that support plant growth, according to the results of the study. The findings encourage the use of artificial wetlands for the treatment of municipal wastewater that can be installed in residences and rural regions in order to minimize the burden on natural water resources.

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11. Sustainable Waste Management Solutions for Bhagavati Village, Bagalkote

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ABSTRACT

Environmental pollution is the major thing that contributes to the hazards for living organisms. It becomes ones' moral duty to conserve the environment and treat the pollutants and make it sustainable for the survival of living beings. The present study emphasizes on treatment of wastewater of a village named Bhagavati, in Bagalkot district, Village has a lake which is contaminated with high levels of blue-green algae and toxins which make it susceptible to harming the residents staying nearby. For treatment of the wastewater in that village, wetland has been constructed, in which the treatment of wastewater is done by phytoremediation, and contaminant removal is done by Chrysopogon zizanioides (Vetiver) and Azolla pinnata. It was also observed that the village had lack of solid waste disposal system. The solid wastes like wastes from cattle sheds, gardens, kitchens, plastic wastes etc were dumped on the roade side of the villages which were directly thrown without treatment. So solid waste management was designed for the village, vermicomposting technique proved to have great impact as it provides an economic solid waste storage, collection, transportation and disposal of waste without harming the atmosphere. The main motto of the work carried out was to use the natural resources in a sustainable way by reusing, recycling the resources which reduces the effect of waste on environment, health and many other aspects. Wastewater treatment through Azolla pinnata showed effective insights in 47 days which were, 50% reduction in BOD5, 43% reduction in COD, 38% reduction in nitrite and 45% reduction in phosphate concentration. Vetiver grass also showed good results in 40 days which were, 50% reduction in BOD5, 39% reduction in COD, 67% reduction in nitrite and 50% reduction in phosphate concentration.

KEYWORDS:

Floating Wetlands, Wastewater treatment, Vetiver, Azolla, Solid Waste management, Vermicomposting

I. INTRODUCTION

In India, the adaption of chemical fertilizers, pesticides and presence of untreated wastewater would cause a heavy impact on the residents staying nearby. Solid waste dumped in on the road side would also cause ill effects on the health causing various diseases like whooping cough, diarrhoea, pneumonia etc. Therefore, the present study is focused on the sustainable waste management in the village of Bhagavati, Karnataka, India. Wastewater can be treated using physical method and chemical methods. Physical wastewater treatment involves screening, usage of grit chamber, skimmers etc, whereas Chemical wastewater treatment involves neutralization, disinfection, flocculation and coagulation etc. The present study adopted is an engineered wastewater purification process which encompass biological, chemical and physical treatment of wastewater in a natural way. The floating wetland for the treatment of the wastewater in Bhagavati village is a cost efficient and the most convenient mode of treating the contaminants, and wastes present in the pond.

II. MATERIALS:

The construction of laboratory-scale wetlands was carried out using concrete rings measuring 35 cm in height and 78 cm in diameter. To facilitate the process, floating weed of azolla and vetiver plants were placed in steel wire mesh embedded with PVC pipes. In order to enhance the growth of azolla, cow-dung was mixed with domestic wastewater, providing essential nutrients and promoting rapid multiplication of the plant.

III. METHODOLOGY:

The methodology employed for the treatment of wastewater involved the utilization of a floating wetland technique, utilizing azolla and vetiver plants. Within the concrete rings, one ring contained three vetivers placed inside a PVC pipe, while the other ring had azolla weed sprinkled using

hydroponic techniques (see Fig. 1.a and b). This phytoremediation technique effectively treated the wastewater. To determine the treatment efficiency, the physico-chemical properties including pH, turbidity, conductivity, biochemical oxygen demand, chemical oxygen demand, total dissolved solids, nitrite, and phosphorous were analysed at different time intervals during the treatment period.

The analysis aimed to assess the performance of the constructed wetlands in treating the wastewater. By monitoring the aforementioned physico-chemical properties, the treatment efficiency could be determined. The construction of wetlands provided a viable solution for the treatment of wastewater, and the findings from the lab-scale wetlands served as the basis for further implementation in the Bhagavati village.

This would involve the design and establishment of an upscaled wetland system to address the wastewater treatment needs of the community. Considering the success achieved through the lab-scale wetlands, the study proceeded towards the development of a larger-scale wetland system for the Bhagavati village. This scaled-up system aimed to address the wastewater treatment requirements of the community. By leveraging the knowledge gained from the analysis of physico-chemical properties and treatment efficiency in the lab-scale wetlands, the upscaled wetland system was designed to effectively treat wastewater and contribute to the sustainable management of water resources in the village.

(a)

(b)

Fig. 1 Floating wetlands (a) Vetiver grass, (b) Azolla pinnata

A survey was conducted in Bhagavati village, revealing a concerning practice where dry and wet wastes were indiscriminately disposed of on the roadside. In order to address this issue, a solid waste management system was proposed, which involved the creation of designated bins for proper waste disposal and the introduction of vermicomposting techniques.

Additionally, the villagers were educated about the benefits of wastewater treatment using vetiver grass and azolla. They were also made aware of the importance of solid waste management through the establishment of bins as shown in Fig. 3.

Composting is a highly beneficial process in waste management. It involves the decomposition of organic waste materials, such as food scraps, yard trimmings, and other biodegradable substances, into nutrient-rich compost.

This compost serves as a natural fertilizer and soil conditioner, enhancing soil fertility, promoting plant growth, and reducing the need for synthetic fertilizers. Composting also plays a crucial role in diverting organic waste from landfills, thereby reducing greenhouse gas emissions and contributing to environmental sustainability.

Solid waste management system is designed for the village considering Vermicomposting method for organic waste generated in the Bhagavati village, a suitable location for composting was identified within Bhagavati village as depicted in Fig.2. The design was given to Bhagavati village panchayath for the implementation.

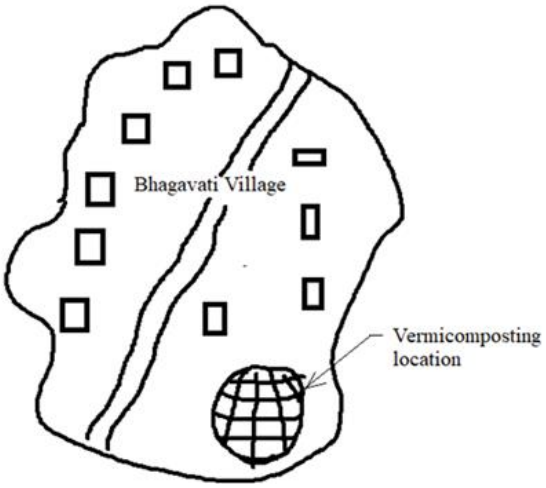

Fig. 2 Line diagram of solid waste management of vermicomposting for Bhagavati Village

(a)

(b)

Fig.3 Awareness program conducted in Bhagavati village

IV. RESULTS AND DISCUSSIONS:

A. Treatment of wastewater by construction of wetlands:

The laboratory scale analysis of physico-chemical characteristics of the wastewater was done and the results were separately obtained for both concrete rings where Chrysopogon zizanioidess and Azolla pinnata were installed.

The systematic analysis was done considering the parameters: pH, conductivity, turbidity, nitrogen, phosphorus, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total dissolved solids. The treatment period was carried out for about 2 months. The results were compared with results from literature and are presented in the following sections.

The introduction of Azolla pinnata and Chrysopogon zizanioides (Vetiver grass) in wetland construction had a significant impact on the physicochemical parameters of the wastewater.

Prior to treatment, the wastewater exhibited high concentrations of chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrites, and phosphates, with values of 276 mg/L, 88 mg/L, 63 mg/L, and 22 mg/L, respectively.

B. Treatment of wastewater using Chrysopogon zizanioides (vetiver):

However, after 40 days of treatment using Chrysopogon zizanioides, a notable reduction in nitrites and phosphates was observed, with levels dropping to 31 mg/L and 11 mg/L, respectively (Table 1).

The removal efficiency during the treatment period reached 50% for BOD5, 39.13% for COD, 66.67% for nitrites, and 50% for phosphates as shown in Fig. 4 and Fig. 5. Previous studies by Darajeh et al. (2019) have also demonstrated the effective utilization of Chrysopogon zizanioides for the phytoremediation of municipal wastewater, showcasing

high removal efficiency of organic nitrogen and COD. In the present study, Chrysopogon zizanioides exhibited higher removal of phosphorus. The Table 1. presents the removal efficiency of various chemical characteristics during the treatment of concrete ring wastewater using Chrysopogon zizanioides (Vetiver).

C. Treatment of wastewater using Azolla pinnata:

Wastewater treatment using Azolla pinnata resulted in reductions of 50% for BOD5, 42.75% for COD, 38.09% for nitrites, and 45.45% for phosphates after a treatment period of 47 days as shown in Fig 4. And Fig 5. Barco et al. (2020) similarly highlighted the efficacy of wetland construction for wastewater treatment.

In the current study, both Chrysopogon zizanioides and Azolla pinnata demonstrated effective removal of physicochemical pollutants from the wastewater. Moreover, an increase in the treatment period using these plants in the wetland led to higher reductions in nitrate, phosphorous, BOD, and COD concentrations. The Table 1. presents the removal efficiency of various chemical characteristics during the treatment of concrete ring wastewater using Azolla pinnata.

Comparing the performance of Azolla pinnata and Chrysopogon zizanioides, it can be observed that both plants showed effectiveness in reducing pollutants in the wastewater. Chrysopogon zizanioides exhibited higher removal of nitrites and phosphates compared to Azolla pinnata. However, Azolla pinnata demonstrated slightly higher removal efficiencies for BOD5 and COD.

The specific mechanisms responsible for the reduction of these parameters can be attributed to the plants' ability to uptake and assimilate pollutants through their roots, thereby mitigating their presence in the wastewater.

Furthermore, the design of the wetland construction for Bhagavati village was determined based on the studies conducted by Arshad et al. (2017) and Gunes et al. (2021). According to their findings, an area of 113.09 m^2 would require 45 *Chrysopogon zizanioides* plants.

Table 1. Removal Efficiency of Chemical Characteristics in Concrete Ring Wastewater Treatment with *Chrysopogon zizanioides* and *Azolla pinnata*

Parameters	**Removal Efficiency using *Chrysopogon zizanioides* at 40 days (%)**	**Removal Efficiency (%) using *Azolla pinnata* at 47 days (%)**
Total Nitrogen (mg/L)	66.67	38.09
Phosphorus (mg/L)	50	45.45
BOD_5 (mg/L)	50	50
COD (mg/L)	39.13	42.75

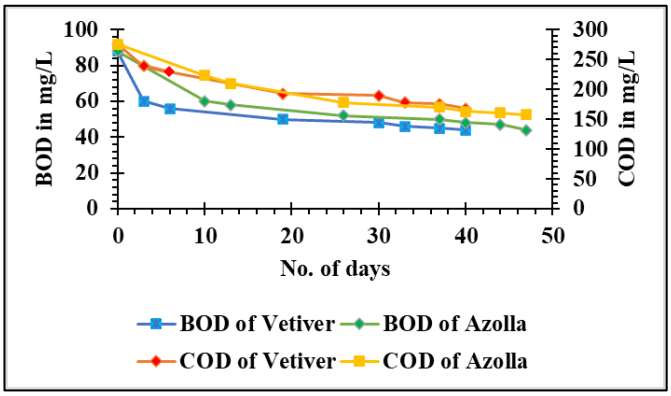

Fig.4 Variation of Nitrogen and Phosphorus concentration of Azolla pinnata and Chrysopogon zizanioides

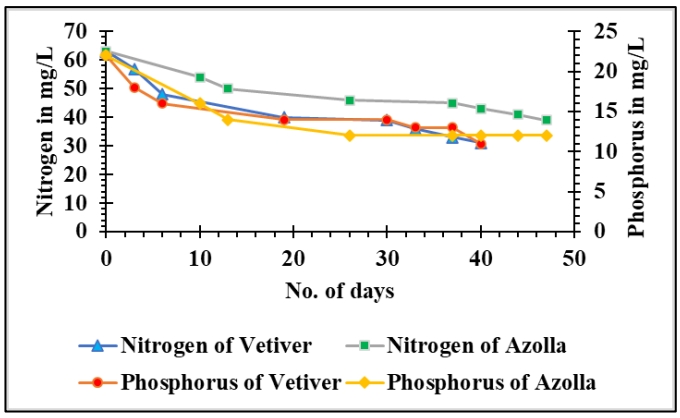

Fig. 5: Variation of Biochemical Oxygen Demand and Chemical Oxygen Demand concentration of Azolla pinnata and Chrysopogon zizanioides

Both *Azolla pinnata* and *Chrysopogon zizanioides* demonstrated their effectiveness in treating wastewater and reducing pollutant concentrations. While *Chrysopogon zizanioides* showed higher removal of nitrites and phosphates, Azolla pinnata exhibited slightly higher removal efficiencies for BOD5 and COD. The design of the wetland construction in Bhagavati village was developed based on the research findings, aiming to implement an efficient and sustainable wastewater treatment system.

D. Design considerations for Solid waste management using Vermicomposting:

According to the survey carried out in the village Bhagavati, the area of the village is 1517.17 hactares. The Population of the village according to village panchayath is 3069. The total number of houses are 581.

Waste generation rate for high, middle and low-income groups were 0.890, 0.612 and 0.346 kg per capita per day, respectively. (Waste management – CPCB). But for this village, waste generation low-income group rate is considered.

E. Calculation of waste generation in village:

- Waste generated in the village is calculated by
- Waste generated by person per day x Total population = 0.346 x 3069 = 1061.87 kg/capita/day
- The generated waste includes both the organic and inorganic waste, the primary treatment of waste is carried out, segregation separates dry and wet waste.
- According to survey, the village consists of more organic waste, 75% of total waste is organic and remaining 25% is inorganic waste.
- Total waste generated = 1061.87 kg/capita/day
- 75% of organic waste = 796.11 kg/capita/day
- 25% of inorganic waste = 265.46 kg/capita/day

Organic waste will be treated by vermicomposting method and the inorganic waste will be treated by open burning method.

F. Design of vermicomposting bed:

The design of vermicomposting beds in Bhagavati Village involved a systematic approach to effectively manage organic waste and promote the production of nutrient-rich vermicompost. The following steps were undertaken to ensure the beds could accommodate the waste generated and facilitate efficient composting.

Firstly, the dimensions of the bed were determined through a literature survey, and it was decided that the bed should measure 10x4x2 ft. The capacity of each bed was set to 1 ton (1000 kg), and the amount of waste generated per capita per day was determined to be 796.11 kg, including cow dung. To ensure optimal composting, 10kg of cow dung and 1kg of dry straw were allocated for each bed, and a waterproof, strong plastic sheet measuring 12x4 ft was used to line the bed. The red earthworms required for decomposition were also calculated to be 10kg per bed.

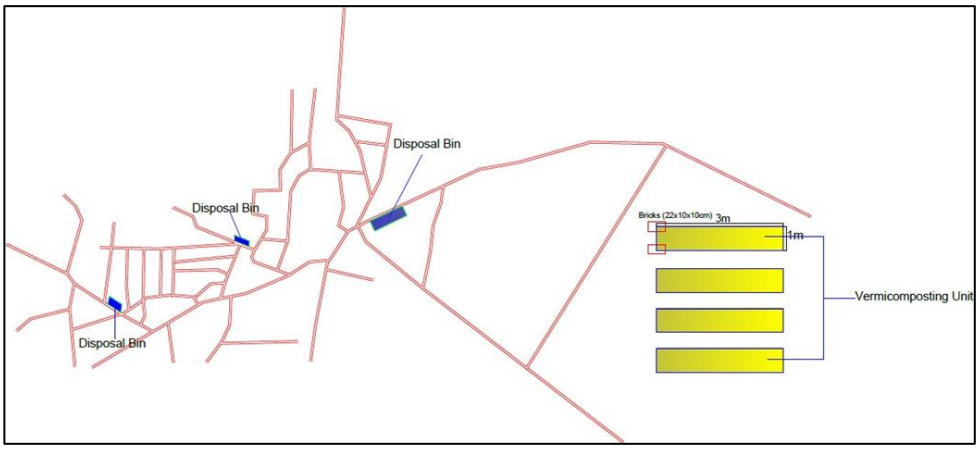

Fig. 6 Line diagram of road map of Bhagavati village showing vermicomposting unit and disposal units

Based on the number of houses in the village, the four beds were distributed at three different nodes as per the map as shown in Fig. 6. The total number of beds was set to four, and the waste was distributed evenly among the nodes, with each node servicing approximately 193 houses. Finally, it was determined that for every 1 ton of organic waste, 0.8 tons of vermicompost would be generated. These steps were taken to ensure that the vermicomposting beds in Bhagavati village were designed optimally to manage solid waste efficiently and effectively.

V. CONCLUSIONS:

The floating wetland system demonstrated its cost-effectiveness and energy efficiency as a wastewater treatment system, while also providing additional environmental benefits for aquatic habitats. The results of the present study highlighted the significant reduction in the concentrations of BOD5 (50%), COD (43%), nitrite (38%), and phosphate (45%) over a treatment period of 47 days, when Azolla pinnata weed was employed. Similarly, the wetland utilizing Chrysopogon zizanioides showed notable reductions in BOD5 (50%), COD (39%), nitrite (67%), and phosphate (50%) during a 40-day treatment period. The increase in dissolved oxygen levels over time further indicated the effectiveness of the floating wetland treatment implemented using concrete rings.

Moreover, the proposed design for vermicomposting pits, coupled with the awareness created among the villagers, holds great potential for providing a cost-effective and sustainable solution for solid waste management in Bhagavati village. By implementing the designed vermicomposting system, the community can achieve proper waste disposal while contributing to sustainable practices. This study emphasizes the importance of adopting innovative and eco-friendly approaches like floating wetlands and vermicomposting for wastewater treatment and solid waste management. These solutions not only address environmental concerns but also provide economic benefits and contribute to the overall well-being of the Bhagavati village community.

ACKNOWLEDGMENTS:

We thank to Mr. Abhishek S. Tippa, National Water Quality Specialist, ACIWRM, Govt. of Karnataka & Technical Mentor at iNODE Software Co. for his insightful suggestions and advices for working on this project. Also, we thank Department of Civil Engineering, BEC, Bagalote for proving the lab facility for the project work.

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12. Isolation And Evaluation of Antidiabetic Property of Punicalagin Extracted from Pomegranate Peel

Sharada S. B., Bhakti Kulkarni, Aishwarya R. Gunari, Shruti A. Belagali, Pooja B. Naik, Nisarga P. Hiremath

Department of Biotechnology

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ABSTRACT

Diabetes mellitus (DM), commonly referred to as diabetes, is a metabolic disorder characterized by high blood glucose levels over a prolonged period. Diabetes level of 70-110mg/dL is considered as normal, 100-125mg/dL is considered as prediabetes and 126mh/dL or higher is considered as diabetes. Diabetes is mainly divided into 2-major types: type 1 and type 2.

This is a chronic metabolic disorder which is a fast-growing global problem with huge social, health, and economic consequences. Pomegranate peel, derived from the processing of Punica granatum L. (pomegranate), has traditionally been considered agricultural waste. Recent studies have shown its potential as a rich source of bioactive compounds with diverse pharmacological effects. Pomegranate peel is a rich source of antioxidants, polyphenols, dietary fibers and vitamins which contribute remarkable bioactivity. Punicalagin, a polyphenol found majorly in Punica granatum have pharmacological activities including anticancer, antioxidant, hepatoprotective, antimicrobial, antivirus, neuroprotective, anti-inflammation, gastro protective antidiabetic and anti-hyperlipidemia. In this project, extraction of punicalagin has been carried out by three-different methods, namely, soxhlet extraction, water extraction and cloud point extraction. The recovery percentage of punicalagin by various extraction methods is compared and the method without any drawback is further selected. analysis of punicalagin is done by Thin Layer Chromatography (TLC), High Performance Liquid Chromatography (HPLC). The determination of effectiveness of the sample as an antidiabetic agent is done by preclinical trials.

KEYWORDS:

Punicalagin, Antidiabetic, Cloud Point Extraction, Pomogranate pod, Polyphenol activity.

I. INTRODUCTION:

Pomegranate (Punica granatum) is a plant native to Central Asia and principally cultivated in the Mediterranean and California (although now widespread almost all over the globe). In India, it is cultivated commercially only in Maharashtra. Small scale plantations are also seen in Gujarat, Rajasthan, Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, Punjab and Haryana. It has several nutritional and potential health benefits that come out from the various parts of plant (Carpellary membranes, arils, peel, seeds and bark). Indeed, the phytochemical composition of the fruit abounds in compounds (flavonoids, ellagitannins, proanthocyanidins, polyphenols etc) presenting a significant biological and nutraceutical value.

II. MATERIALS AND METHODOLOGY:

II. A Collection of Pomegranate:

Fresh pomegranate fruits were collected from Kaladgi, Karnataka. The fruits were washed with tap water followed by salt water (saline). The peels were separated from the fruits and dried under shed drying for approximately a week until it gets fully dried. The peels were then powdered using mixer grinder and sieved using sieve of pore size 140 µm. The powder was then packed in the zip lock bag and stored until further processing.

The polyphenol analysis was carried out by three different methods as mentioned below:

1. Soxhlet Extraction
2. Conventional Water Extraction
3. Cloud Point Extraction

II. B Determination of Moisture Content:

Temperature of oven was set at 105°C. The oven was left for half an hour to check stability of temperature before using it for actual experiment. Petriplates were preheated with lids in hot air oven for 30 minutes. Petriplates were cooled to room temperature. The initial weight of fresh pomegranate peel was recorded using electronic balance. Further, the pomegranate peel was dried in hot air oven at 105°C for 2.5 hours. The final weight of dried peel was recorded.

% of moisture content = [(Initial weight – Final weight) / Initial weight] × 100

Crucibles were cooled to room temperature. 2 g of dried peel was weighed in crucible and kept in muffle for 3 hours. Further, crucibles were removed and cooled at room temperature. The ash was weighed after cooling.

% of ash content = [(W3-W1) / (W2-W1)] × 100

(Reference: ITC manual)

II. C Soxhlet Extraction:

40 g of peel powder was weighed and dissolved in 240 ml methanol (solvent). The aqueous extract was allowed for the soxhlet extraction. The extraction of powder with a soxhlet extractor was done for 36 hours. Further, the extract from soxhlet extractor was allowed for drying in petri plates under shed drying until it gets fully dried. The dried extract was the separated from the petri plates using spatula and collected in an Eppendorf tube.

Approximately 9 grams of the dried extract was collected and stored in a refrigerator until further processing.

II. D Determination of Total Phenolics Content in Soxhlet Extract:

0.05 grams of soxhlet extract was weighed and dissolved in 5 ml of methanol. Aliquotes of 10 µl of sample was mixed with 2.5 ml of 10-fold diluted Folin-Ciocalteu reagent and 2 ml of 7.5% sodium carbonate. The total volume of the sample should be adjusted to 25 ml using distilled water.

The mixture was then allowed for incubation at room temperature for 30 min before the absorbance was measured at 760 nm using UV-spectrophotometer. The total phenolics content in the extract was calculated and expressed as gallic acid equivalents (GAE; mg/g dry mass) using a gallic acid standard curve.

II. E Conventional Water Extraction:

Pomegranate peel powder of different weights (1, 2 and 3 grams respectively) was dissolved in 70 ml distilled water. The sample was then kept in a thermostable water bath shaker at 40° C for 3 hours.

The liquid extract was allowed for centrifugation at 10,000 rpm for 8 minutes. The supernatant was analysed for TPC. solution addition. The final volume was made upto 5ml by diluting it with the distilled water. The sample was incubated at 25° C in the dark for 30 min and the absorbance was measured at 750 nm in a UV-VIS spectrophotometer. A standard gallic acid graph of different concentration was used. The final yield of total polyphenol content was expressed as mg GAE/g of sample.

II. F Determination of total phenolics content in water extract:

Total phenolic content of the extract was determined by the Folin- Ciocalteau method,which was described by Chun et al. (2005). The sample and Folin-Ciocaltaeu reagent of same volume (100 µl each) was taken in Eppendorf tube followed by 700 µl of 20% sodium carbonate solution addition.

The final volume was made upto 5ml by diluting it with the distilled water. The sample was incubated at 25° C in the dark for 30 min and the absorbance was measured at 750 nm in a UV-VIS spectrophotometer. A standard gallic acid graph of different concentration was used. The final yield of total polyphenol content was expressed as mg GAE/g of sample.

II. G Cloud Point Extraction:

The CPE of polyphenols and flavonoids was performed as per the method of Katsoyannos et al. with slight modifications. 0.5 gram of pomegranate peel powder, 50 ml distilled water and a surfactant (Triton X-100, 5-11% v/v) was made into a mixture and was taken in a centrifuge tube and vortexed for 1 min, followed by adjustment of pH (4-8). The tubes were kept on the shaker for 30 min maintaining the temperature of 37 ± 2° C. The mixture is then allowed for centrifugation at 10,000 rpm for 10 min. The supernatant was transferred to another tube. Salt (NaCl) was added into the sample solution for smoothing of phase separation by reducing the cloud point temperature (CPT) due to salting out effect with increase in the density of aqueous phase followed by thermostatic water bath for 30 min. The sample was the centrifuged for 10 min at 8,000 rpm.

III. H Determination of Total Phenolics content in Cloud Point Extract:

Total phenolic content of CPE extract of pomegranate peel powder was determined by Folin-Ciocalteu assay with slight modifications. According to the method, 0.1 ml of extract or standard gallic acid solution, 0.1 ml of 80% methanol, 0.1 ml of Folin-Ciocalteu reagent and 0.7 ml Na2CO3 were added into 2 ml Eppendorf's tube.

The samples were vortexed and incubated in the dark at room temperature for 20 min. Further, the samples were allowed for centrifugation at 8000 rpm at 4°C for 8 min. The absorbance of supernatant was measured at 735 nm in 1 ml quartz cuvettes by using a UV-vis spectrophotometer. The final yield of total polyphenol content was expressed as mg GAE/g pomegranate peel powder.

II. I Determination of Punicalagin By HPLC-UV:

Quantification of punicalagin was performed by HPLC having C18 column. A sample of 10 dilutions was taken from each method by auto sampler and 30°C temperature of column was ensured throughout the analytical process. Mobile phase was comprised of Methanol (eluent-A) and 0.1% (vol/vol) Trifluroacetic acid in HPLC grade water (eluent-B). Chromatographic conditions (Gradient): 0-10 minutes, 5-20% A in B; 10-20 minutes, 20-40% A in B; 20-26 minutes, 70% A in B. These protocols were trailed by re-equilibrium for 10 minutes. The flow rate was adjusted at 1 ml/min and punicalagin was quantified at 378 nm wavelength using UV-Vis detector.

II. J Determination of Punicalagin By TLC:

TLC analysis of peel extract of pomegranate was developed on analytical plates over silica gel-G of 0.2 3611 mm thickness. Acetic acid: Distilled water (1:3, v/v) was the mobile phase that has good separation and sensitivity for the analysis of phenolic compounds. thidentification of phenols on TLC plate, it was sprayed with 2% sulphuric acid and kept in hot air over for 5 min and allowed to dry. For the identification of phenols on TLC plate, it was sprayed with 2% sulphuric acid and kept in hot air over for 5 min and allowed to dry. The reported spots were separated with enough space showing the presence of phenols and calculated retention factor (Rf) value.

II. K Preclinical Studies:

K.1 Selection of animals:

The wistar rats of either sex (190-330 g) was taken from animal house. The animals were housed at room temperature (22-28°C) with 65+10% relative humidity for 12 hours dark and light cycle and given normal pellets (rat feed) and water. The study was approved and conducted as per the norms of the Institutional Animal Ethics Committee of H.S.K. College of Pharmacy, Bagalkote and carried out in accordance with CPCSEA (Committee for the Purpose of Control and Supervision of Experiments on Animals) guidelines for the use and care of laboratory animals.

II. K .2 Induction of diabetes:

After 1 week of quarantine, rats were fasted overnight and the animals were rendered diabetic by a single intraperitoneal injection of Streptozotocin (STZ, 35 mg/kg BW). STZ (Sigma USA) at a dose of 35 mg/kg were prepared in cold citrate buffer (pH 4.4, 0.1M) and administered. The STZ injected animals showed hyperglycemia after 72 hours [4].

III. A. Determination of Punicalagin by TLC:

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III.B.1 Selection of animals:

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III.B.2 Induction of diabetes:

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III.C Determination of serum glucose level in rats:

The blood samples from each rat were taken in centrifuge tubes and labelled as B1-B6 which is further centrifuged at 8000 rpm for 10 min and supernatant was collected. Test tubes containing 1ml of glucose were labelled as B1-B6 respectively. 1 ml of supernatant was added into the test tubes containing glucose according to the order.

The test tube samples were stirred properly and kept for incubation at room temperature for 10 min. After incubation, the absorbance was measured by UV- spectrophotometer at 505 nm. The glucose level was estimated according to the formula,

Calculation of glucose level = (Test/ Std) × 100

If the calculated glucose level is 140, then it is considered as normal.

Fig 1 Oral injection of dosage

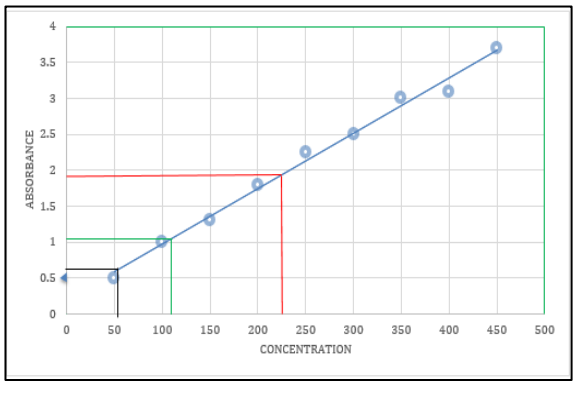


Fig 2 Standard gallic acid curve for polyphenols (punicalagin)

- Water Extract
- Soxhlet Extract
- CPE

Table 1 Concentration of total phenolic in different extraction method

Extraction	Wavelength (nm)	Absorbance	Concentration (µg/ml)
Water extract	760	0.5665	60
Soxhlet extract	750	1.180	110
Cloud point extract	735	1.9331	225

III.D. Determination of moisture and ash content:

The moisture content was calculated by the formula mentioned below.

Initial weight of peel = 120.6gms

Final weight of peel = 31.822gms

Formula

% of moisture content = [(Initial weight – Final weight) / Initial weight] ×100

= [(120.6 – 31.822) / 120.6] × 100

= 73.61%

The moisture content was found to be 73.61%.

III.E Determination of Ash Content:

Weight of empty crucible, W1 = 67gms

Weight of crucible + sample weight before ashing,

W2 = 69gms

Weight of crucible + ash, W3 = 68.2gms

Formula:

% of ash content = [(W3-W1) / (W2-W1)] × 100

= [(68.2 – 67) / (69 – 67)] × 100

= 60%

The ash content was found to be 60%.

III.F Determination Of Punicalagin By Analytical Methods:

III.F.1High Performance Liquid Chromatography (HPLC):

The chromatogram of HPLC has shown the peak in a time period of 5 min which represents the presence of punicalagin.

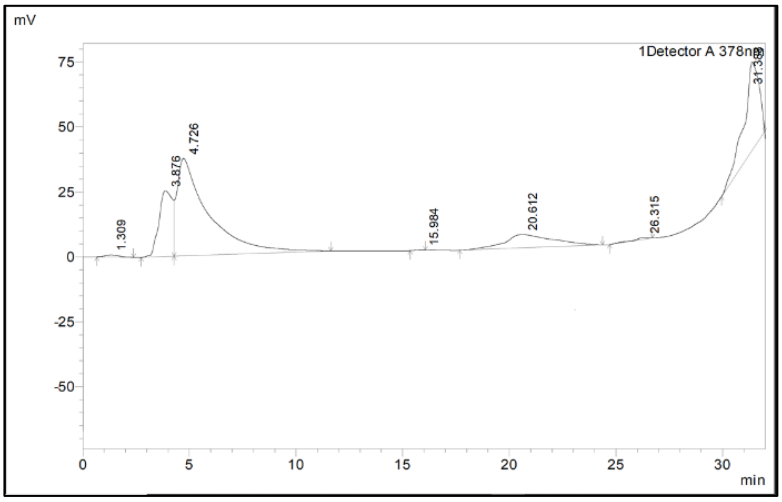


Fig 3 HPLC chromatography for extract

Fig 4 TLC analysis for soxhlet extract and water extract

Solute front = 6.8 cms

Solvent front = 16 cms

Formula:

Rf value = Solute front / Solvent front

= 6.8/16

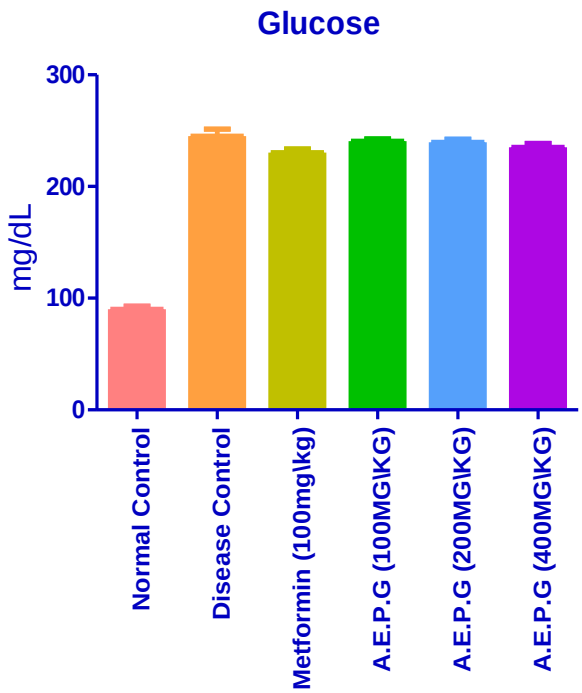
= 0.425 0.43

The Rf value of punicalagin was found to be 0.425 which is similar as compared to the literature (Ref: http://ejchem.journals.ekb.eg/).

From the above results we can conclude the presence of punicalagin in pomegranate peel.

Glucose level (mg/dl)				
Treatment group	**0th day**	**7th day**	**14th day**	**21st day**
Normal control	90.00±2.769	93.00±2.422	92.67±2.906	94.67±1.961
Diseased control	245.2±6.145	256.8±5.237	265.2±3.885	282.0±3.661
Metformin(100mg/kg)	230.3±3.273	217.3±1.498	206.8±3.390	186.5±3.871
A.E.P.G (100mg/kg)	240.5±2.187	238.2±5.369	222.8±2.561	217.7±2.777
A.E.P.G (200mg/kg)	239.5±2.930	229.0±3.000	222.5±2.391	215.2±1.721
A.E.P.G (400mg/kg)	235.2±3.390	225.0±4.211	215.8±2.372	220.0±15.73

Table 2 Determination of glucose level



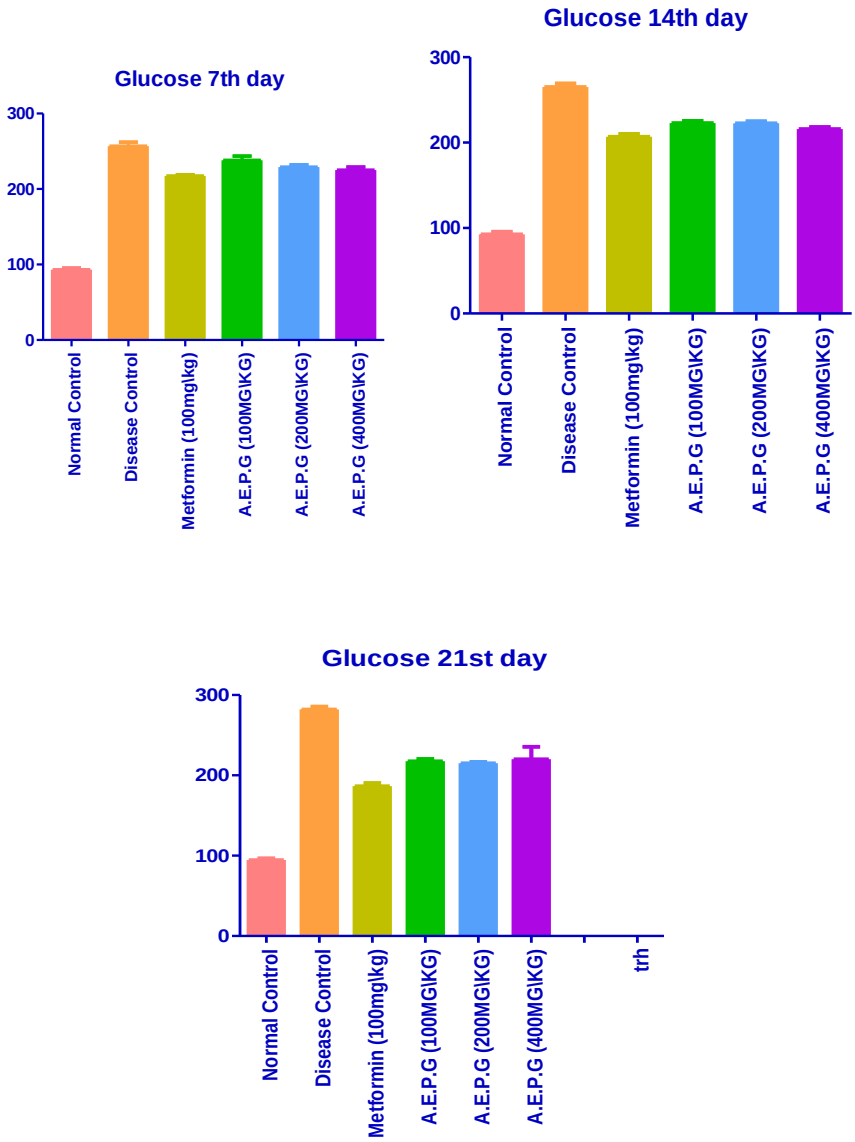


Fig 5 Graphical analysis of glucose levels

III.F.2 Determination of Blood Glucose Levels:

Blood glucose level was analyzed at fasting level and the results showed that the extract had no significant effect on fasting state of normal rats but lowered the serum glucose level.

On 0th day, after inducing diabetes, the sugar levels in diseased control was high which was gradually increasing when studied every week till 21st day without any treatment. When treated with readily available antidiabetic drug, metformin, sugar levels were gradually decreasing.

Approximately similar results were obtained when treated with extracted sample which showed the significant decrease in diabetes in rats when compared with metformin.

IV. Conclusion:

The punicalagin was extracted by three methods, namely, soxhlet extraction, water exraction and cloud point extraction. Among these three methods carried out, water extraction is more effective without any drawbacks, which is a non- hazardous method.

The extracted punicalagin has shown effective antidiabetic property in rats at the dosage of 400mg/kg.

Acknowledgement:

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13. Development of Bio-Derived Antimicrobial, Nanocomposite for Packaging

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ABSTRACT

In the present investigation focuses on the use of Zinc oxide (ZnO) in preparation of Nanocomposite film. ZnO is currently listed as a generally recognized as safe material by the Food and Drug Administration and is used as food additive. Since, there has been wide application of nanotechnology utilizing them as a antimicrobial agents. Accordingly, in the current study the potential antibacterial activity against the gram-negative bacteria such as E. Coli, film ZnO in a nanoscale has shown antimicrobial properties and potential applications in food preservation.

To give the packaging material anti-microbial activity and enhance packaging qualities, ZnO nanoparticles have been added to polymeric matrix. The primary techniques for synthesizing ZnO nanoparticles, their key attributes and antibacterial action mechanisms, and the results of their integration into polymeric matrices are all covered in this paper. This effort is will open the new dimension of packaging applications.

KEYWORDS:

Zinc Nanoparticles, nanotechnology, bioplastic, antimicrobial property, Polymeric blends.

INTRODUCTION:

The second most common metal oxide after iron is zinc oxide nanoparticle, which is also cheap, safe, and simple to make. Zinc oxide nanoparticles' physical and chemical behaviors can be readily altered by altering their shape and producing nonmaterial by other synthesis techniques, precursors, or materials. Zinc oxide nanoparticles are used in chemical sensors, photocatalysis, and solar cells because of these characteristics. The low toxicity and great UV absorption of zinc oxide nanoparticles make them a promising option for usage in the biomedical industry [1].

Foodborne illnesses are a major concern for world public health. According to the CDC (2011), there were an estimated 47.8 million foodborne illnesses, 127,839 hospitalizations, and 3,037 fatalities in the United States alone in 2011. These numbers would have an impact on trade, the economy, and global health in addition to costing money in medical bills and lost productivity. As a result, there has been a noticeable increase in demand in recent years for novel technology to manage foodborne infections.

Food packaging is crucial for ensuring food safety and quality, for these reasons. Active packaging is food packaging that has additional uses. It was created in response to consumer demand for safer, more natural products with longer shelf lives, better cost-benefit ratios, and convenience.a strong contender for application in the biological sciences [2]. As a subset of active packaging, antimicrobial packaging works with the product or the headspace inside it to lessen, prevent, or delay the growth of any bacteria that might be on food surfaces.

This reduces the need for additional, high concentrations of antimicrobials to be applied directly to food products by allowing the progressive diffusion of target bacteriostatic or bactericidal chemicals into a food matrix through the inclusion of antimicrobials into packaging materials. Antimicrobial packaging can also be a significant factor in lowering the risk of pathogen contamination and prolonging the shelf life of food, as researchers have found it to be an extra barrier against food contamination following nonthermal activities [3].

The emergence of nanotechnology, encompassing the production and application of materials as small as 100 nm in one or more dimensions, has created enormous prospects for the creation of novel materials with antimicrobial agent applications.

As a result, for the past ten years, interest in inorganic compounds at the nanoscale has been rapidly rising. Because of their distinct chemical and physical characteristics and high surface area to volume ratio, inorganic compounds with nanoscale size have potent antibacterial action even at low concentrations [4].

In addition, some of them are thought to be nontoxic and even include mineral components that are necessary for human health [5]. They are also more stable in harsh environments like high temperatures and pressures. According to researcher’s [6, 7], the majority of antibacterial inorganic materials are metallic nanoparticles and metal oxide nanoparticles, such as silver, copper, titanium oxide, and zinc oxide (ZnO).

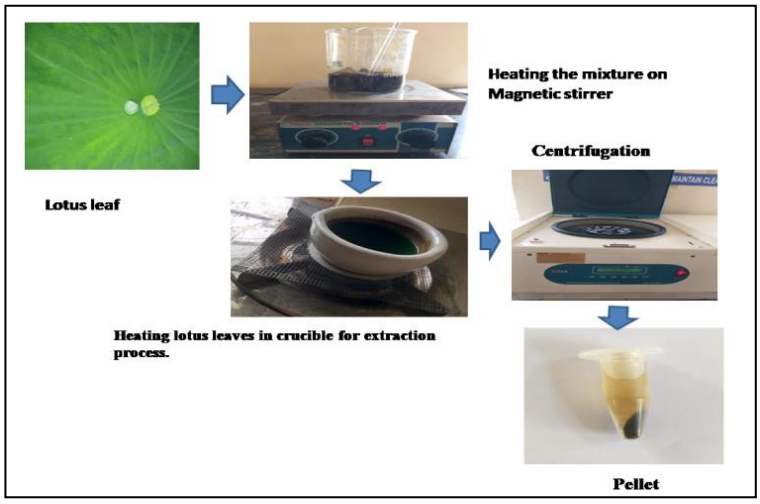


Fig 1: Schematic representation of ZnO nanoparticles synthesis.

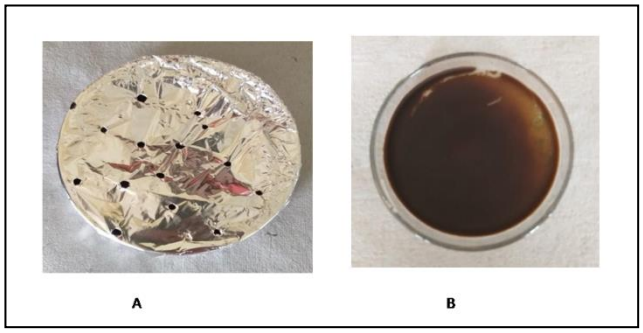
MATERIALS AND METHODS:

2.0 Synthesis of ZnO nanoparticles

Preparation of aqueous lotus leaf extract:

Nelumbo nucifera leaves that had just been picked, were briefly submerged in running water and then gently wiped with a fresh white cloth. Hands wearing sterile surgical gloves lotus leaves were cut into tiny bits. A 200 ml beaker was filled with 100 ml of distilled water and about 25 grams of the leaf bits. With the beaker partially capped with a watch glass, the heterogeneous mixture was heated at 75°C for three hours while being constantly stirred on top of a hot plate-magnetic stirrer (8). After cooling and further filtering the extract using Whatman filter paper grade 1, a deep, dark brown solution of lotus leaf extract was obtained. As will be explained below, this was utilized in the creation of ZnO NPs. ZnO NPs were produced utilizing a lotus leaf extract solution combustion process as part of a green synthesis approach. Initially, 0.595 g of zinc nitrate was added to 20 ml of distilled water while stirring constantly at room temperature to create a 0.1 M aqueous solution (8).

The 20 ml of leaf extract was combined with the resulting aqueous zinc nitrate solution at 60°C, drop by drop. After the mixture was transferred to a silica crucible, it was heated using a gas burner to 100°C for 30 minutes. This reaction causes Zn (II) ions to combine with the oxygen in the medium, forming ZnO NPs, while the other components evaporate. The resulting crude ZnO NPs were then treated with distilled water and ethanol, as will be explained below, to further purify them. The resulting crude product was added to 20 milliliters of distilled water, the mixture (suspension) was centrifuged, and the leftover supernatant was disposed of. This process was then performed four more times. The substance was centrifuged at 5000 rpm for 15 mins. After that, the resultant product was added to 20 milliliters of rectified spirit (ethanol) and subjected to a brief sonication. The supernatant was then disposed of, and this process was repeated five more times. The product was then sonicated for 10 minutes at 10 Hz and 75 °C.



2.1 Fig 2. Synthesized Nanoparticles.

2.2 Biodegradation test using soil burial method:

A small piece of bioplastic was weighed about 0.500 grams and was inserted in a flower pot to check its decomposition. After every five days the bioplastic was removed from the pot and was weighed. Each interval percentage of weight loss was calculated.

2.2 Preparation of polymeric blend coated with nanoparticles:

Preparation of solution (For 200ml: Cornstarch-5.5gms, Agar-1.1gms, Gelatin-2.3gms, Glycerol- 4ml, Distilled water- 190ml), Keep the mixture on magnetic stirring at 70-80°C for3 hours. Let it cool down. Pour on glass slab after washing and wiping it with ethanol to avoid the contamination from the airborne microbes.

Keep it for drying at room temperature for 3 days and peel it off. And the films sample was peeled from the glass slab, and four samples were prepared (one is control, negative control, Test 1 and Test 2), Negative control was not exposed to bacteria, control consists of normal film with bacterial inoculation, test 1 and test2 consists of different concentration (50µl and 100µl) of ZnO coated film samples. Results were recorded after 2 days of incubation of petriplates at temperature 37oC.

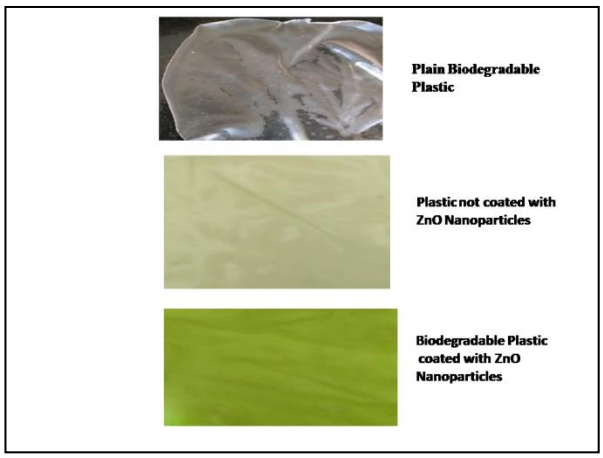


Fig 3: Coated and non-coated and plain biodegradable plastics samples.

2.3 Testing the antimicrobial activity of the blends:

Thus, developed blends can be tested for their antimicrobial activity, were after the preparation of the sterile agar plates, four types of plates were kept, in one plate only normal biodegradable plastic was kept as control which was also inoculated with E. Coli, where another plate as negative control which was not inoculated with any microbes.

Other two plates (Test1 and Test 2) where each film samples were coated with 50µl and 100µl of ZnO nanoparticles respectively. The synthesis of Zincoxide nanoparticles were confirmed using the UV-Visible spectroscopic method.

RESULTS AND DISCUSSION:

There was incremental in the biodegradation of the film sample, so soil microbial action with their enzymatic degradation accelerated the decomposition of the developed film sample. This is totally in natural conditions, if you provide that will enhance the Aw activity of the microbes.

This could also tremendously stimulate the degradation process. So, you can use this technique whenever needed, means if you biodegrade the utilized film material.

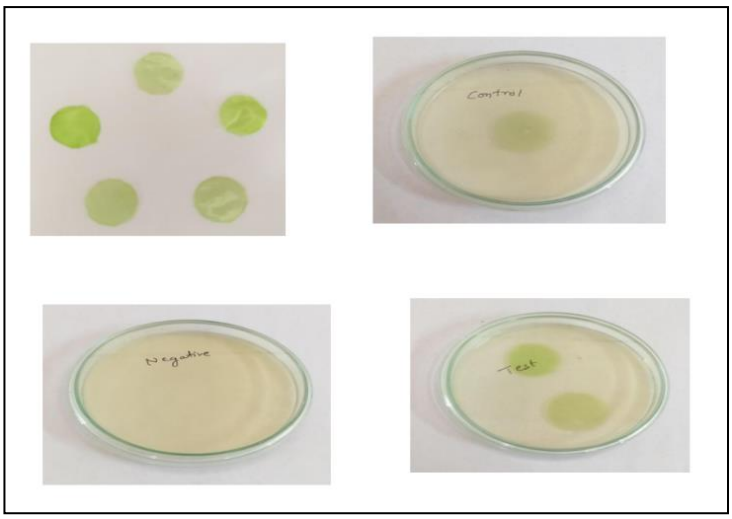


Fig. 4. Measured round shape chopped film samples control, negative control and the test samples.

The film sample were subjected for their microbial resistance, as there is high demand in the market for supplying antimicrobial packaging, this is due the outbreak of the Covid-19 in 2020 that has made people to focus on the properly packaged food.

Accordingly, this specific work was designed to develop the biodegradable packaging material typically which should have the antimicrobial applications.

Table 1: Percentage of soil degradation with respect to time.

No.of Days	Initial weight	Final weight	Difference (%)
5 Day	0.50	0.499	0.20%
10	0.499	0.497	0.40%
15	0.497	0.494	0.60%
20	0.494	0.490	0.80%
25	0.490	0.486	0.81%

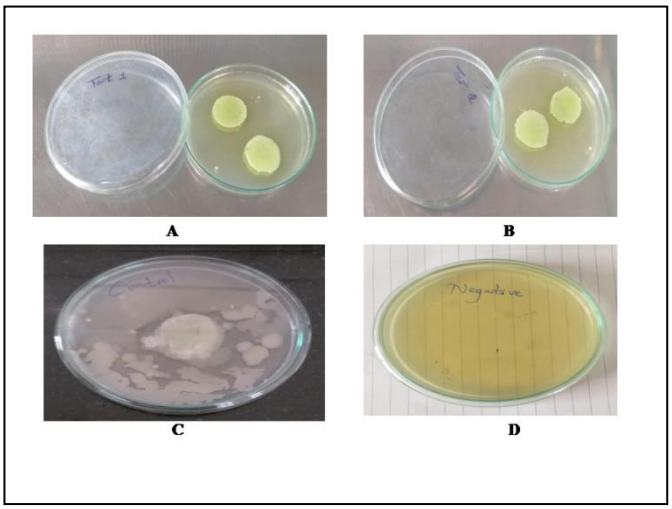


Fig 5. Antinmicrobial activity of the samples (Test samples coated with ZnO in A and B). Microbial growth in Control plate exposed to bacteria and no growth of bacteria in negative plate without inoculation.

The spectra of ZnO nanoparticles were based on the distinctive absorption peak at wavelengths of about 375 nm, which is similar to the results of Ishan et al., (2023) [9]. This peak allows for the analysis of uncommon, uniformly distributed nanoparticles, the majority of which are nanosized. The fact that no additional peak was seen over the whole absorption spectrum, indicating that ZnO had successfully formed, serves as evidence.

Features of Zinc Oxide Nanoparticles: ZnO nanoparticles range in size from 30 to 150 nm and come in three distinct shapes: rod-like, star-like, and isometric.The majority of the ZnO particles were found in clusters. ZnO nanoparticles range in size from 30 to 150 nm and come in three distinct shapes: rod-like, star-like, and isometric. In contrast to the previous research [10, 11] they were mainly explored microorganisms in controlling pathogenic organisms, the present investigation emphasized the potential inhibition of the bacteria to protect the foods from getting spoiled. Reports also indicated that nanotoxicity of zinc oxide nanoparticles against halophilic gram-negative Marinobacter species, gram-positive halophilic bacterial species showed 80% growth inhibition. It was demonstrated that zinc oxide nanoparticles below 5 mM concentration are ineffective against bacteria [12]. However, the antibacterial activity towards few marine bacteria is not yet known [13,14]

Conclusion:

ZnO nanoparticle synthesis and production was observed. In order to prepare the polymeric blend, it was left to dry and scraped with a sterile micro tip before being placed in a glass bottle. Additional research demonstrates ZnO nanoparticles' antibacterial properties. The experiment demonstrating antibacterial action concluded that germs grew around the film but not on it because ZnO nanoparticle coating prevented microbes from growing on the film. It takes three to six months for the biodegradable plastic to fully break down into the soil. The ZnO nanoparticle spectrum is shown in the picture, where the sample's distinctive 375 nm absorption peak is recognized.This peak allows for the analysis of uniformly distributed nanoparticles, the majority of which are nanosized. The fact that no other peak is seen over the whole spectrum, indicating that ZnO has successfully formed, serves as evidence.

Future Scope:

ZnO nanoparticle-infused food packaging may have uses in the preservation of food. To date, ZnO nanoparticles have been used to create antibacterial materials using petroleum-derived polymers like PP and LDPE. Even if they are new, the applications of this nanoparticle in biodegradable polymeric matrices appear to have no limits because the addition of ZnO would enhance the mechanical, thermal, and barrier qualities of the material. Furthermore, more study is required to comprehend the toxicological impacts of ZnO nanoparticles in order to assess the influence on consumers. Furthermore, investigating the potential of food packaging made using nanotechnology in conjunction with other cutting-edge technologies.

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14. Removal of Heavy Metals from Wastewater by Bioremediation Method using Microalgae

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ABSTRACT

Bioremediation is a method of using natural processes to clean up sites contaminated by toxic chemicals. The presence of these heavy Metals on the surface of water is due to anthropogenic activities. Chlorella vulgaris and many microalgae are of capable to synthesis peptides, metallothioneins & Phytochelating which can bind effectively to heavy metals and undergo biosorption. Wastewater collected from, Lake was tested for heavy metals and it was found that Lead was 0.58mg/l, Chromium of 0.12 mg/l, Cadmium of 0.04 mg/l, Iron of 0.15mg/l, Arsenic of 0.07 mg/l. Chlorella Vulgaris was grown & its growth was optimized. Based on the growth curve, the organism was inoculated into the wastewater and was analyzed in different intervals. The reduction began on 8th day of inoculation and by 21st day it was found that about 83% of lead, 66% of chromium, 25% of cadmium, 60% of Iron, and 71.42% of arsenic was reduced. This indicates that Chlorella vulgaris is found to be the best option for removal of heavy metals from wastewater by using biosorption.

KEYWORDS:

Biosorption, Heavy metals, Chlorella vulgaris, Bioremediation and biosorbent.

INTRODUCTION:

Algae are neither bacteria nor plants they make their own food through photosynthesis like plants and in turn they produce oxygen necessary for human consumption.Chlorophyceae, Phaeophyceae, Rhodophyceae are the three main algae used in bioremediation. Among them Chlorella vulgaris is, an alga, found to be more relevant and has been used in removal

of heavy metals in wastewater bodies consisting of Lead, Chromium, Arsenic and Cadmium. In areas where food is not easily available, they are valuable protein source and contain healthy fats [1]. Bioremediation is the process used to degrade the pollutants in the wastewater. Biosorption is the process where the algae take in and build up heavy metals onto their cell walls or within cellular structure. This process is helpful for removing metals like lead, cadmium, mercury and arsenic from contaminated water sources. Chlorella vulgaris has several characteristics that make it suitable for heavy metal removal, including its high surface area-to-volume ratio, rapid growth rate, and ability to increase in various environmental conditions. The effectiveness of Chlorella vulgaris in removing heavy metals depends on factors such as concentration of metals, biomass concentration and metal contaminants in the water. Research continues to explore ways to optimize the use of Chlorella vulgaris and other algae species for environmental remediation purposes. Several species of Scenedesmus, Spirulina, Chlorella, Anabaena, marine algae have been used for the removal of heavy metals. Microalgae capable to synthesize peptides metallothioneins, mainly the post transcriptional synthesized class III metallothioneins or phytochelatins those efficiently bind to heavy metal [2]. There are different types of Bioremediations and each type of bioremediation has its advantages and limitations, and the selection of technique depends on factors such as the type and amount of contamination, conditions of site and cost effectiveness.

Methodology:

Fig. 1 Stock solution

Fig. 2 Inoculation of Stock solution and algae into fresh water

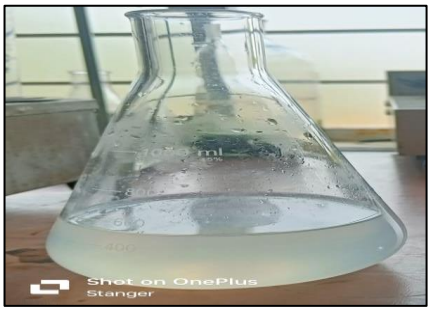

Fig. 3 Synthetic lead solution

Fig. 4 Inoculation into Wastewater

Fig. 5Growth of Chlorella vulgaris

Fig.6 Growth of Chlorella vulgaris

Culture preparation:Chlorella vulgaris culture was maintained in the refrigerator at 18°C and then this was used as starter culture for cultivating the algae. In BBM media, and suitable growth conditions of pH 7.0 and inoculated at 27°C.

Preparation of fresh water media:BBM was prepared and sterilized in autoclave at 121°C at 15lb pressure for 20 mins.

Inoculation: Introduce the Chlorella vulgaris into the BBM media. Allow it to multiply and check the growth curve at different intervals of 24hrs, every day the OD was checked to observe the growth pattern of algae.

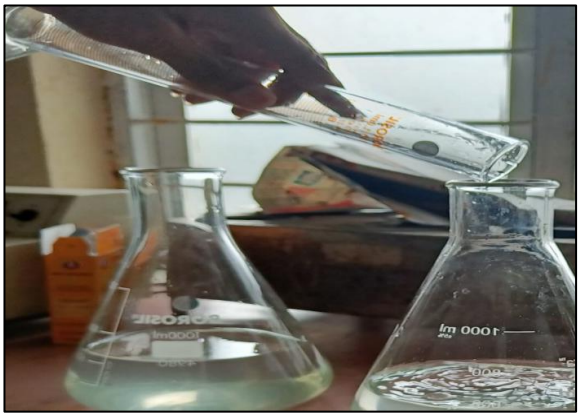

Fig. 7 Fresh water media

Preparation of Synthetic media (Lead nitrate): Dissolve 1gm of Lead Nitrate in 750ml of Sterilized water followed by the addition of 250ml of algal solution of Chlorella vulgaris to grow. Based on growth pattern the reduction of lead was analysed by using spectrophotometer. The reduction analysis was done after 5 days of growth, this period was allowed for the algae to acclimatize to the lead environment further every 2 days the reduction of lead was analysed till the maximum reduction was found.

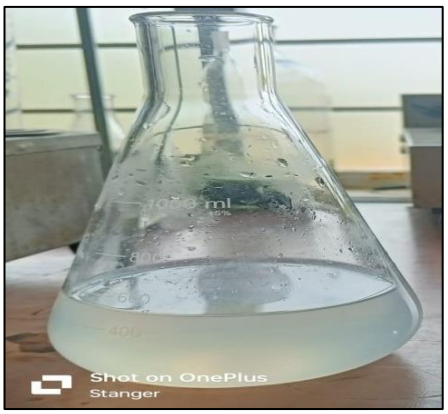

Fig. 8 Synthetic media

Growth curve of Chlorella vulgaris in fresh water:There is no growth of algae for 1st five days as it need to acclimatize to the media condition. The gradual increase in its growth was observed from 6th to 20th day (as shown in graph), its stationary phase from 21st to 23rd day and declining phase from 24th till 26th day (as shown in graph).

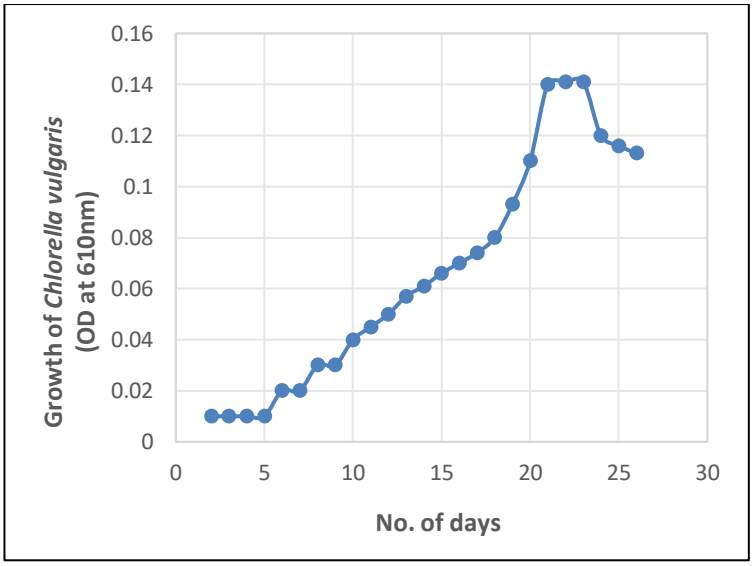

Fig. 9 Growth curve of Chlorella vulgaris in fresh water

Table.1 Experimental value of growth of algae in fresh water

Days	Concentration	Days	Concentration
1	0.005	13	0.057
2	0.01	14	0.061
3	0.01	15	0.066
4	0.01	16	0.07
5	0.01	17	0.074
6	0.02	18	0.08
7	0.02	19	0.093
8	0.03	20	0.11
9	0.03	21	0.14
10	0.04	22	0.141
11	0.045	23	0.141
12	0.05	24	0.12
13	0.057	25	0.116
14	0.061	26	0.113

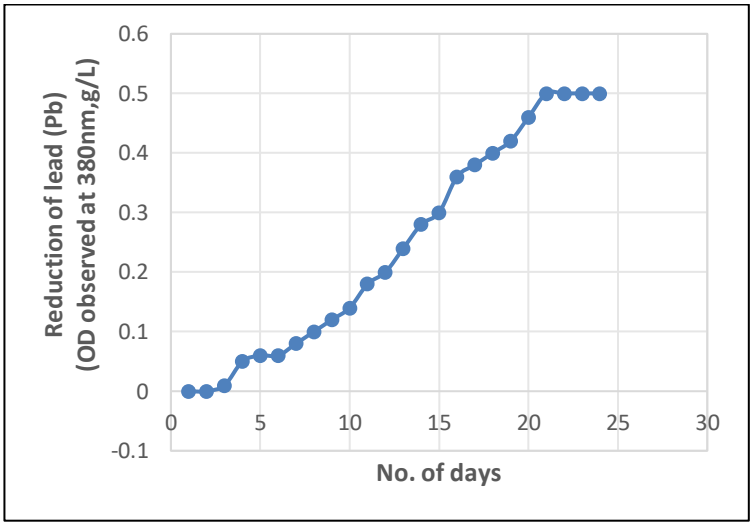

Fig. 10 Reduction of Lead in synthetic media

Table.2 Reduction of lead in synthetic media

No. of days	Concentration in Lead (g/L)	Percentage (%) in Lead
1	0	0
5	0.05	5
8	0.1	10
12	0.2	20
15	0.3	30
18	0.4	40
21	0.5	50
22	0.5	50
23	0.5	50

There is no change in the OD for 1sttwo days as the algae showed no growth, as it need to acclimatize to the synthetic Lead solution because Lead is toxic in nature. After two days there was slight increase in OD.

After fifth day slowly there was increase in OD which indicates gradual increase. Upto 13th day there was rapid increase in the no. of cells. Maximum growth was found on 21st day and further growth was stationary. Reduction of lead in synthetic media was observed by analysing the sample in Spectrophotometer at 380nm from 8th day the reduction began, where the concentration was 0.5 mg\L and results in 50% of reduction.

Wastewater analysis:

pH of the lake wastewater is 8.5. Temperature of the lake waste water is 27.4ºC.

Table.3 Various parameters of Wastewater

Sr. no.	Parameter	Result	Permissible limit
1.	Lead	0.53 mg/l	0.1 mg/l
2.	Chromium	0.12 mg/l	0.1 mg/l
3.	Cadmium	0.04 mg/l	2.0 mg/l
4.	Iron	0.15 mg/l	3.0 mg/l
5.	Arsenic	0.07 mg/l	0.2 mg/l
6.	BOD	16.0 mg/l	30 mg/l
7.	COD	47.1 mg/l	250 mg/l

Table.4 Various parameters of treated Wastewater

Sr. no.	**Parameter**	**Result**	**Permissible limit**
1.	Lead	0.09 mg/l	0.1 mg/l
2.	Chromium	0.04 mg/l	0.1 mg/l
3.	Cadmium	0.03 mg/l	2.0 mg/l
4.	Iron	0.06 mg/l	3.0 mg/l
5.	Arsenic	0.02 mg/l	0.2 mg/l
6.	BOD	9.8 mg/l	30 mg/l
7.	COD	20.1 mg/l	250 mg/l

Various parameters of analyzed wastewater: There was a reduction of 83% of Lead, 66% of Chromium, 25% of Cadmium, 60% of Iron, 71.42% of Arsenic. This indicates that Chlorella vulgaris has been found to act as good biosorbent in reducing theheavy metals fromwastewater. The process is inexpensive comparatively and eco-friendly.

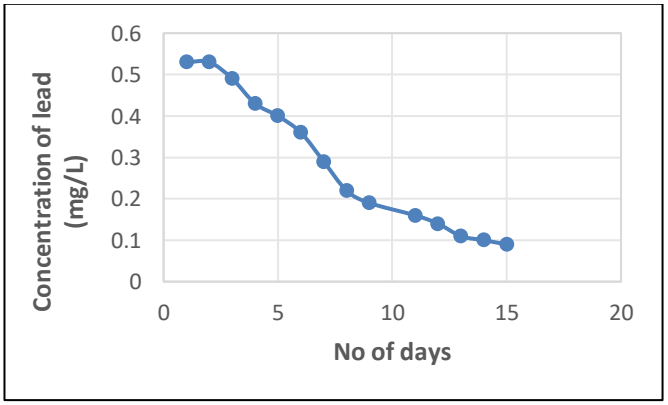

Fig.11Reduction of Lead in wastewater

Table.5 Growth of algae in wastewater

Days	Concentration
1	0.53
2	0.53
3	0.49
4	0.43
5	0.40
6	0.36
7	0.29
8	0.22
9	0.19
10	0.16
11	0.14
12	0.11
13	0.10
14	0.10
15	0.09

CONCLUSION:

Wastewater contains many heavy metals such as lead, chromium, arsenic, zinc, copper etc. From above results it is concluded that lead is in more concentration. As lead is harmful for human health and environment it is necessary to to reduce the concentration of the lead in the water.

Biosorption is a biological process in which environmental contaminants such as metal ions can be absorbed or adsorbed by a plant biomass or microorganisms. Chlorella vulgaris an alga is found to be biorelevant and has been used in removal of heavy metals in wastewater consisting of lead, arsenic, chromium, cadmium etc.

The growth curve of the Chlorella vulgaris studied and it was found to be maximum on 21st day. Further the organism was used for the reduction of lead in synthetically prepared lead solution of 1mg/l there was 50% of reduction.

Based on the results it was inoculated in wastewater the algae started to grow after 2 days and further there was slow reduction from 5th day and reduction was increased from 15th day.

There was maximum reduction of 83% of Lead, 66% of Chromium, 25% of Cadmium, 60% of Iron, 71.42% of Arsenic. This indicates that Chlorella vulgaris has been found to act as good biosorbent in reducing the heavy metals from wastewater. The process is inexpensive comparatively and eco-friendly.

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15. NDWI Analysis for Monitoring Water Resources of Bagalkote City Planning Using Remote Sensing and GIS

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ABSTRACT

the application of the Normalized Difference Water Index (NDWI) in assessing water resources provides valuable insights into the spatiotemporal variations of water bodies. This study conducted an NDWI analysis for Bagalkote City Boundary with 4km Buffer zone over the years 1991, 2021, 2022, 2023 and 2024 revealing significant in water presence and distribution.

The highest NDWI values, ranging from -0.254 to -0.498, indicated areas with a higher concentration of water, suggested regions with reduced water content or potential land cover changes.

The consistency in NDWI patterns across the three years highlighted a stable spatial distribution of water bodies, despite minor annual variations. These findings have important implications for water resource management, disaster preparedness, and sustainable development, emphasizing the need for informed decision-making to safeguard water resources.

Future research should explore the factors influencing NDWI variations and integrate NDWI analysis with other datasets for a comprehensive understanding of water dynamics.

KEYWORDS:

NDWI, Water resources, Water scarcity and sustainable management.

I. INTRODUCTION:

Water is a fundamental resource essential for life, ecosystems, and human activities. Effective water resource management is crucial for ecological balance, agriculture, community sustenance, and economic growth.

Remote sensing and Geographic Information Systems (GIS) have become powerful tools in monitoring and managing water bodies. The Normalized Difference

Water Index (NDWI), a spectral index derived from remote sensing data, is particularly promising in assessing water presence and distribution by leveraging the distinct spectral characteristics of water and non-water features.

NDWI has applications in hydrology, environmental monitoring, urban planning, and disaster management.

For instance, Hamedianfar et al. (2015) used a modified NDWI to monitor agricultural drought, while Jiang & Li (2005) demonstrated how integrating NDWI with GIS enhances the interpretability of results.

This study focuses on Bagalkote City Boundary with 4km Buffer zone, where water resources are vital for both ecological and human systems. By analyzing NDWI values from 1991, 2021, 2022, 2023 and 2024, the study aims to uncover trends in water presence and distribution, providing insights for water resource management, disaster preparedness, and sustainable development in the region.

A. Study Area:

The Bagalkot district consists of six taluks namely Badami, Bagalkot, Bilagi, Hu-nagund, Jamakhandi and Mudhol. Bagalkot District occupying an area of 6593 sq. km. The study area Bagalkote City Boundary with 4km Buffer zone covers an area of approximately 224.94 sq. km. The taluk is situated in the Krishna River basin.

The longitude coordinates of Bagalkote City Boundary with 4km Buffer zone range from 16°05'30" to 16°16'0" East, while the latitude coordinates range from 75°33'0.0" to 75°49'30" North.

The specific survey of India Topo sheet numbers that cover Bagalkot taluk are 47P/8, 12, 15, 16, 56. Fig. 1 shows the location map of the study area, along with its satellite imagery (Fig. 2). A drainage map is generated by analyzing a Digital Elevation Model (DEM) using GIS tools to identify flow direction, accumulation, and delineate the drainage network and watersheds.Drainage map (Fig. 3).

The soil is mainly Black cotton soil and red soil with Jowar, Groundnut, maize and sugarcane as major crops. Krishna and its tributary Ghataprabha flow in the study area, with large area covered by backwaters of Alamatti dam.

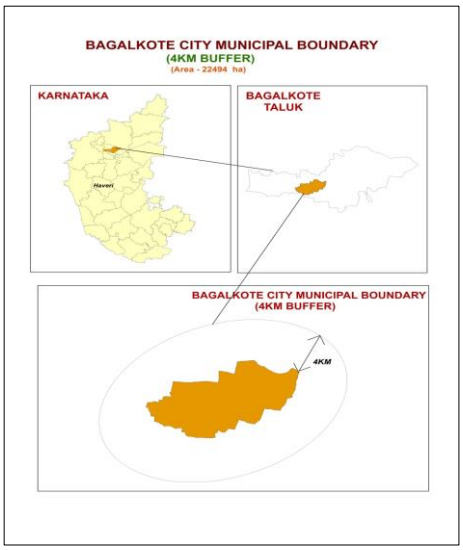

Fig. 1. Location map of Study Area

Fig. 2. Satellite image of Study Area

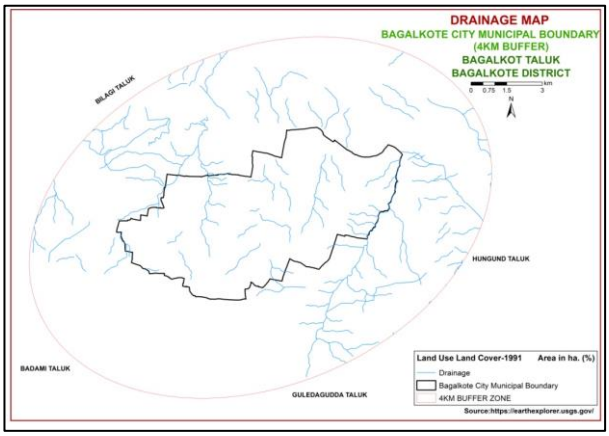

Fig. 3. Drainage map of Study Area

II. METHODOLOGY:

The methodology for Normalized Difference Water Index (NDWI) analysis involves a series of steps to calculate and interpret NDWI values from remote sensing data.i

A. Data Acquisition:

The Landsat satellite imagery covering Bagalkote City Boundary with 4km Buffer zone for the years 1991, 2021, 2022, 2023 and 2024 was obtained from reliable sources. These multispectral images are pivotal for NDWI analysis, capturing the spectral information required to quantify water presence.

B. Preprocessing:

The acquired imagery underwent preprocessing steps to correct for atmospheric interference, sensor calibration, and geometric distortions. Preprocessing ensures that the data are accurate and suitable for analysis using software such as ArcGIS and open-source GIS tools.Units

C. NDWI Calculation:

The The NDWI is calculated using the formula ({Green} - {NIR}) / ({Green} + \{NIR})\), where Green represents the green band and NIR signifies the near-infrared band. This index highlights water bodies by minimizing the impact of vegetation.

Additionally, an alternate formula (({NIR} - {SWIR}) / ({NIR} + {SWIR})\) is used for specific applications, where SWIR represents the shortwave infrared band. The resulting NDWI values typically range from -1 to 1, with negative values indicating non-water features, values close to zero indicating mixed pixels, and positive values representing water bodies. By following these steps, NDWI values are calculated for each pixel in the image, enabling a detailed analysis of water presence and distribution within Bagalkote Taluk.

Raster Calculator-Map algebra = Float ("Band 3.TIF" - "Band 5.TIF") / Float ("Band 3.TIF" + "Band 5.TIF").

III. RESULTS AND DISCUSSIONS:

The analysis of the Normalized Difference Water Index (NDWI) for Bagalkote Taluk across the years 2019, 2020, and 2021 reveals notable in water presence and distribution. The calculated NDWI values indicate varying water content within the study area, providing valuable insights into water resource dynamics and potential environmental changes. The following summary highlights the observed NDWI for each year:In the year 2019, the calculated NDWI values ranged from a highest value of -0.0975 to a lowest value of -0.455. These values suggest the presence of water bodies within the region, with the highest NDWI values indicating areas with a higher concentration of water. The lower NDWI values may correspond to areas with reduced water content or minimal water bodies.The NDWI value in 1991, ranging from -0.2540 to 0.1821 shown in Figure 4,

The NDWI value in 2021, ranging in January from -0.4630 to 0.1641 shown in Figure 5, in March from -0.4187 to 0.1472 shown in Figure 6, in May from -0.4928 to 0.1399 shown in Figure 7, in December from -0.4338 to 0.2269 shown in Figure 8. The NDWI value in 2022, ranging in January from -0.4630 to 0.1731 shown in Figure 9, in March from -0.3843 to 0.090, in May from -0.3843 to 0.0903 shown in Figure 10, in December from -0.4338 to 0.2269 shown in Figure 11.

The NDWI value in 2023, ranging in January from -0.4980 to 0.2056 shown in Figure 12, in March from -0.4826 to 0.1669 shown in Figure 13, in May from -0.4176 to 0.0915 shown in Figure 14, in December from -0.4354 to 0.1641 shown in Figure 15.

The NDWI value in 2024, ranging in January from -0.4482 to 0.1671 shown in Figure 16, in March from -0.4187 to 0.1670 shown in Figure 17, in May from -0.4607 to 0.1530 shown in Figure 18.

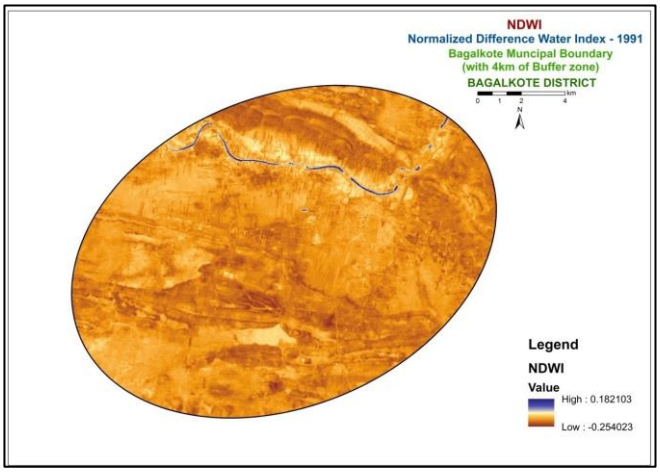

Fig. 4. Normalized Difference Water Index (NDWI) Map 1991

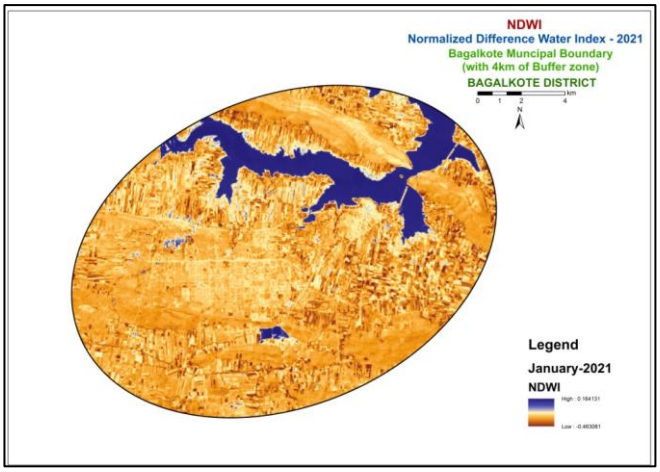

Fig. 5. Normalized Difference Water Index (NDWI) Map January-2021

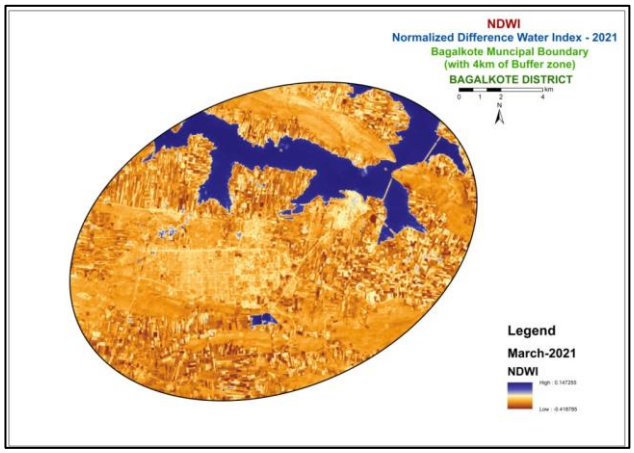

Fig. 6. Normalized Difference Water Index (NDWI) Map March-2021

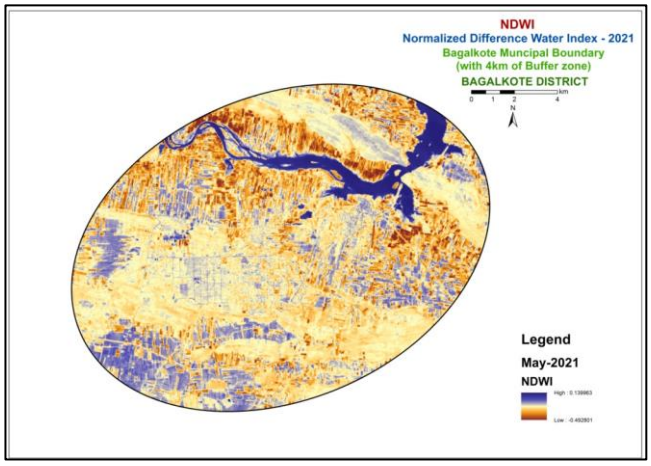

Fig. 7. Normalized Difference Water Index (NDWI) Map May-2021

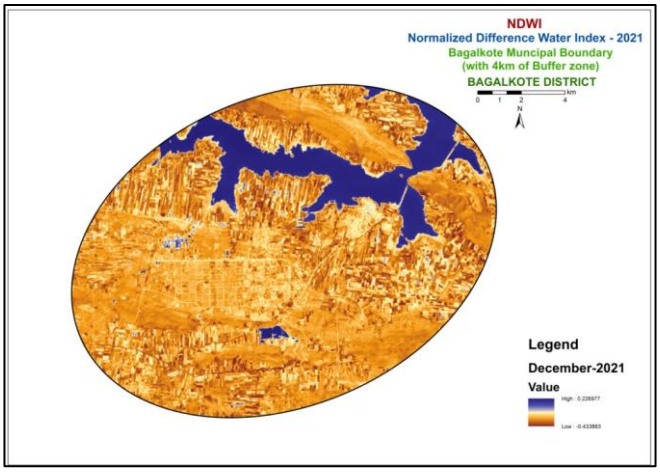

Fig. 8. Normalized Difference Water Index (NDWI) Map December-2021

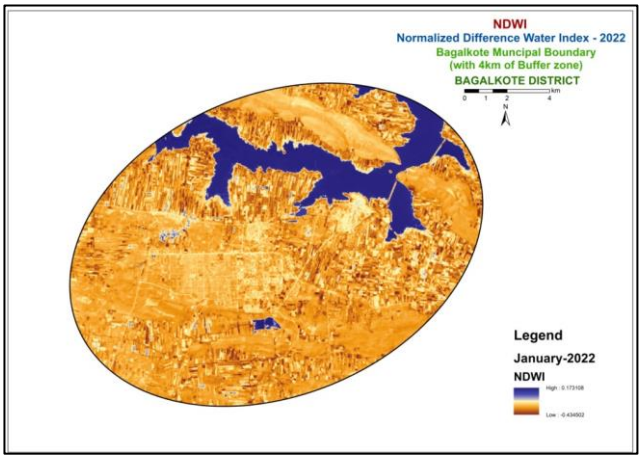

Fig. 9. Normalized Difference Water Index (NDWI) Map January-2021

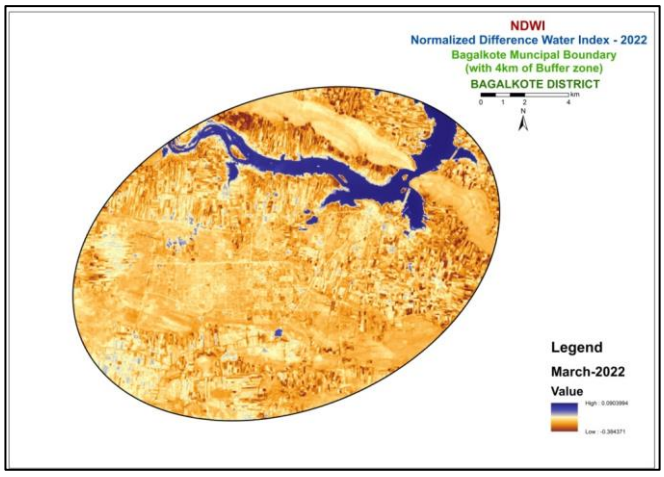

Fig. 10. Normalized Difference Water Index (NDWI) Map March-2022

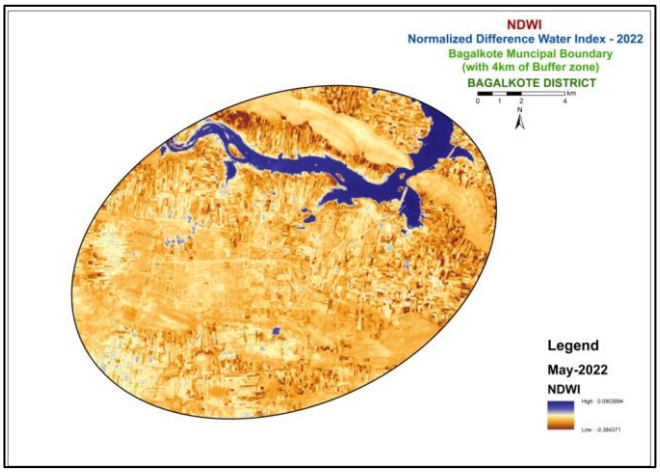

Fig. 11. Normalized Difference Water Index (NDWI) Map May-2022

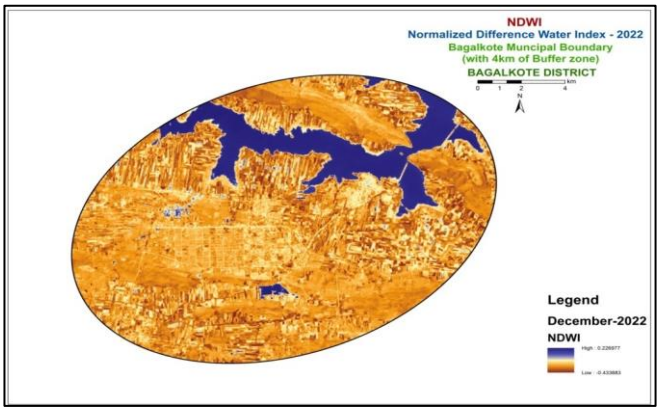

Fig. 12. Normalized Difference Water Index (NDWI) Map Dec-2022

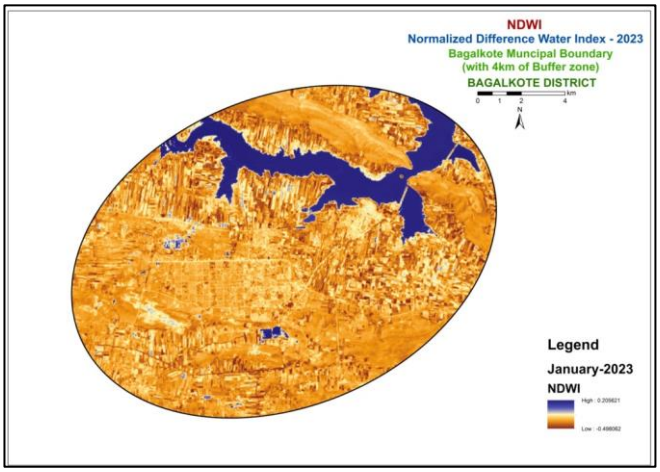

Fig. 13. Normalized Difference Water Index (NDWI) Map January-2023

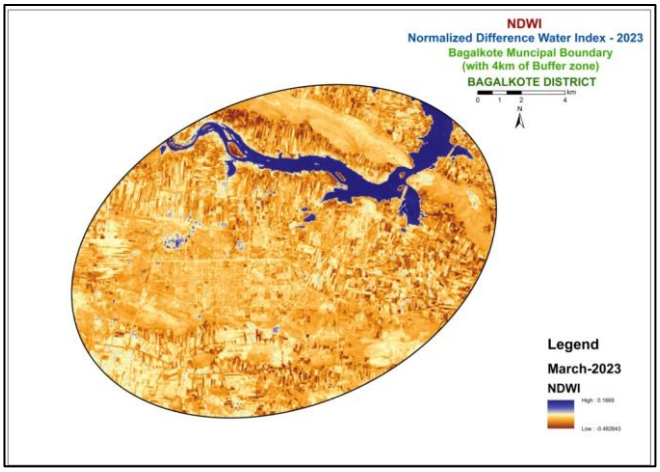

Fig. 14. Normalized Difference Water Index (NDWI) Map March-2022

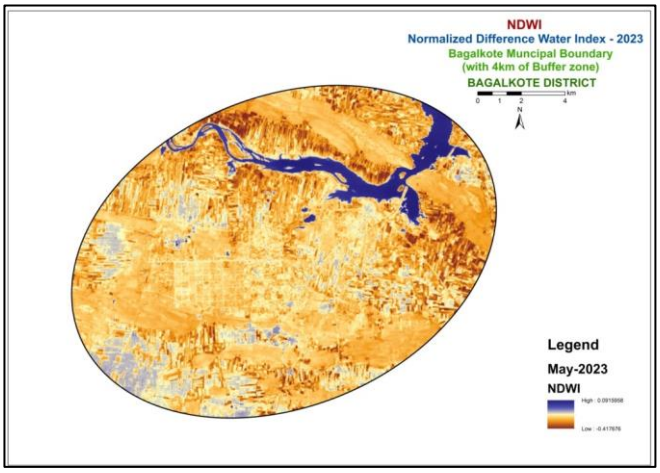

Fig. 15. Normalized Difference Water Index (NDWI) Map May-2023

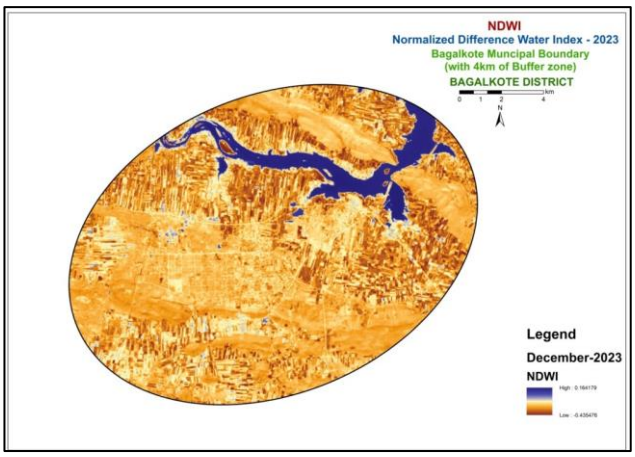

Fig. 16. Normalized Difference Water Index (NDWI) Map Dec-2023

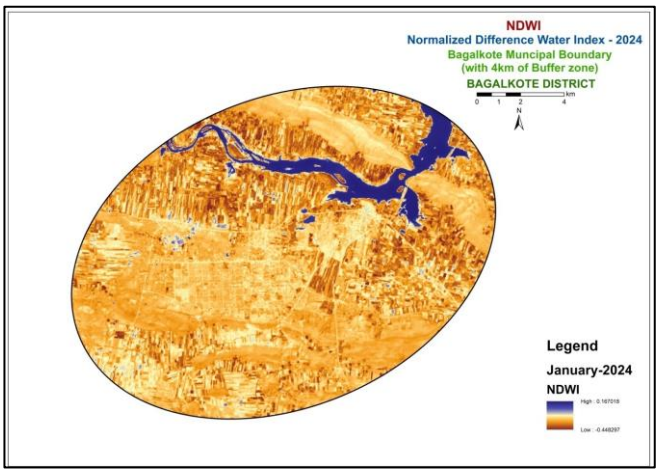

Fig. 17. Normalized Difference Water Index (NDWI) Map January-2024

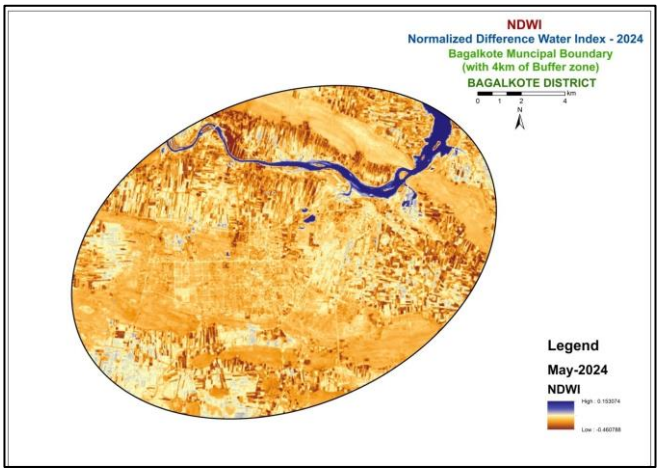

Fig. 18. Normalized Difference Water Index (NDWI) Map March -2024

A. Significance of the Study:

1. Addressing Water Resource Management Challenges: Water scarcity and inefficient water management are critical issues in Bagalkote city, impacting both agriculture and urban development. This study is significant as it provides a scientific approach to monitor and manage water resources effectively.

2. Innovative Use of Remote Sensing and GIS: The integration of Remote Sensing and GIS technologies offers a modern, accurate, and efficient method for analysing water bodies. The NDWI analysis can identify water features with greater precision, leading to better decision-making in water resource management.

3. Supporting Sustainable Urban Planning: By analysing the availability and distribution of water resources, this study aids in sustainable urban planning. The findings can guide city planners and policymakers in developing strategies that align with the water availability, thereby ensuring the long-term sustainability of Bagalkote city.

4. Environmental and Ecological Benefits: The study contributes to preserving the local environment by enabling the monitoring of water bodies, which are vital for maintaining the ecological balance. By ensuring the protection of these resources, the study supports biodiversity and the overall health of the ecosystem.

5. Foundation for Future Research: This study lays the groundwork for further research in water resource management using advanced technologies. It can inspire more detailed studies on water quality, flood risk assessment, and drought monitoring in Bagalkote and similar regions.

6. Societal Impact: Efficient water resource management has direct benefits for the local population, including improved access to clean water, enhanced agricultural productivity, and reduced vulnerability to water-related disasters. This study, therefore, has a meaningful societal impact, contributing to the well-being and resilience of the community.

This section underscores the relevance of the study and its potential to make a meaningful difference in both scientific understanding and practical applications related to water resource management in Bagalkote city.

IV. CONCLUSIONS:

Remote sensing and GIS, coupled with NDWI analysis, offer a robust approach to monitor and manage water resources in Bagalkote Taluk. The applications extend from water body monitoring to agricultural and urban planning. The utilization of the Normalized Difference Water Index (NDWI) in assessing water resources and dynamics within Bagalkote Taluk has yielded valuable insights into water presence and distribution over the years 2019, 2020, and 2021. The calculated NDWI values have illuminated the spatiotemporal variations of water bodies, enabling a comprehensive understanding of the region's water-related dynamics. Through NDWI analysis, it has been observed that water bodies persistently exist within Bagalkote Taluk across the three years under study. The range of NDWI values, with the highest values ranging from -0.0903 to -0.022 and the lowest values ranging from -0.254 to -0.498, indicates the presence of water bodies of varying magnitudes. These water bodies encompass a spectrum of aquatic features, including lakes, rivers, and reservoirs, which play a vital role in supporting various ecological, agricultural, and socio-economic activities. The consistency in NDWI patterns from 2021 to 2024 suggests a stable spatial distribution of water bodies within the study area. While minor fluctuations in the highest and lowest NDWI values were observed between years, the overall underscores the enduring significance of water resources. This knowledge is crucial for effective water resource management, sustainable land use planning, and informed decision-making. The results highlight the enduring significance of water bodies in the region and emphasize the importance of holistic water resource management practices for the sustainable development and well-being of the local community and ecosystem.

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16. Studies on Energy Efficient Design of Building for Warm and Humid Climate Zone in India

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ABSTRACT

This study investigates the use of red mud, a byproduct of bauxite processing, in cement mortar mixes to enhance thermal properties and address disposal challenges. By examining strength, thermal conductivity, specific heat, decrement factor, and time lag of mixes with varying red mud proportions, the research aims to improve building energy efficiency in hot, dry climates according to the Energy Conservation Building Code (ECBC). Results indicate red mud enhances mortar's thermal insulation, reducing cooling energy consumption and providing a sustainable solution for red mud utilization in construction.

KEYWORDS:

Energy Efficiency, Building Design, Warm and Humid Climate, India, Structural Engineering, Energy Optimization

I. INTRODUCTION:

A. General:

Red mud is a solid residue generated by the processing of bauxite ore into alumina (Al_2O_3) using caustic soda. Approximately 35 to 40% of the bauxite ore processed becomes red mud, a slurry containing 15-40% solids, producing 0.8-1.5 tonnes of red mud per tonne of alumina. Globally, an estimated 70 million tonnes of red mud are produced annually, with significant quantities in countries like Greece, India, Australia, and China. Due to its fine and highly alkaline particles (pH 11-12.4) and the presence of micronutrients, the disposal of red mud poses serious environmental challenges, including soil and groundwater contamination and air pollution from dust. To mitigate these issues, extensive research has been conducted to find cost-effective and environmentally sustainable recycling methods for red mud. For instance, red mud from HINDALCO Belgaum contains Al_2O_3 (17-20%), Fe_2O_3 (44-47%), SiO_2 (7-9%), TiO_2 (8-11%), Na_2O (3-5%), CaO (1-3%), and LOI (10-14%).

Potential applications for red mud include use in removing heavy metals from wastewater, as a component in building materials such as bricks and ceramics, and in polymer-based composites. Utilizing red mud in building materials not only ensures high consumption rates but also offers a sustainable solution to the disposal problem.

B. Cement and Environment:

Cement is a crucial adhesive material in construction, binding other components together to form concrete. Despite constituting only 10-15% of the concrete mix, cement's interaction with water is vital for the mixture's hardening and bonding.

However, the extensive use of cement has significant environmental drawbacks, including a substantial carbon footprint and high thermal conductivity, which reduces its effectiveness as an insulator. Thus, finding alternatives to partially or completely replace cement can reduce environmental impact and contribute to the development of sustainable concrete.

C. Need for Thermal Comfort in Buildings:

The variation in climatic conditions often leads to temperature fluctuations, causing discomfort for building occupants. The thermal conductivity of mortar is crucial as it affects the thermal insulation properties, temperature gradient, thermal deformation, and crack formation in the material.

High thermal conductivity in traditional Portland cement contributes to heat generation, which can be mitigated by selecting cements with chemical compositions that reduce heat generation rates. Improving the thermal insulation of buildings is essential for maintaining thermal comfort and energy efficiency.

D. Thermal Properties of Cement Mortar and Concrete:

The increasing demand for building materials that can insulate against heat is driven by global warming. These materials not only enhance thermal insulation but also contribute to energy savings in buildings.

Key thermal properties of concrete include thermal conductivity, specific heat, coefficient of thermal expansion, and thermal diffusivity. A desirable mortar mix should have low thermal conductivity and high specific heat to provide effective thermal insulation.

1) Thermal Conductivity:

Thermal conductivity measures a material's ability to conduct heat, defined as the ratio of heat flow to thermal gradient, and is influenced by factors such as density, moisture content, and mix ratio. The conductivity of cement mortar is significantly affected by moisture content, as water is more conductive than air. Thermal conductivity (K) is also defined by specific thermal power (C), density (ρ), and thermal diffusivity (δ), with $K = C\rho\delta$. Methods for measuring thermal conductivity include the hot shielded plate method and the thermal flow meter method, with the transient method being preferred for its efficiency.

2) Specific Heat:

Specific heat is the amount of heat required to raise the temperature of a unit mass of a material by 2°C, representing the material's heat capacity. It depends on the density, aggregate type, and moisture content of the cement mortar. Specific heat is measured in joules per kilogram per Kelvin (J/kg·K).

3) Decrement Factor and Time Lag Factor:

In hot weather, heat transfer from the exterior to the interior surfaces of buildings occurs in a sinusoidal wave, with the amplitude decreasing as it passes through wall materials. The decrement factor represents the reduction in amplitude, while the time lag indicates the duration for the heat wave to travel from the outer to the inner surface. Low decrement rates and longtime lags are desirable for maintaining thermal comfort and energy efficiency.

4) Energy Conservation in Hot and Dry Regions:

In hot and dry climates, like that of Ahmedabad, energy conservation is critical. By adjusting cooling set points based on neutral temperatures, significant energy savings can be achieved. According to the Energy Conservation Building Code (ECBC), energy savings of up to 44% can be achieved compared to current practices, with additional savings possible through adaptive measures.

5) ECBC Code:

The ECBC defines energy efficiency requirements for commercial buildings in India, aiming to reduce energy consumption in the construction sector, which accounts for a significant portion of the country's electricity usage. ECBC-compliant buildings can consume 40-60% less energy than conventional buildings, contributing to substantial energy savings nationwide.

6) Design Builder Software:

Design Builder software, an advanced graphical user interface for Energy Plus simulations, is used to generate Energy Performance Certificates (EPCs) and demonstrate building code compliance. It simplifies the building modeling process, enabling users to quickly assess the functionality and performance of construction projects, thus aiding in the design of energy-efficient buildings.

II. LITERATURE REVIEW:

A. Literature on Red Mud:

Red mud, a byproduct of alumina production, has been the focus of various studies aimed at finding sustainable uses and management solutions. Samal et al. (1999) explored the potential for using red mud in brick production. They found that when mixed with clay and subjected to mechanical processing, red mud can be used to produce hand-shaped or wire-

cut bricks, similar to conventional mud bricks. Rai et al. (2012) examined the neutralization and utilization of red mud for waste management. They concluded that while many potential uses exist, a cost-effective and environmentally friendly solution for large-scale red mud utilization has yet to be found.

They emphasized the need for a systematic strategy tailored to each alumina refinery to achieve a zero-waste operation. Sutar et al. (2014) presented findings that the physical properties of bricks made with red mud are comparable to conventional building bricks. They described a process where red mud is directly used from storage tanks to clay pits, resulting in a moldable plastic mixture for brick production.

B. Literature on Thermal Conductivity:

The thermal properties of building materials have been extensively studied, with a focus on enhancing performance through material modifications. Benz et al. (2010) evaluated the thermal properties of HVFC (High Volume Fly Ash Concrete) samples.

They analyzed the impact of different cement types, fly ash types, and internal curing methods. Their study highlighted the importance of gypsum addition in maintaining normal hydration characteristics and improving thermal properties.

Herrero et al. (2010) investigated the effect of rubber particle size and content on the thermal and acoustic properties of mortar. They found that finer rubber particles increased hardness and improved thermal conductivity and sound insulation properties.

Raheem et al. (2011) studied the thermal conductivity of cement slurries mixed with corn cob ash (CCA). They found that the thermal conductivity decreased as the CCA content increased, indicating potential for better insulation properties.

Coppola et al. (2018) examined lightweight mortars made from foamed plastic waste fillers. They observed that the presence of lightweight aggregates (LWA) improved thermal conductivity and water vapor permeability while reducing capillary water absorption, resulting in a stronger, lightweight mortar with enhanced hydrothermal properties.

Daniel VR et al. (2010) explored the addition of red mud to Portland cement slurry. They noted that red mud accelerated the setting process due to its alkaline nature and presence of polymerization accelerators, though it also reduced compressive strength due to increased porosity and reduced binder content.

Falguni (2019) studied the compressive strength of mortar cubes with varying proportions of ceramic waste and barite powder. They concluded that increasing the percentage of these waste materials decreased compressive strength.

Patrick Achard (2013) and Cerne et al. (2005) investigated the thermal behavior of building walls, focusing on the effects of insulation and wall configuration on energy consumption and thermal comfort. Their studies highlighted the importance of optimizing wall mass and insulation distribution.

Kaska (2009) examined temperature differences between building walls and roofs in the Turkish climate, emphasizing the influence of maximum and minimum temperatures on thermal performance.

Mavromatidi et al. (2012) conducted digital studies in Greece and America, evaluating the impact of complex wall configurations and multilayer insulation on energy efficiency and solar building performance.

Mazzeo et al. (2016) studied the effects of boundary conditions on thermal performance in the Italian climate, noting the significance of wall orientation and boundary conditions on time lag and reduction factors.

Sun et al. (2013) conducted experimental work on the effect of exterior air temperature on wall thermal properties, solving one-dimensional non-stationary temperature equations to understand the impact of temperature changes.

Thongtha et al. (2014) experimentally studied the delay and reduction factor of autoclaved aerated concrete residues, finding that added materials affected the thermal retention and shrinkage rate of walls.

Jyotirmay Mathur (2011) researched energy efficiency improvements in India's challenging climate, demonstrating the effectiveness of energy conservation measures in both air-conditioned and unconditioned buildings.

Pawar B. (2018) evaluated the energy efficiency of commercial buildings using simulation software, comparing results with national energy conservation standards to identify efficiency improvements.

C. Summary of Literature:

Research on red mud indicates its potential for various applications, including cement production, which addresses the disposal issue. However, the recycled or reused quantity remains small relative to red mud production. Studies on the thermal properties of building materials show that partially replacing cement with durable materials like plastic fillers, fly ash, corn cobs, rubber, red mud, and ceramic waste improves the properties of mortar mixtures.

The detailed literature review highlights the following objectives for the present study on red mud:

1. To study the strength and thermal properties of mortar mixes with varying dosages of red mud.
2. To study the thermal characteristics such as decrement factor and time lag factor of mortar mixes with varying dosages of red mud.
3. To use the mortar mixes as a plastering material in a typical building in a hot and dry region, as per ECBC (Energy Conservation Building Code).

III. METHODOLOGY:

A. Mortar Mix Design:

This section details the materials used and the mix design procedure for the mortar mixes. The materials used in this experiment are Ordinary Portland Cement, Red Mud, Fine Aggregates and Super Plasticizer.

1) Cement:

The cement used for the experimental study is Coromandel OPC 43 grade cement (Fig. 1), confirming to IS 8112:1989. The properties of the cement have been tested as per IS: 4031 (Part 4) - 1998, and the results are listed in Table 1.

Fig. 1. Ordinary Portland Cement

1) Red Mud:

Red mud is a byproduct of the Bayer process for the production of alumina. The red mud used in this study was obtained from HINDALCO Alumina Industry, Belagavi. It is in slurry form with a solids content of 10-30% and a pH ranging from 10-12.5. The red mud was passed through a 150-micron IS sieve before being used. Chemical analysis showed it contains silica, iron, calcium, titanium, and aluminum, among other elements. The properties and chemical composition of red mud are shown in Tables 2 and 3, respectively.

TABLE I. TEST RESULTS OF CEMENT

Sr. No.	Properties	Values
1	Normal Consistency of cement (IS 4031-PART VI- 1988)	28%
2	Setting time (IS 4031-PART V- 1988)	
	Initial Setting Time	2hr
	Final Setting Time	2hr 50min
3	Fineness of cement (IS 2386-PART III)	3.33%
4	Specific Gravity (IS 460-1962)	3.04

Fig. 2. Red Mud

TABLE II. CHEMICAL COMPOSITON OF RED MUD

Component	**Percentage**
Ferric Oxide	25% - 55%
Aluminium Oxide	8% - 18%
Silicon Dioxide	5% - 48%
Sodium Oxide	3% - 12%
Oxocalcium	3% - 9%
Titanium Oxide	24%

TABLE III. PROPERTIES OF RED MUD:

Sr. No.	**Properties**	**Values**
1	Fineness of Red Mud	71%
2	Specific Gravity	2.30
3	Moisture Content	23.7%
4	Physical Appearance	Red Colour
5	Particle Size	0.8 to 50 micrometers
6	pH	10-12.5
7	Al2O3	10-20%

2) Fine Aggregate:

The fine aggregate used in this experiment is locally sourced river sand, tested as per IS: 2386 (Part III) - 1963. The properties of the fine aggregate are listed in Table 4.

TABLE IV. TEST RESULTS OF FINE AGGREGATE

Sr. No.	Properties	Values
1	Sieve Analysis	2.54
2	Bulk Density	2.96 gm/cm³
3	Specific Gravity	2.67
4	Moisture Content	1.58%

3) Super Plasticizer:

The super plasticizer used for the study is Aura Mix 400, which provides high water reduction and long workability retention. It complies with IS: 9103-1999 (2007)

B. Mortar Mix Proportion:

The mix proportion of the mortar is crucial for ensuring uniformity in characteristics and appearance. The mortar mix ratio is formulated with a water-cement ratio of 0.45 and a cement-sand ratio of 1:3. The mixing ratios for different percentages of red mud replacement are shown in Table 5.

TABLE V. MIX PROPORTIONS

Sr. No.	% Replacement	Cement (g)	Red Mud (g)	Sand (g)	Water (g)	Super Plasticizer (g)
1	0	2200	-	6600	990	4.4
2	10	1980	220	6600	990	5.3
3	20	1760	440	6600	990	7.0
4	30	1540	660	6600	990	8.8
5	40	1320	880	6600	990	10.6
6	50	1100	1100	6600	990	12.3
7	60	880	1320	6600	990	14.1

IV. RESULTS AND DISCUSSIONS:

A. Thermal energy efficiency of Model-01:

The energy consumption of these model results is below. The building size 10.55m×10.55m outer dimensions. Aspect ratio 1:1, North-South or East-West orientation and 30%, 40%, and 50% window to wall ratio from Fig 3. The other parameters are the same. show the above chapter-3. The room electricity, lighting, heating, cooling, DHW, and Temperature values are below. The following outcomes were obtained as appeared in Table 6.

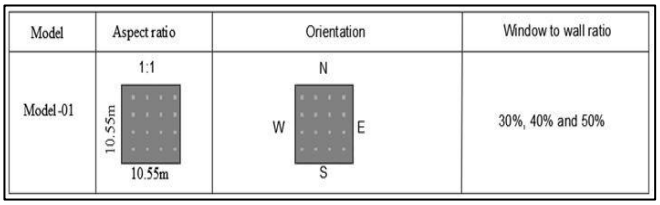

Fig. 3. Details of the aspect ratio, orientations and window to wall area ratio

TABLE VI. ENERGY CONSUMPTION RESULTS

Description		**Values**		
Aspect ratio		1:1		
Orientation		NS and EW		
Window to wall ratio		30%	40%	50%
Room Electricity(kWh)		1722.8	1722.8	1722.8
Lighting(kWh)		1197.14	1179.70	1169.16
Heating + DHW (kWh)		2171.61	2171.61	2171.61
Cooling(kWh)		9314.08	10007.93	10699.93
Annual energy consumption(kWh)		14405.11	15081.55	15762.98
Temperature (°C)	Outside	36.60	36.60	36.60
	Inside	33.10	33.51	34.00

Thermal energy efficiency model-1 results Table 6 shows room electricity requirement 1722.28 kWh constant remain different window to wall ratios. Lighting electricity small variations window to wall ratio 30% for 1197.14 kWh, 40% for 1179.70kWh, and 50% for 1169.16kWh. heating and DHW electricity 2171.61Kwh constant remain different window to wall ratios. Cooling electricity more variations window to wall ratio 30% for 9314.08kWh, 40% for 10007.93kWh, and 50% for 10699.93kWh. annual energy consumption large variations window to wall ratio 30% for 14405.11kWh, 40% for 15081.55kWh, and 50% for 15762.98 kWh.

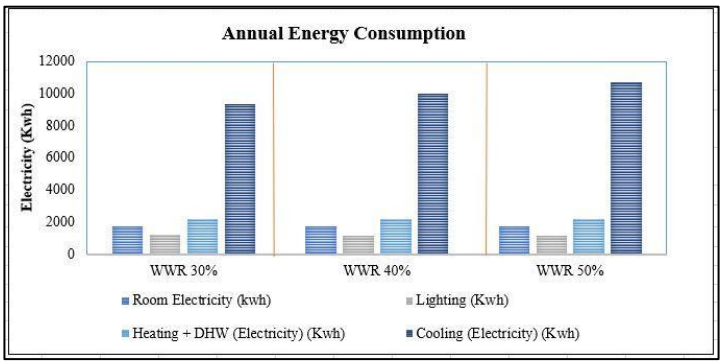

Fig. 4. Energy Consumption Model-01 chart

Thermal energy efficiency model-1 results chart Fig 4 shows. room electricity requirement for equipment remains constant for the different window to wall ratio. Lighting electricity requirement compare with window to wall ratio 30% to 40% for 17.44kWh and 40% to 50% for 10.54kWh.

Heating and DHW electricity remain constant for the different window to wall ratio. Cooling electricity requirement compare with WWR 30% to 40% for 693.85kWh and 40% to 50% for 692kWh. Annual energy consumption electricity requirement compere with WWR 30% to 40% for 676.44kWh and 40% to 50% for 681.43kWh.

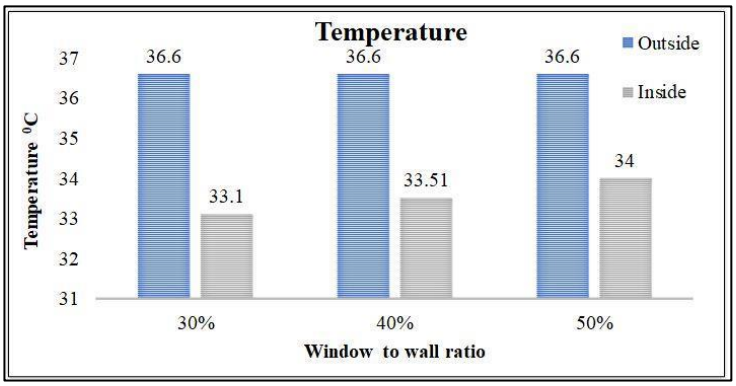

Fig. 5. Temperature Model-01 chart

A building model is analysed in the design building software to find out the thermal energy efficiency of the building.

From Table 6 it is observed that inside temperature decreases as a different percentage of the window to wall ratio for constant \outside temperature 36.60C

From Fig 5. Window to wall area ratio (WWR) 30%, 40%, and 50% values are 33.1, 33.51, and 340C respectively temperature increased.

TABLE VII. ANNUAL ENERGY CONSUMPTION FOR WWR:

Window to wall ratio	Annual energy consumption(kWh)	Difference in %
30%	14405.11	-
40%	15081.55	4.695
50%	15762.98	4.518

Annual energy consumption model-01 Compare window to wall ratio (WWR) 30% to 40% for 4.695 percentage consumption and window to wall ratio (WWR) 40% to 50% for 4.518 percentage consumption.

Average annual energy consumption 4.60 percentage consumption. Similarly, the analysis is carried out for other two models. The analysis has been provided in Table 8.

V. CONCLUSIONS:

1. In warm and humid climate conditions, the Aspect ratio of 1:1 That is a square building, energy consumption is 8 to 12% lesser in compere with aspect ratio 1:1.5. It is observed as aspect ratio decrees, energy consumption increase.
2. Annual energy consumption of north-south Orientation for 1:1.5 is 2.61, 2.03, and 1.68% lesser when compere to East-West Orientation for window to wall ratio 30%, 40%, and 50% respectively. Similar results are also observed for aspect ratio of 1:2.
3. 3) A window to wall ratio increases overall energy consumption also increase but the energy required for lighting decrease.
4. 4) Every 10% increase window to wall ratio inside temperature by the 0.250C-0.50C increase.

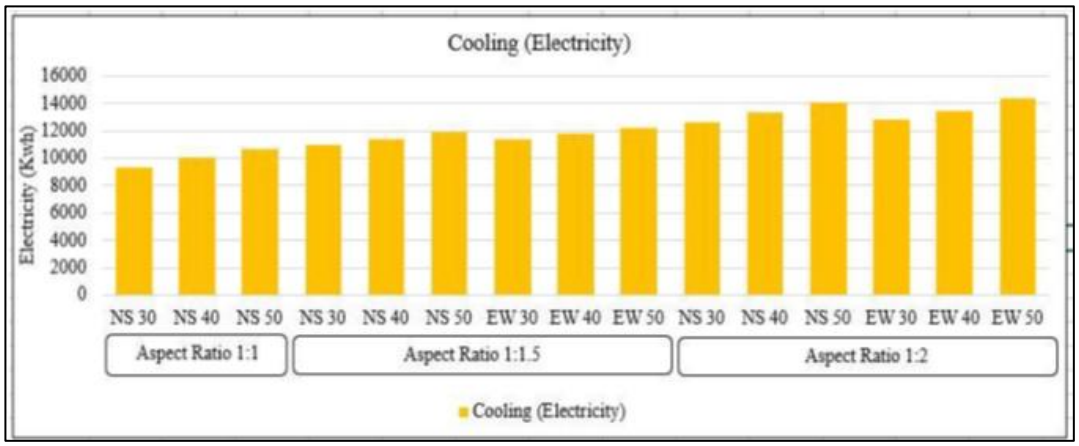

Fig.6. Cooling chart

TABLE VIII. ANNUAL ENERGY CONSUMPTION RESULT:

Aspect ratio		1:1 10.55m×10.55m			1:1.5 8.63m×12.93m						1:2 7.45m×14.96m					
Orientation		NS or EW			NS			EW			NS			EW		
Window to wall ratio		30%	40%	50%	30%	40%	50%	30%	40%	50%	30%	40%	50%	30%	40%	50%
Room Electricity (kWh)		1722.2	1722.2	1722.2	1530.4	1530.4	1530.4	1530.4	1530.4	1530.4	1448.9	1448.9	1448.9	1448.9	1448.9	1448.9
Lighting (kWh)		1197.1	1179.7	1169.1	1158.5	1145.8	1139.5	1161.8	1146.7	1139.0	1131.9	1172.0	1167.8	1179.6	1170.9	1166.5
Heating + DHW (Electricity) (kWh)		2171.6	2171.6	2171.6	2386.6	2386.6	2386.6	2386.6	2386.6	2386.6	2516.8	2516.8	2516.8	2516.8	2516.8	2516.8
Cooling (Electricity) (kWh)		9314.0	10007.9	10699.9	10937.0	11429.1	11893.9	11352.5	11764.6	12180.4	12576.8	13367.2	14111.0	12883.7	13483.0	14416.1
Annual energy consumption (electricity) (kWh)		14405.1	15081.5	15762.9	16012.5	16491.9	16950.3	16431.3	16828.3	17236.4	17674.4	18504.9	19244.5	18029.0	18619.6	19548.3
Temperature (°C)	Outside	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60	36.60
	Inside	33.10	33.51	34.00	34.25	34.50	34.75	33.77	34.01	34.24	34.5	34.61	34.65	33.75	33.9	34.1

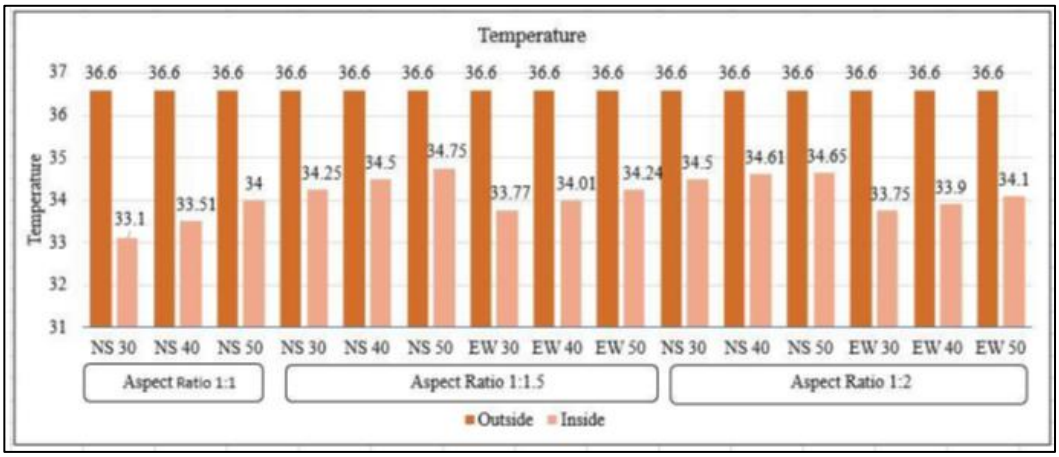

Fig. 7. Annual Energy Consumption chart

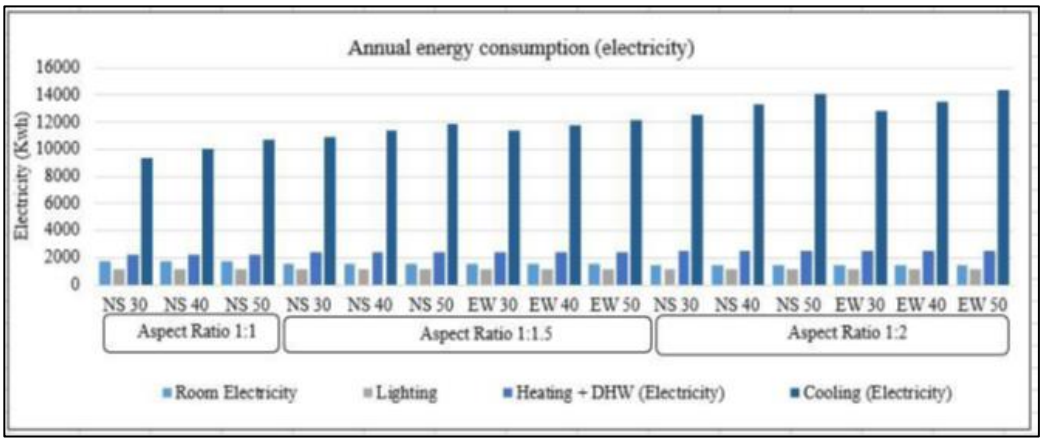

Fig 8: Temperature chart

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17. *Swietenia mahagony* Seed Extract Coated Starch Based Biodegradable Plastic for Antimicrobial Food Packaging

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ABSTRACT

Biodegradable plastics (Bioplastic) with antimicrobial property has become new trend in packaging segment. In present market there has been limited availability biodegradable plastic with antimicrobial packaging, so there is huge potential in supply of such material. By keeping this scope in mind the current investigation was aimed to produce bioplastics using a simple and feasible casting method using starch, gelatine, agar, glycerol with varied concentrations. Subsequently the antimicrobial property, biodegradability, water and oil permeability were evaluated. The potential antimicrobial substance was extracted from Swietenia mahagoni and are found to be flavonoids which are responsible for imparting antimicrobial resistance property to the film. Further, the produced film was confirmed for its antimicrobial activity using plate assay method. Developed film showed resistance effect against airborne microbes. Then the film was also tested for biodegradability test through soil burial method which inferred that the film could be degraded in about 60 days. Collectively the data showed that the polymer film can be used as a prerequisite for development of bio plastics in food manufacturing industry especially packaged foods.

KEYWORDS:

Bioplastics, airborne pathogens, food packaging, Swietenia mahagony, antimicrobial activity.

INTRODUCTION

Synthetic polymers have been the material of choice for many applications because of their superior physicochemical qualities, viz., availability, flexibility, durability, and low weight [1]. Petroleum is the primary source of most polymers, which makes them resistant to biodegradation [2]. Plastics are frequently used to store and package food. One of the disadvantages of using plastics for food packaging is that they may leak or emit harmful compounds that are harmful to people and other living things. Researchers have shown that

using plastic increases the risk to one's health. Many of the chemicals included in these containers, bottles, and other packaging materials pose substantial health risks. Among the most notable instances are the potentially dangerous exposure to toxic substances such as antimony trioxide, polyfluorinated compounds, bisphenol A (BPA), brominated flame retardants and phthalates [3]. It is recommended to switch from traditional petroleum-based plastics to biodegradable and environmentally friendly bioplastics in order to prevent exposure to hazardous and carcinogenic substances.

Also to avoid the various infectious microbes after covid-19 has received a huge attention from the researchers in development of antimicrobial food packing material. Many researchers have explored various blends of polymers for biodegradable plastic production [4-7] but there are limited work on biodegradable plastic with antimicrobial property.

In order to prevent infections, a recent study produced an antibacterial polymeric composite coating on the surface of titanium (Ti) utilizing Ag nanoparticles (20–30 nm), poly-L-lysine, sodium alginate, and dopamine.

The artificial coating effectively inhibited and killed the bacterium Streptococcus mutans and S. aureus for more than 27 days while also demonstrating the release of Ag+ [8]. Furthermore, as a straightforward and adaptable technique, spray and electrophoretic deposition were used to create antibacterial surface coating systems based on gentamicin, chitosan, and silica on titanium substrates in a recent study by Ballarre et al. [9].

When tested against S. aureus and E. coli, the produced coating demonstrated excellent antibacterial activity. Furthermore, edible coatings with antiviral properties were made by Fabra et al. [10] using a 50:50 mixture of Persian gum and gelatin. Various proportions of the polymer mixture were employed. Persian gum's mechanical and barrier qualities are the result of electrostatic interactions between polymers, which strengthen the cohesive system. The created coating performed well against viruses.

Meanwhile the *Swietenia mahogoni* commonly called as "Mahogany," belongs to the group Swietenioideae and the family Meliaceae. This huge, deciduous, West Indies-native timber tree is significant to the economy. Swietenia mahogoni is closely linked to the African genus Khaya [11]. *Swietenia mahagoni* is distributed around the world, particularly in Bangladesh, China, India, Cuba, Jamaica, and nations in North and South America.

Different components of the Mahagoni plant have been used in traditional medicine to treat a variety of conditions, including diabetes, malaria, amoebiasis, coughs, hypertension, tuberculosis and chest pain. It has also been used as an antiseptic, abortificient, depurative, astringent, and tonic [12].

It can also be used as phytochemical with low or no toxicity to host cells and the capacity to either stop the spread of infectious organisms or eradicate them are being explored as possible candidates for the development of novel antimicrobial drugs. Considering these important properties the seed extracts of Swietenia mahagony was selected as coating material.

Biodegradable plastics are plastics that can be decomposed by the action of living organisms usually microbes, into water, carbon dioxide, and biomass. Biodegradable plastics are commonly produced with renewable raw materials, micro-organisms, petrochemicals, or combinations of all three. Biodegradable plastics are commonly used for disposable items, such as packaging, crockery, cutlery, and food service containers. A unique combination of starch-based biopolymer with natural antimicrobial extract is tried to prevent microbial contamination of food. This bio plastic is developed specifically for food packaging (13).

Methodology:

Extraction of antimicrobial compound:

Flavonoids in Swietania mahagoni have antibacterial properties. The Soxhlet extraction method (Fig. 1) was used to extract these flavonoids [14, 15]. Using this approach, the sample is gradually filled with fresh methanol from a distillation flask by placing it in a thimble holder. A siphon aspirates the whole contents of the thimble holder and unloads it back into the distillation flask, conveying the extracted analytes in the bulk liquid, when the methanol reaches an overflow level.

Until full extraction is accomplished, this process is repeated [16] to extract the flavonoids; additional purification of the flavonoids is not being pursued in order to make the method practical.

Fig. 1 Sox hlet extraction of flavonoids from *Swietenia mahagony*

Composition of polymer film:

The compositions for starch-based bioplastic were found through a literature survey of various research papers [17-19]. Based on the literature a composition is made to prepare bioplastic (Table1).

Table 1: Composition of polymer film

Constituents	Quantity
Starch	6gm
Gelatin	2.3gm
Agar	1.0gm
Glycerol	6ml

Steps involved in producing biodegradable plastic sample

1. Above mentioned constituents were weighed and dissolved in 50ml of water and dilute to 100 ml.
2. Solvent was concentrated on heating magnetic stirrer at 70-80 °C about 1 hr.
3. Concentrated blend was casted on the solid surface.

A. Antimicrobial assay:

A set of petri plates with polymer film were taken

Control - Without Antimicrobial Substance Test

1. With antimicrobial substance blended with polymer.
2. Antimicrobial substance is coated over the surface of the film.

Both of them were exposed to open air which consists of airborne microbes to check for the resistance of the films [20, 21].

B. Biodegradability test:

Soil burial method: The weight of the polymer film is initially recorded. The polymer film was cut into small pieces; a pre weighed sample was tagged with the help of thread. It is then buried in a pot of soil (Fig. 2). The weight of the polymer film is recorded at regular interval of 2 days upto 20 days (Fig. 3) [22, 23].

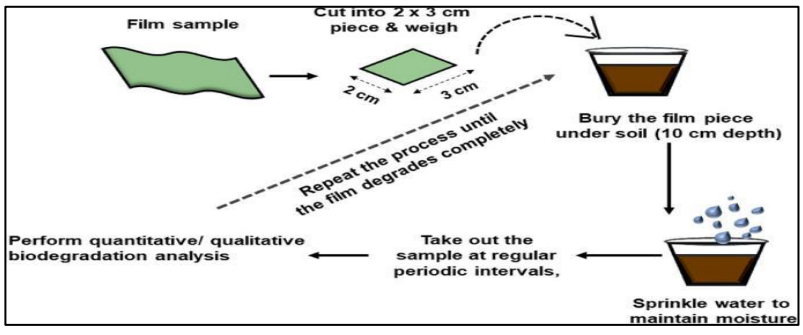

Fig. 2: Soil burial method for the polymer film.

Fig. 3: Soil burial method

C. Water permeability:

A filter funnel is taken and the developed polymer film is placed in the funnel instead of the filter paper. Then, this funnel was placed in a conical flask. 5 ml of water is added the funnel. The water permeability of the polymer is analyzed by observing whether the water drips in the conical flask.

Oil permeability

The same procedure is followed to indicate the oil permeability as followed for the determination of water permeability.

Results and Discussion:

A. Antimicrobial assay:

The results were recorded after two days – test wasn't affected with microbes whereas, control was contaminated.

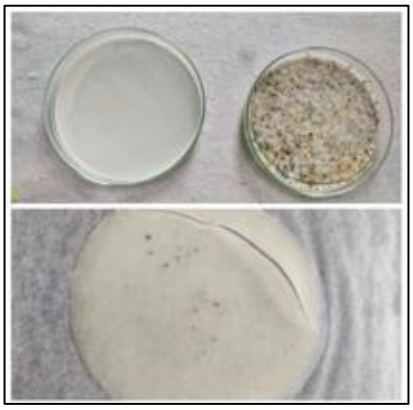

Fig. 4: Antimicrobial assay to indicate antimicrobial tolerance of the bioplastic film.

Biodegradation:

Soil burial method: The test showed a considerable reduction in the weight of the polymer film. The sample was observed about 16 days, calculated the weight loss after every two days according to the statistics analysis, indicated the polymer film would completely get degraded in about 60 days.

Thus, the developed polymer film had a good degradability rate which symbolizes its biodegradability (Fig. 3, Table 2).

Table 2: Soil burial degradation test.

No. of Day	Initial Weight	Overall weight loss (gm)	% Weight loss
0	0.581	0	0
2	0.581	0	0
4	0.557	0.023	4
6	0.553	0.017	3
8	0.550	0.058	10
10	0.488	0.092	16
12	0.476	0.104	18
14	0.447	0.133	23
16	0.429	0.151	26

Initial weight (W0) = 0.581

% Weight loss = W0-Wf / W0 * 100

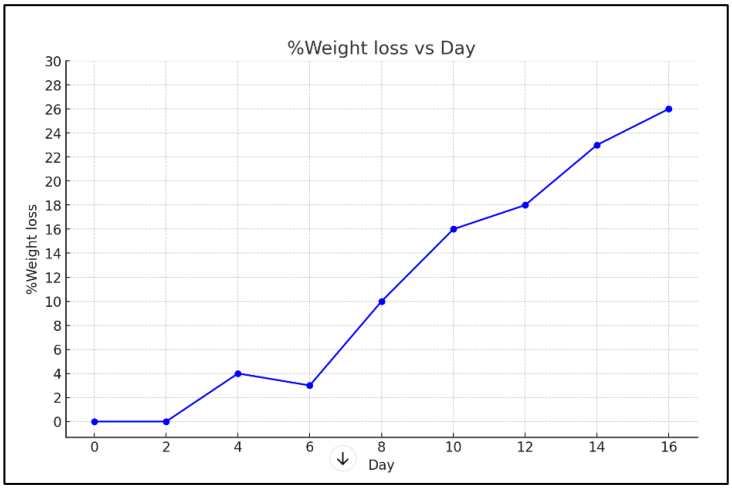

Fig 5: Reduction in weight of the film % weight loss in grams.

(Expected complete degradation in approx. 60 days)

B. Water and oil permeability:

Here the developed polymer films showed good impermeable effect towards both water and oil. This implies that the developed film can be used for food packaging purpose.

Conclusion:

During the process investigation biodegradable plastic with antimicrobial property has been successfully developed and our results have showed the developed film has a potential antimicrobial effect on airborne microbes. As the tested film which contained the bioactive compound extracted from the Swetenia mahogony plant could inhibit the growth of airborne microbes when compared to the film without the plant extract (Fig. 4). Thus, it can be used as a promising material for ideal food packaging process. Besides this the developed film can also biodegradable within 60 days and which is most anticipated to substitute existing conventional plastic (Fig. 5). From the study it is also reveal that the developed film has low permeability to oil and water which is highly recommended for the seamless packaging segment and can be used for the large-scale production process. Thus, the feasible and eco-friendly biodegradable plastic has been successfully established pertaining to the objective that we have aimed for.

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Conflict of Interest: Authors declare there is no conflict of interest in publication of this article.

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18. Mapping Potential Evapotranspiration using Optimal Empirical Techniques

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ABSTRACT

This study focuses on the estimation of spatial Potential Evapotranspiration (PET) in the Ghataprabha River Basin using various empirical methods, validated by the pan evaporation method. The Penman-Monteith method, known for its comprehensive approach, served as the standard for comparison.

Among the five empirical methods evaluated—Hargreaves, Turc, Thornthwaite, Blaney-Criddle, and Kharrufa—the Hargreaves method demonstrated the closest correlation with the Penman-Monteith method, making it a practical alternative due to its minimal data requirements.

Spatial Land Surface Temperature (LST) data, extracted from Landsat 8 satellite images, enabled the application of the Hargreaves method for spatial PET estimation. The study revealed higher potential evapotranspiration (PET) values over water surfaces, moderate values over well-irrigated agricultural lands, and lower values over dry surfaces, highlighting the influence of surface characteristics and moisture availability on ET rates. The pan evaporation method provided effective validation, aligning closely with the Penman-Monteith estimates. The integration of remote sensing data with empirical methods facilitated detailed and accurate mapping of ET patterns across the basin. These findings underscore the importance of selecting appropriate empirical methods tailored to regional climatic conditions and the value of remote sensing in enhancing ET estimation accuracy, crucial for effective water resource management and agricultural planning in the region.

KEYWORDS:

Potential Evapotranspiration, Empirical equations, Spatial PET.

I. INTRODUCTION:

Evapotranspiration (ET) is the combined process through which water is lost from the environment via two distinct mechanisms: evaporation and transpiration [1]. Evaporation involves the transformation of water from the soil surface into vapor, which is then released into the atmosphere. Transpiration, on the other hand, occurs when water is absorbed by plant roots, moves through the plant, and is then released as vapor through small pores in the leaves known as stomata. Together, these processes play a critical role in the water cycle, influencing both agricultural productivity and environmental sustainability [2]. Estimating Potential spatial evapotranspiration (PET) is necessary for effective water management, agricultural optimization, climate studies, ecosystem monitoring, urban planning, and policy formulation [3]. It ensures the sustainable use and management of water resources, which is vital for human and environmental well-being. Estimation of spatial PET is complicated due to the estimation of complex hydrological parameters [4]. Therefore, many researchers have been adopted region specific empirical methods for the estimation of ET. Estimating spatial PET is a complex process due to the need to account for various hydrological parameters that can vary significantly across different regions. The complexity arises from factors such as soil moisture, vegetation type, land use, and meteorological conditions, all of which influence ET rates [5]. As a result, many researchers have adopted region-specific empirical methods tailored to the unique characteristics and data availability of their study areas. These empirical methods provide practical solutions by leveraging local climate data, soil properties, and vegetation types to produce more accurate ET estimates. By customizing the estimation techniques to fit regional conditions, researchers can achieve better precision in their ET calculations. This approach helps in addressing the inherent variability in hydrological processes. Penman-Monteith Method widely regarded as one of the most accurate methods, it combines energy balance and aerodynamic principles [6]. It requires data on solar radiation, air temperature, humidity, wind speed, and crop characteristics. Hargreaves Method is simpler method that estimates PET based on temperature and extraterrestrial radiation [7]. Thornthwaite Method [8] is based on empirical relationships between temperature and PET, considering monthly average temperature. So, it is useful for historical climate studies and regions with limited data. Blaney-Criddle Method [9] is an older method that uses temperature and day length to estimate PET. It is suitable for preliminary estimates and regions with limited data. Turc Method [10] requires mean air temperature and solar radiation data. It is best suited for temperate climates and regions with moderate solar radiation levels. Kharrufa Method [11] requires mean air temperature and relative humidity data. It is arid and semi-arid regions, where temperature and humidity are the dominant factors affecting ET. Many researchers have proposed many empirical methods but choice between these methods depends on the climatic conditions of the region being studied. There is a need to check the optimal empirical techniques which perform better over Ghataprabha river basin with minimum data requirement. Numerous researchers have proposed various empirical methods for estimating PET. However, the selection of the most appropriate method depends heavily on the climatic conditions of the region under study. For the Ghataprabha River Basin, it is crucial to identify and evaluate the optimal empirical techniques that can provide accurate PET estimates while requiring minimal data inputs. The need to identify the optimal empirical method for estimating PET in the Ghataprabha River Basin is paramount for effective water resource management and agricultural planning. By evaluating methods such as Hargreaves-Samani, Blaney-Criddle, Turc, and Kharrufa, researchers can determine which approach offers the best balance of accuracy, simplicity, and minimal data

requirements, ensuring reliable and practical ET estimates for the region. The objectives of this study are to estimate Potential Evapotranspiration (PET) using various empirical methods and to evaluate their effectiveness by comparing them with a standard PET estimation method. The study aims to calculate PET for the study area by leveraging available meteorological parameters and spatial data. Additionally, the accuracy of the PET estimates will be validated using the pan evaporation method.

II. STUDY AREA:

The Ghataprabha River Basin is selected as the study area, and its land use land cover features illustrated in Fig. 1. The Ghataprabha River is a significant right-bank tributary of the Krishna River. It originates in the Western Ghats at an altitude of 884 meters and flows eastward for 283 kilometers before merging with the Krishna River at Almatti. The river basin covers an area of 8,829 square kilometers, spanning across the states of Maharashtra and Karnataka [12]. The Hiranyakeshi and Markandeya Rivers are notable tributaries of the Ghataprabha river. A LULC map of the study area was generated using a Landsat 8 satellite image captured on January 8th, 2014, as shown in Figure 1. The map was created through supervised classification utilizing the maximum likelihood classification algorithm, resulting in an overall accuracy rate of 86.8%. The entire study area was categorized into four main classes: water, thick vegetation, sparse vegetation, barren land and exposed rock.

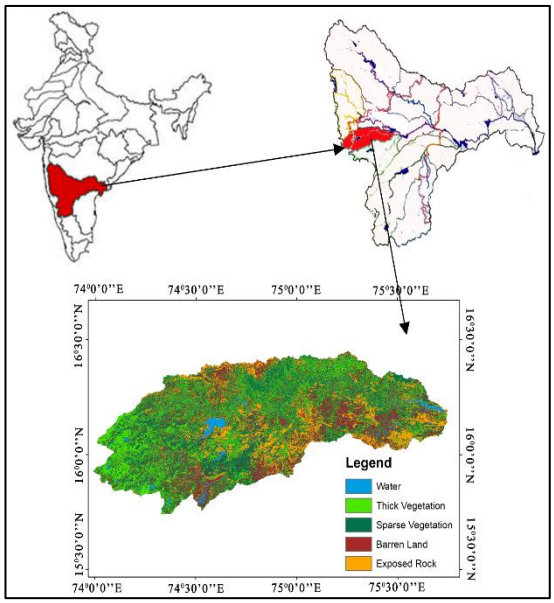

Fig. 1. Study area (Ghataprabha river basin)

III. METHODOLOGY:

The Ghataprabha River Basin has been selected as the study area, with its catchment area delineated using a Digital Elevation Model (DEM) in GIS software. Meteorological data for the region is collected from the Indian Meteorological Department (IMD) in Pune. Potential Evapotranspiration (PET) is estimated using several empirical methods, including

Hargreaves, Turc, Thornthwaite, Blaney-Criddle, and Kharrufa, which require minimal meteorological data. The FAO 56 Penman-Monteith method serves as the standard for ET estimation in this study. ET calculations using the Penman-Monteith method are performed with the FAO 56 ET0 calculator.

The results from the empirical methods are compared to those obtained using the FAO 56 Penman-Monteith method, with the comparison based on correlation coefficients to identify the most accurate empirical method. The selected empirical method, which shows the best correlation with the FAO 56 Penman-Monteith results, is then validated and calibrated using the pan evaporation method.

A pan evaporation device is designed and fabricated according to standard specifications for this purpose. Additionally, Landsat 8 satellite images of the study area are obtained from the USGS Earth Explorer website. Landsat 8 is having two thermal bands from thermal infrared sensor, to provide LST.

Spectral radiance to brightness temperature can be converted from TIRS band using the thermal constants provided in the metadata file and LST calculation method specified by USGS.

These images are processed using QGIS image processing software, where land surface temperature is calculated using the Raster Calculator. This temperature data is then used, along with the selected empirical method, to map evapotranspiration across the study area. This approach allows for an assessment of spatial variations in ET at the field level throughout the entire basin as shown in Fig 2.

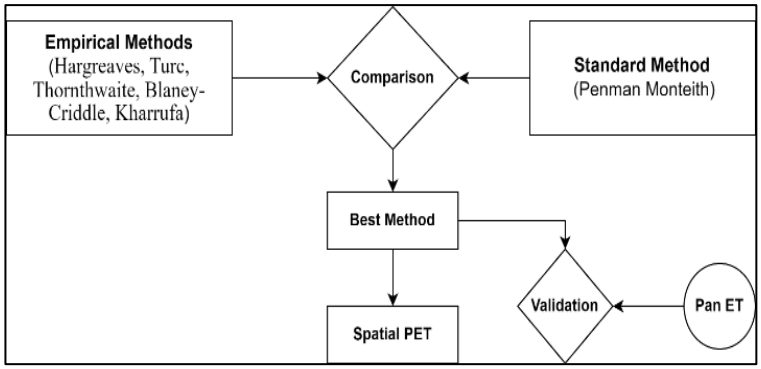

Fig. 2. Methodology flow chart

IV. RESULTS AND DISCUSSION:

The evapotranspiration (ET) values for the Ghataprabha River Basin from May 8 to May 13, 2024, are presented in Table 1. The ET values were estimated using six different empirical methods and the pan evaporation method, with the Penman-Monteith method considered as the standard [13]. The pan evaporation method is used for validation [14].

The Penman-Monteith method is considered the standard due to its comprehensive approach, incorporating various meteorological parameters. The ET values from this method range from 4.6 mm/day to 5.2 mm/day, showing consistent and stable estimates over the observed period. The Hargreaves method provides ET values ranging from 4.707 mm/day to 5.251 mm/day. These values are closely aligned with the Penman-Monteith method, with slightly higher estimates.

This method shows good correlation and can be considered a reliable alternative with minimal data requirements. The Turc method yields significantly higher ET values, ranging from 6.07 mm/day to 6.28 mm/day. This indicates a tendency to overestimate compared to the Penman-Monteith method. The high estimates suggest that the Turc method may not be suitable for the Ghataprabha River Basin without further calibration. The Thornthwaite method produces ET values between 5.89 mm/day and 6.04 mm/day. While these values are higher than the Penman-Monteith estimates, they are lower than those from the Turc method, suggesting moderate overestimation. The Blaney-Criddle method estimates ET values from 5.523 mm/day to 5.867 mm/day. These values are closer to the Penman-Monteith estimates but still tend to be higher, indicating slight overestimation. The Kharrufa method results in the highest ET values, ranging from 6.631 mm/day to 7.530 mm/day. This significant overestimation suggests that the Kharrufa method may not be suitable without calibration for the local climatic conditions of the Ghataprabha River Basin. The results indicate that the Penman-Monteith method is the most reliable and consistent for ET estimation in the Ghataprabha River Basin. Additionally, the Hargreaves method demonstrates good correlation with the Penman-Monteith method, making it a practical alternative that requires fewer data inputs.

Among the five empirical equations evaluated, the Hargreaves method was selected as the most suitable for estimating spatial evapotranspiration in the Ghataprabha River Basin. This method primarily relies on temperature data, making it both practical and effective given the available resources. To implement the Hargreaves method for spatial analysis, Land Surface Temperature (LST) map (Figure 2) was extracted from Landsat 8 satellite images, providing the necessary spatial temperature data across the study area. Utilizing this LST data, spatial Potential Evapotranspiration (PET) (Figure 3) was calculated using the Hargreaves method, allowing for a detailed and accurate mapping of evapotranspiration patterns across the basin.

TABLE I. EVAPOTRANSPIRATION VALUES IN MM/DAYS

Date	**Penman Monteith Equation ET_0 (mm/day)**	**Hargreaves Equation ET_0 (mm/day)**	**Turc Equation ET_0 (mm/day)**	**Thornthwaite Equation ET_0 (mm/day)**	**Blaney Criddle Equation ET_0 (mm/day)**	**Kharrufa equation ET_0 (mm/day)**	**Pan ET_0 (mm/day)**
08/05/2024	4.7	4.866	6.18	5.970	5.711	7.118	5.1
09/05/2024	4.6	4.707	6.12	5.93	5.617	6.874	4.5
10/05/2024	4.7	4.867	6.07	5.89	5.523	6.631	5.25
11/05/2024	5.0	5.177	6.13	5.93	5.617	6.874	5.3
12/05/2024	5.0	5.251	6.28	6.04	5.867	7.530	5.2
13/05/2024	5.2	5.166	6.27	6.03	5.842	7.464	5.0

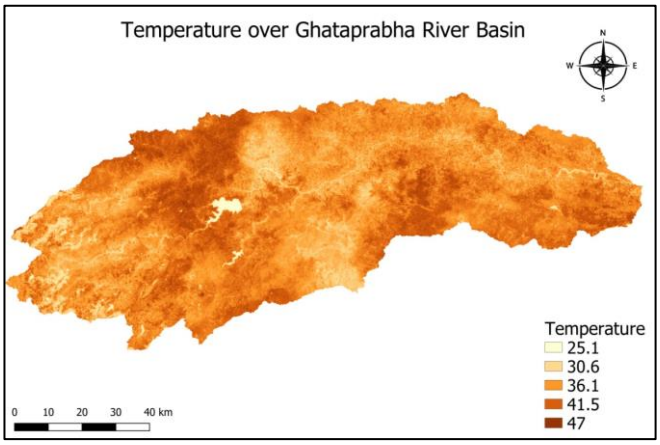

Fig. 2. Land surface temperature map of Ghataprabha river basin

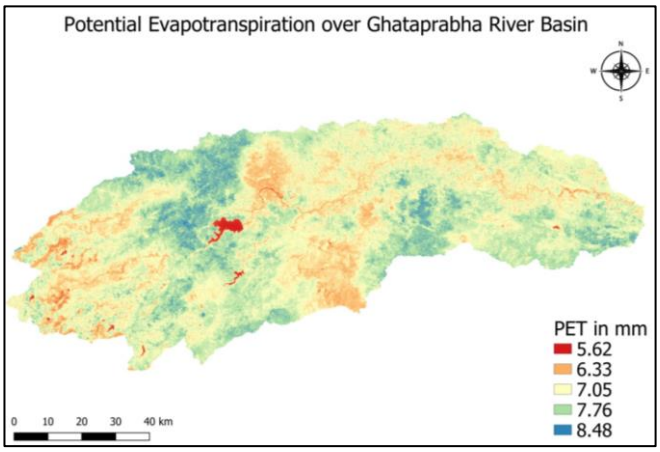

Fig. 3. Potential Evapotranspiration map of Ghataprabha river basin

Higher spatial potential evapotranspiration (PET) values were observed over water surfaces, as illustrated in Figure 3. This is likely due to the abundance of available water, which enhances the evaporation process. Moderate PET values were recorded over well-irrigated agricultural lands, reflecting the presence of sufficient soil moisture that supports both evaporation from the soil and transpiration from crops. In contrast, lower PET values were observed over dry surfaces, such as arid or non-irrigated areas, where the lack of moisture limits the evaporation and transpiration processes.

V. CONCLUSIONS:

This study aimed to estimate spatial evapotranspiration (ET) in the Ghataprabha River Basin using best performing empirical method and validate the results with the pan evaporation method. The Penman-Monteith method, recognized for its comprehensive approach and reliability, was used as the standard for comparison. Among the five empirical equations evaluated, the Hargreaves method demonstrated the closest correlation with the Penman-Monteith method. Given its simplicity and reliance primarily on temperature data, the

Hargreaves method emerges as a practical alternative, especially in scenarios with limited meteorological data availability. Spatial Land Surface Temperature (LST) data extracted from Landsat 8 satellite images enabled the application of the Hargreaves method for spatial ET estimation. This integration of remote sensing data with empirical methods allowed for detailed and accurate mapping of ET patterns across the basin. The study revealed higher PET values over water surfaces, moderate values over well-irrigated agricultural lands, and lower values over dry surfaces. These variations underscore the significant influence of surface characteristics and moisture availability on ET rates. The pan evaporation method served as an effective validation tool, with its ET values closely aligning with the Penman-Monteith estimates. This reinforces the utility of the pan method for practical field validation. In conclusion, the study highlights the efficacy of using the Hargreaves method, supported by remote sensing data, for spatial ET estimation in the Ghataprabha River Basin. The findings emphasize the importance of selecting appropriate empirical methods tailored to regional climatic conditions and the value of integrating remote sensing data to enhance the accuracy and spatial resolution of ET estimates. These insights are crucial for effective water resource management and agricultural planning in the region. The study advances the understanding of spatial ET estimation in the Ghataprabha River Basin, offering new methodologies and insights that can be applied both in this region and in other areas with similar climatic conditions.

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19. Machine Learning Approach to Predict the Malnutrition Status of Women

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ABSTRACT

The study uses machine learning techniques to address malnutrition among women and children, a prevalent concern in many regions. Malnutrition significantly impacts health, development, and mortality rates, necessitating accurate and efficient predictive models to identify at-risk individuals. The specific objective of the research is to develop and evaluate a machine learning-based approach that can reliably predict the malnutrition status of women and children, utilizing various socioeconomic, demographic, and health-related data.

This study presents a comprehensive analysis of malnutrition among women by applying machine learning techniques to data from the Demographic and Health Surveys (DHS) Program. A total of 2,32,920 raw data samples were meticulously collected and cleaned, comprising approximately 1600 parameters. A thorough analysis identified 19 parameters as significant contributors to anemia among women. Utilizing the Random Forest Classifier Algorithm implemented via Python code, a machine learning model was developed and trained on 80% of the sample size (1,86,336 samples) for effective prediction and analysis. Subsequently, the model was thoroughly tested on the remaining 20% of the sample size (46,584 samples) using the Google Colab platform. The results indicated an anemia prediction accuracy of 72.95% for the test cases, demonstrating the efficacy of the machine learning model in predicting anemia among women. This study underscores the potential of machine learning techniques in identifying and addressing public health challenges, particularly in nutrition and women's health.

KEYWORDS:

Malnutrition, DHS, Random Forest Classifier, Machine Learning, and Predictive Modeling.

I. INTRODUCTION:

Malnutrition remains a critical public health challenge affecting millions of women and children worldwide. It significantly contributes to morbidity and mortality, impairs cognitive and physical development, and perpetuates the cycle of poverty and poor health. Despite various efforts and interventions to combat malnutrition, early identification and intervention remain vital to mitigating its adverse effects. Traditional malnutrition identification methods, often relying on manual data collection and clinical assessments, can be resource-intensive and time-consuming. Highlight the need for more efficient, scalable, and accurate approaches.

Recent advancements in machine learning have opened new avenues for addressing complex health issues, including malnutrition. Machine learning models can analyze large datasets, uncover patterns, and make highly accurate predictions, offering a promising solution to identify individuals at risk of malnutrition more effectively. By leveraging socioeconomic, demographic, and health-related data, machine learning can comprehensively understand the factors contributing to malnutrition and predict its occurrence more precisely.

This study aims to develop and evaluate a machine learning-based approach to predicting the malnutrition status of women and children. The study uses machine learning algorithms and feature selection techniques to create a robust predictive model to assist health practitioners and policymakers in early identification and targeted intervention for at-risk people. This approach not only aims to improve the accuracy and efficiency of malnutrition prediction but also seeks to contribute valuable insights into the underlying determinants of malnutrition.

This paper reviews the literature on malnutrition prediction and machine learning applications in health. We then describe the dataset and methodologies used for developing the predictive model. The results section presents the performance of different machine learning algorithms, followed by a discussion of the findings and their implications for public health practice. Finally, we conclude with recommendations for future research and potential applications of our model in real-world settings, instilling a sense of hope in the audience about the practical application of our research.

II. LITERARURE SURVEY:

The Demographic and Health Surveys (DHS) Program [1-2], collects nationally representative health and population data in developing countries.

The DHS Program provides survey data to program managers, healthcare providers, policymakers, country leaders, researchers, and media members to improve public health. This work uses data from the DHS. Machine learning (ML) and artificial intelligence (AI) have become increasingly prevalent in predicting malnutrition, driven by the need for efficient and accurate tools. Various studies have explored different ML algorithms and their applications in identifying malnutrition, highlighting the potential of these technologies to transform public health practices.

Islam et al. [3] highlighted the robustness of the Random Forest classifier and the importance of feature selection for enhancing model performance. Additionally, the authors used deep learning approaches to classify malnutrition in children aged 0-59 months, employing rectifier activation functions in the hidden layer and a sigmoid function in the output layer. Liu et al. [4] introduced the Random Forest algorithm, known for its accuracy and efficiency in handling large datasets and complex variables, and widely adopted in health prediction models.

Pavani Varma and Prasad [5] investigated the prevalence of malnutrition among children aged 0-5 years in rural India, emphasizing the socioeconomic and environmental factors contributing to child malnutrition. Although they did not use machine learning, their findings provide crucial context for feature selection in ML models predicting child malnutrition. Chakravorty and Manisha [6], reviewing numerous contributing factors. Their study highlighted the complexity of malnutrition and the necessity of multifactorial approaches in prediction models, aiding in understanding the diverse variables that ML models must consider for accurate predictions.

Shahriar et al. [7] utilized deep learning to predict malnutrition among children in Bangladesh. Their approach leveraged Convolutional Neural Networks (CNNs) to analyze health data, demonstrating the potential of deep learning in handling complex health datasets and improving prediction accuracy. Kavya Priya et al. [8] proposed an innovative application using machine learning to predict malnutrition and anemia. The study showcased how combining multiple health indicators in ML models can enhance predictive capabilities and assist in early diagnosis.

Vichave et al. [9] explored AI for malnutrition detection, emphasizing the role of various ML algorithms in enhancing screening efficiency and accuracy. Dhamane et al. [10] developed a multi-agent system for diagnosing and preventing malnutrition, showcasing the integration of AI in real-time monitoring and intervention strategies, thereby demonstrating practical ML applications in public health.

Thangamani and Sudha [11] employed supervised data mining techniques, including Decision Trees and Artificial Neural Networks, to identify malnutrition, highlighting their effectiveness in processing large health datasets and delivering accurate predictions. In the International Journal of Research Publication and Reviews, Dhorea et al. [12] examined using CNNs with ADAM optimization to detect vitamin deficiencies, a related health concern. Their findings on the effectiveness of deep learning in health prediction models are relevant to malnutrition studies, given the overlapping data requirements and methodologies. Rao et al. [13] investigated vitamin deficiency detection using CNNs, emphasizing the importance of optimization techniques in improving model accuracy. Their study provides insights into advanced ML techniques applicable to malnutrition prediction. Kishore et al. [14], in their Research Square study, focused on predicting malnutrition in newborn infants using ML techniques. They emphasized early detection's importance for timely intervention and improved health outcomes, showcasing ML's potential in neonatal health. Ghodsi et al. [15] highlighted the importance of longitudinal data in understanding and addressing malnutrition. These studies illustrate machine learning and AI's broad application and effectiveness in predicting malnutrition. They emphasize the importance of selecting relevant features, utilizing robust algorithms like Random Forest and CNNs, and

integrating comprehensive datasets to improve prediction accuracy and support public health interventions. Continued research is essential for refining these models, ensuring their practical application in diverse settings, and developing the trained model on the Indian malnutrition data set.

III. DATASET:

With due permission, data from the Demographic and Health Surveys (DHS) Program is used to apply a comprehensive analysis of malnutrition among women using machine learning techniques. Two hundred thirty-two thousand nine hundred twenty raw data samples were meticulously collected and cleaned, comprising approximately 1600 parameters. After thorough analysis, 19 parameters were identified as significant contributors to anemia among women. These 19 parameters are considered inputs to the model, with one output; details of each input are depicted in Tables 1 to 5. Table 1 shows details of three inputs: respondent's current age, type of residence, and Indian state. Table 2 shows details of the following three inputs: sources of drinking water, religion, educational attainment, and wealth index. Table 3 shows the total number of sons living in the house, the total number of daughters living in the house, alcohol consumption, frequency of milk and curd consumption, frequency of pulse consumption, frequency of leafy vegetable consumption, and the output anemia level. Table 4 shows the frequency of fruit consumption, the frequency of egg consumption, and the frequency of fish consumption. Table 5 shows inputs such as the frequency of chicken or meat consumption, frequency of fried food consumption, and frequency of aerated drink consumption.

Table 1: Details of input no. 1 to 3

Sl. No.	Case Identification	Respondent's Current age	Type of place of residence: 1: Urban 2: Rural	State: 1 = "Jammu & Kashmir" 2 = "Himachal Pradesh" 3 = "Punjab" 4 = "Chandigarh" 5 = "Uttarakhand" 6 = "Haryana" 7 = "Nct Of Delhi" 8 = "Rajasthan 9 = "Uttar Pradesh" 10 = "Bihar" 11 = "Sikkim" 12 = "Arunachal Pradesh" 13 = "Nagaland" 14 = "Manipur" 15 = "Mizoram" 16 = "Tripura" 17 = "Meghalaya" 18 = "Assam" 19 = "West Bengal" 20 = "Jharkhand" 21 = "Odisha" 22 = "Chhattisgarh" 23 = "Madhya Pradesh" 24 = "Gujarat" 25 = "Dadra & Nagar Haveli And Daman & Diu" 27 = "Maharashtra" 28 = "Andhra Pradesh" 29 = "Karnataka" 30 = "Goa" 31 = "Lakshadweep" 32 = "Kerala" 33 = "Tamil Nadu" 34 = "Puducherry" 35 = "Andaman & Nicobar Islands" 36 = "Telangana" 37 = "Ladakh"
Null	Null	Input	Input	Input
Sl. No	CASEID	V012	V025	V101
1	0100101399 02	38	2	1
- -	- -	- -	- -	- -
- -	- -	- -	- -	- -
- -	- -	- -	- -	- -
232918	3700401546 02	35	1	37
232919	3700401554 02	28	1	37
232920	3700401592 04	28	1	37

Table 2: Details of input nos. 4 to 7

Source of drinking water: 10 = "PIPED WATER" 11 = "Piped into dwelling" 12 = "Piped to yard/plot" 13 = "Piped to neighbor" 14 = "Public tap/standpipe" 20 = "TUBE WELL WATER" 21 = "Tube well or borehole" 30 = "DUG WELL (OPEN/PROTECTED)" 31 = "Protected well" 32 = "Unprotected well" 40 = "SURFACE FROM SPRING" 41 = "Protected spring" 42 = "Unprotected spring" 43 = "River/dam/lake/ponds/stream/canal/irrigation channel" 51 = "Rainwater" 61 = "Tanker truck" 62 = "Cart with small tank" 71 = "Bottled water" 92 = "Community or plant" 96 = "Other" 97 = "Not adejure resident"	Religion: 1 = "Hindu" 2 = "Muslim" 3 = "Christian" 4 = "Sikh" 5 = "Buddhist / Neo-Buddhist" 6 = "Jain" 7 = "Jewish" 8 = "Parsi / Zoroastrian" 9 = "No religion" 96 = "Other"	Educational attainment: 0: None, 1: incomplete primary, 2: complete primary, 3: incomplete secondary, 4: complete secondary, 5: higher education.	Wealth index combined: 1 = "Poorest" 2 = "Poorer" 3 = "Middle" 4 = "Richer" 5 = "Richest"
Input	Input	Input	Input
V113	V130	V149	V190
14	2	3	3
--	--	--	--
--	--	--	--
--	--	--	--
61	2	0	4
61	2	0	4
97	2	5	3

Table 3: Details of input nos. 8 to 13 and the output

Total number of sons living at home	Total number of daughters living at home	Anemia level: 1: Severe; 2: Moderate; 3: Mild; 4: Not Anemic; 9: Missing	Do you drink alcohol: 0 = "No" 1 = "Yes"	Frequency takes milk or curd: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 ="Occasionally"	Frequency eats pulses or beans: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 ="Occasionally"	Frequency eats dark green leafy vegetable: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 = "Occasionally"
Input	Input	Output	Input	Input	Input	Input
V202	V203	V457	S720	S731A	S731B	S731C
1	2	4	0	1	2	1
--	--	--	--	--	--	--
--	--	--	--	--	--	--
--	--	--	--	--	--	--
1	1	2	0	1	2	2
0	1	2	0	1	2	2
1	0	2	0	1	2	1

Table 4: Details of input nos. 14 to 16

Frequency eats fruits: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 = "Occasionally"	Frequency eats eggs: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 = "Occasionally"	Frequency eats fish: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 = "Occasionally"
Input	Input	Input
S731D	S731E	S731F
1	1	3
--	--	--
--	--	--
--	--	--
3	3	3
1	3	3
3	3	3

Table 5: Details of input nos.17 to 19

Frequency eats fruits: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 = "Occasionally"	Frequency eats eggs: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 = "Occasionally"	Frequency eats fish: 0 = "Never" 1 = "Daily" 2 = "Weekly" 3 = "Occasionally"
Input	Input	Input
S731D	S731E	S731F
1	1	3
--	--	--
--	--	--
--	--	--
3	3	3
1	3	3
3	3	3

IV. ALGORITHM AND IMPLEMENTATION:

The Random Forest Classifier is a versatile and widely used machine learning algorithm for classification tasks. It constructs multiple decision trees and combines their results for more accurate and stable predictions. Below is a detailed overview of its functionality and key components:

Algorithm Key Concepts:

Decision Tree: A decision tree is a flowchart-like structure where an internal node represents a feature (or attribute), each branch represents a decision rule, and each leaf node represents the outcome.

Ensemble Learning: This technique merges predictions from multiple machine learning algorithms to achieve more accurate results than any single model. Bootstrap Aggregating (Bagging): Random Forest uses this method to generate multiple training data subsets, each used to train a different decision tree.

How Random Forest Works:

Creating Multiple Decision Trees: Randomly select a subset of the training data (with replacement) to create multiple bootstrapped datasets. For each subset, a decision tree is built.

However, instead of considering all features for splitting nodes, Random Forest randomly selects a subset of features at each node. This introduces more diversity among the trees.

Training: Each decision tree is trained independently on its respective bootstrapped dataset. The trees are grown to their maximum depth, meaning they are not pruned, which often results in high variance for individual trees but low bias.

Prediction: For classification, each tree in the forest makes a prediction (votes) for the class. The final prediction is the class with the most votes (majority voting). For regression, the average tree prediction is taken as the final output.

Implementation:

The following steps are implemented using a random forest algorithm to train the data set and test.

Import libraries: In AIML, libraries such as NumPy, Pandas, Scikit-learn, and Matplotlib are commonly used for data manipulation, analysis, visualisation, and machine-learning tasks. Importing these libraries allows access to their functions and classes for various tasks.

Import the dataset: AIML projects typically begin by importing the dataset to be used for analysis and modelling. This involves loading the dataset into the programming environment, often using functions provided by libraries like Pandas (e.g., PD.read_csv() for CSV files).

Convert categorical variables into Numerical: Many machine learning algorithms require numerical input data, so categorical variables must often be converted into numerical format. Depending on the nature of the categorical data, techniques such as one-hot or label encoding are commonly used.

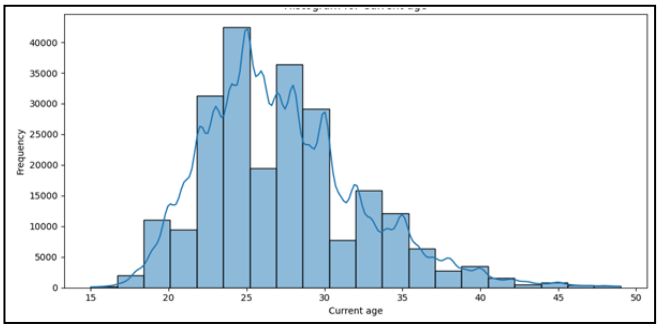

Fig. 1 Histogram of Current age

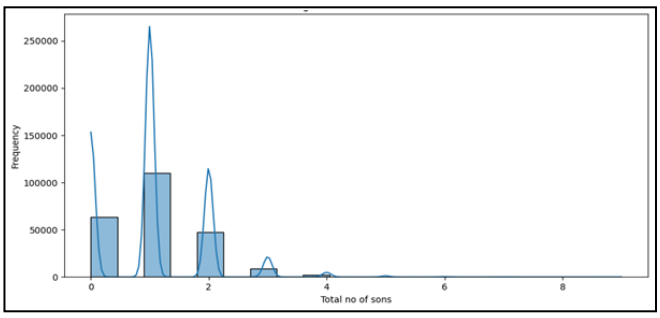

Fig. 2 Histogram of Total no. of Sons in a Family

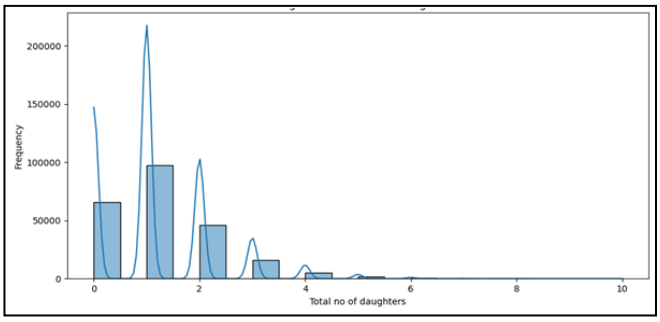

Fig. 3 Histogram of Total no. of Daughter a Family

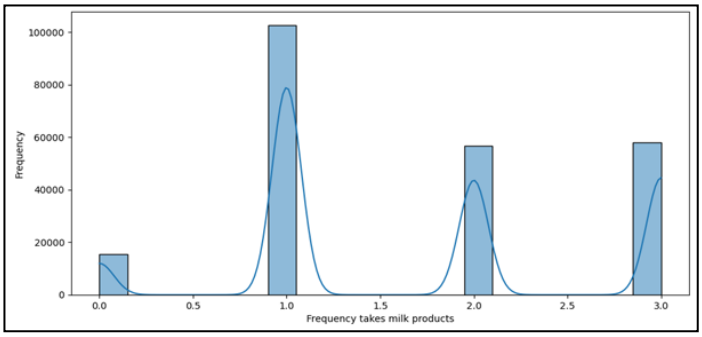

Fig. 4 Histogram of Frequency of Milk Product Taken

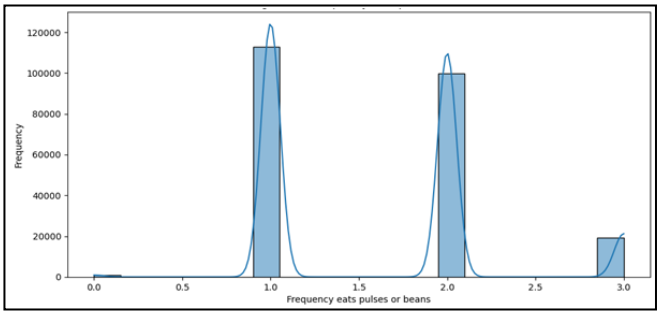

Fig. 5 Histogram of Frequency of Pulses or Beans Taken

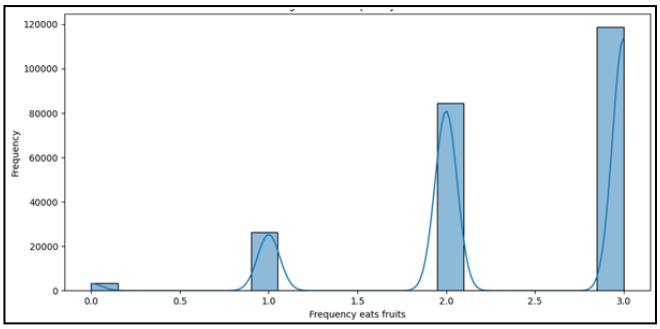

Fig. 6 Histogram of Frequency of Fruits Taken

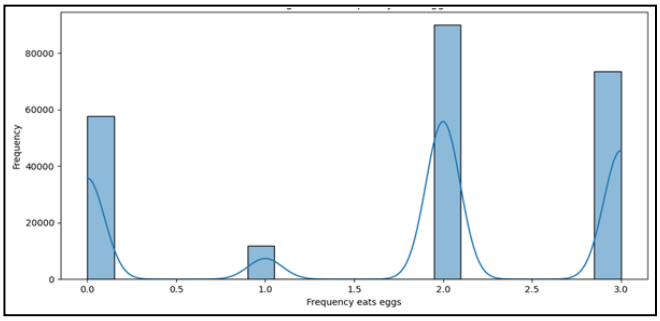

Fig. 7 Histogram of Frequency of Eggs Taken

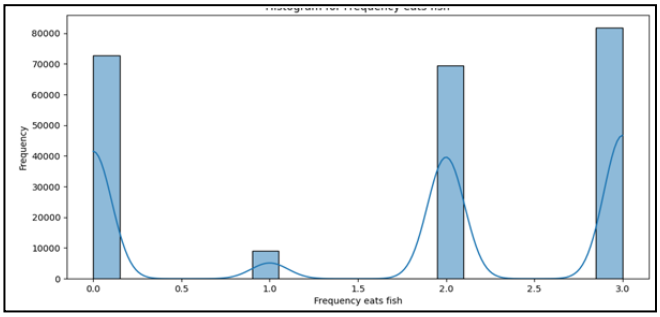

Fig. 8 Histogram of Frequency of Fish Taken

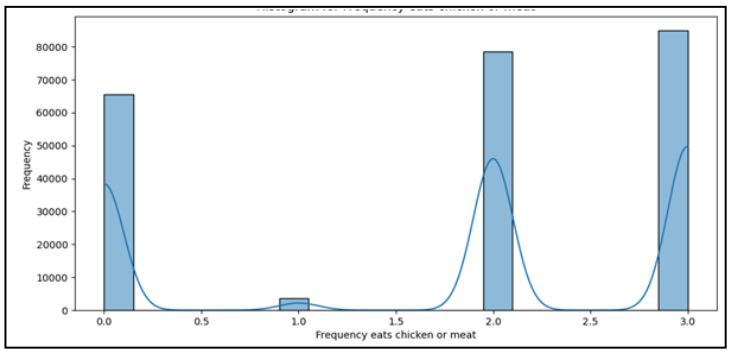

Fig. 9 Histogram of Frequency of Chicken or Meat Taken

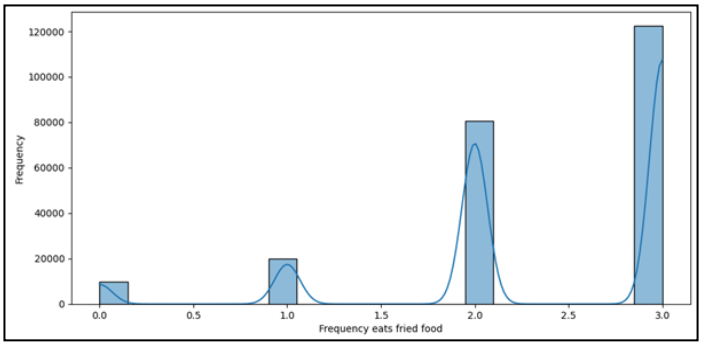

Fig. 10 Histogram of Frequency of Fried Food Taken

Find the correlation between input and output variables:

Understanding the correlation between input features and output variables is crucial for building accurate machine-learning models. This involves calculating correlation coefficients. Histogram analysis: Histogram analysis involves examining the distribution of numerical variables in the dataset. Histograms provide insights into the data distribution's central tendency, spread, and shape, which can help understand the data and make decisions about preprocessing or model selection.

Model development: Model development involves selecting appropriate machine learning algorithms, training them on the dataset, and tuning their parameters for optimal performance. Standard algorithms include linear regression, decision trees, support vector machines, and neural networks

V. RESULT ANALYSIS:

After training [16]-[17] and evaluating the machine learning models, performance analysis involves metrics like accuracy, precision, recall, F1-score, and ROC curves to assess generalization and identify areas for improvement.

Understanding model predictions and their strengths and weaknesses is also crucial. Fig 1 to 11 shows histograms of different inputs from data set. Fig. 11 displays the confusion matrix, which compares predicted and actual labels to evaluate classification performance.

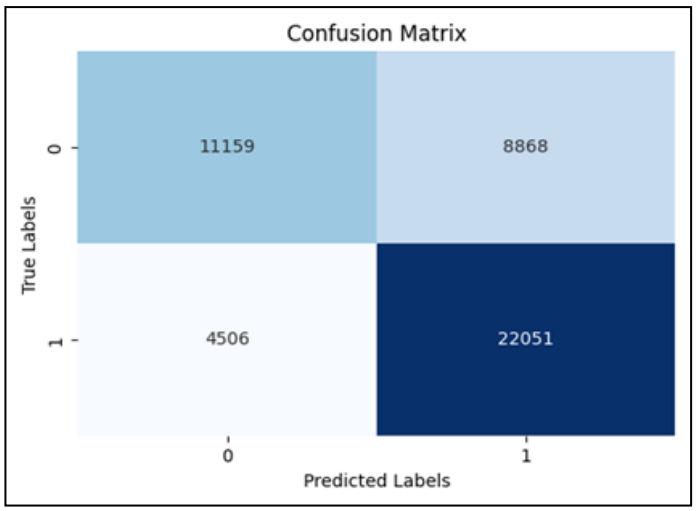

Fig. 11 Confusion Matrix

VI. CONCLUSION:

In conclusion, this research highlights the effectiveness of machine learning in predicting malnutrition among women using Demographic and Health Surveys (DHS) data. By analyzing 232,920 samples with 1,600 parameters, 19 key factors contributing to malnutrition were identified.

The Random Forest Classifier, trained on 80% of the data (186,336 samples) and tested on 20% (46,584 samples) using Google Colab, achieved a prediction accuracy of 72.95%.

These findings underscore the potential of machine learning in informing public health interventions aimed at addressing malnutrition among women. By leveraging large-scale datasets and advanced analytical techniques, such as Random Forests, we can gain valuable insights into the factors influencing malnutrition, enabling more targeted and effective interventions to improve women's health outcomes.

Further research and application of machine learning in public health are warranted to advance our understanding and address the complex challenges of malnutrition and related health disparities.

This study highlights the need for continued innovation and application of machine learning in public health to develop more precise and impactful solutions for improving women's health and well-being. Future work involves improving the prediction accuracy by exploring other machine learning algorithms and predicting malnutrition status, such as anemia level: Severe, moderate, mild, and not anemia.

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20. Formulation of Herbal Cleanser for Fruits and Vegetables

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ABSTRACT

Fruits and vegetables are highly nutritious and forms as key food commodity in the human consumption ,they are highly perishable due to their low shelf life and contaminants, these food commodities with microbes and health hazardous chemicals such as pesticides ,hence it is very necessary to remove the pesticides and prevent the microbial contamination of fruits and vegetables without changing its nutritional value ,washing with the tap water is the mostly common practice of consumers to reduce microbial contamination of fruits and vegetables but tap water has limitation and less effect on killing microbes and also water contains chlorine thus our project aims to design effective herbal cleanser in order to reduce contamination from the various sources for food safety that is the prime concern of today for consumers.

KEYWORDS:

herbal wash, sanitisers, microbial load, contaminants, fruits and vegetable cleanser

I. Introduction

Fruits and vegetables play an important role in the agriculture and industrial economy. These crops, which are perishable commodities, are important ingredients of human diet. Fruits are one of the oldest forms of food known to human beings. Moreover, in country like India 20-40 percent of the population is vegetarian, the need of fruits and vegetables in our diet is evident. Almost all the fruits and vegetables contain varying amount of food contents such as carbohydrates, fats, proteins, vitamins, minerals etc. Hence, they play a vital role in improvement of the body given their high health benefits, are a great resource to help prevent diseases. India is the second largest producer of both fruits and vegetables in the world after China with an annual production of fruits of about 97.97 million MT from an area of 6648 thousand Ha and the annual production of vegetables is about 185.883 million MT in an area of 101 thousand Ha. Fresh fruit and vegetables are an essential component of a healthy and balanced diet.

Their consumption has increased worldwide in recent years as a result of the promotion of healthier lifestyles. In many cases, these commodities are ready-to- eat (RTE). One-third of increased consumption of salads and prepared vegetables resulting in an increase in human infections associated with raw fruits and vegetables.

II. Material and Methodology:

A. Microbial assessment of fruits and vegetables:

Microbial assessment is done to check the risk of contamination of the fruits and vegetables and to provide scientific information for development of the hygiene field i.e., cleanser for public health. The procedure for the microbial assessment is given below.

II.A.1 Sample collection: Samples of six different fruits and vegetables including apple, sapota, grapes, tomato, radish and spinach are obtained from the Vidyagiri, Bagalkote, Fruits and vegetables shops and roadside vendors.

II.A.2 Sample processing: 1 g of each fruit and vegetables peel is mixed with 9 ml of distilled water in a sterile container and centrifuged at 10000 rpm for 2 minutes prior to dilution. Then 1ml of this mixture is taken to make serial dilutions up to 10-7 (Suman Vikas Bhat et al., 2013).

II.A.3 Total plate count: One ml aliquot from 10-1, 10-3, 10-5 and 10-7 dilutions are transferred into petri dishes. This was followed by pouring aseptically 20-25 ml of molten Nutrient agar (NA). The inoculum was mixed by swirling the plates and later allowed to solidify. The plates are incubated at 37°C for 24 hours. After incubation, the colonies are counted and recorded.

II.A.4 Gram staining: This is the most important widely used procedure for characterizing bacteria. This method divides the bacteria into two groups, Gram positive which is purple in colour and Gram negative which is pink in colour. This technique is based on the ability of bacteria to retain primary stain (crystal violet dye) during decolourisation with alcohol. Gram positive bacteria retain primary stain while Gram negative bacteria are decolorized by alcohol and takes up the red color counter stain. A smear of an isolate was made on a clean slide and allowed to dry. It was then heat fixed by passing the smear through the Bunsen burner, this is done to enhance the sticking of the organism on the microscope slide. The smear was flooded with crystal violet and left for 60sec before washing off with water and decolorized with alcohol for 10 sec. The slide was then washed off, stained with safranin for 30 sec washed off and allowed to air dry. A drop of immersion oil was added to the slide which was then viewed under the microscope using the x 100 objective lens (Amandeep kaur et al., 2017).

B. Preparation of herbal cleanser for fruits and vegetables:

II.B.1 Collection of herbs: Neem leaves, Curry leaves, Papaya leaves, Amla fruits, Lemon peels are collected from Vidyagiri and washed 2-3 times in distilled water to remove surface impurities and sun dried for 3-4 days.

The dried plant material is then ground into fine powder by using grinder. This powdered sample was kept in clean closed containers till extraction. II.B.2 Preparation of herbal extracts: extraction was done by soxhlet apparatus using distilled water as solvent. The finely grounded herbal powders are placed in a filter paper bag and placed in a soxhlet apparatus. The condensed extract dripped into the filter paper bag containing the herbal powder. When the level of liquid in chamber rises to the top of siphon tube the liquid contents of chamber siphon was collected into round bottom flask. This process was continued and carried out until 15 cycles. The collected sample is stored aseptically for further use (Vimal kishor Singh et al., 2017).

C. Formulation of herbal cleanser:

Three formulations are prepared by mixing appropriate concentrations of the herbal extracts as shown in below Table

Table 1: Composition of the designed formulations

components	formulation 1 (100ml)	formulation 2 (100ml)	formulation 3 (100ml)
Neem leaves extract	5 gms	5 gms	7.5 gms
Curry leaves extract	1.5 gms	3 gms	4.5 gms
Papaya leaves extract	2.5 gms	5 gms	7.5 gms
Lemon peel extract	10 gms	15 gms	22.5 gms
Amla fruit extract	14.5 gms	20 gms	30 gms
Soap pod extract	7.5 gms	10 gms	15 gms
Sobitol	7 gms	7 gms	7 gms

II. D Evaluation of formulations:

II.D.1 Characterization of herbal cleanser:

***i.* pH: The pH is determined by using digital pH meter.**

ii. Viscosity: The viscosity of hand wash was determined by using digital Brookfield viscometer. Measured quantity of herbal hand wash was taken into a beaker and the tip of viscometer was immersed into the prepared herbal cleanser and the viscosity is measured in triplicate.

II.D.2 Phytochemical analysis of formulation:

i. Test for Tannin's: 2g of prepared extract was boiled with 45% ethanol for 5 minutes, then the mixture was cooled and filtered then the filtrate were then treated with few drops of leaf acetate solution, the formation of gelatinous precipitate indicated the presence of tannins.

ii. Test for alkaloids: 2-3 drops of Dragendoff's reagent was reacted in the test tube containing 0.1 ml of prepared extract. The presence of alkaloids was indicated by appearance of an orange red precipitate with turbidity.

iii. Test for Flavonoids (Alkaline reagent test): Few drops of 20% NaOH solution were added to 2 ml prepared extract which showed yellow color within a second and became colorless on addition of dilute HCl which indicated the positive result.

iv. Test for Terpenoids (Salkowski test): In 1 ml of chloroform, 2 ml prepared extract was added and few drops of conc. H2SO4 were also added. The formation of reddish-brown precipitate indicated the positive result.

v. Test for Phenols (Ferric Chloride test): Aqueous 5% ferric chloride was added to 2 ml prepared extract. The formation of deep blue/black color indicated the positive result.

iv. Test for Quinons: Few drops of conc. HCl were added to 2 ml prepared extract. The formation of yellow precipitate indicated the positive result.

vii. Test for Cardiac glycosides (Keller kiliani test): 2 ml of glacial acetic acid was added to 5 ml prepared extract then few drops of ferric chloride were also added with 1 ml conc. H2SO4. The formation of brown/violet/green ring indicated the positive result.

viii. Test for Saponins: One gram of the prepared extract was boiled with 5ml of distilled water for 5 minutes. The content was filtered while hot and the filtrate was treated with few drops of olive oil and vigorously shaken. The formation of emulsion indicates the presence of saponins.

II.D.2 Antimicrobial test:

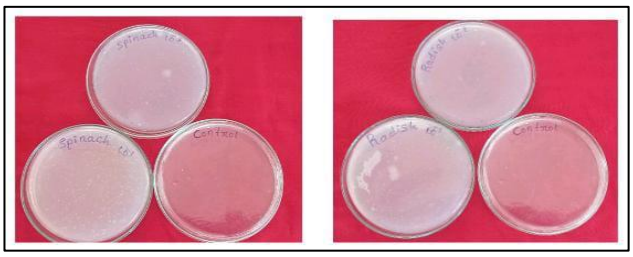
Fruits and vegetables such as apple, sapota, grapes, radish, tomato and spinach are purchased from the Vidyagiri market, Bagalkot. To check the efficacy of the prepared formulation the purchased fruits and vegetables are segregated into four different batches. One batch which is unwashed was swabbed and sent separately in a sterile bag for its microbial evaluation.

Other three batches of fruits and Vegetables are soaked in three different formulations for 1 to 2 mins. Followed by washing all the disinfected samples were then collected separately after drying with sterile towels. Their outer surface was swabbed and sent to the laboratory in a sterile bag for evaluation of their microbiological contamination which was expressed in terms of total colony count.

III. Results and Discussion:

A. Microbial load analysis:

Fruits and vegetables samples such as grapes, apple, sapota, tomato, radish and spinach are collected from Vidyagiri market, Bagalkote. Total microbial load analysis of these samples are carried out by isolating the microbial population. The results show that among vegetable samples the highest count was obtained for samples of tomato i.e. 467 followed by Spinach (367) and Radish (361). Among fruits highest colony count was obtained for grapes i.e. 386 colonies followed by sapota (374) and apple (231).



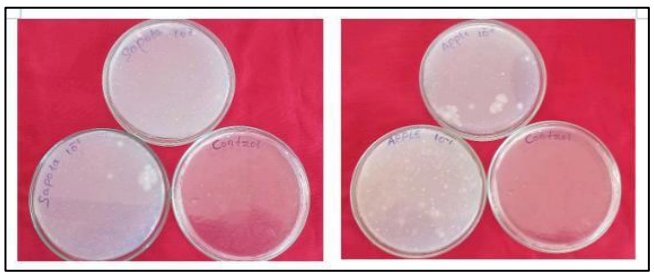
Spinach Radish

control and dilution 10^{-1} control and dilution 10

and 10^{-7} colony count and 10^{-7} colony count

dilution 10^{-1} = 367 dilution 10^{-1} = 361

dilution 10^{-7} = 87 dilution 10^{-7} = 92

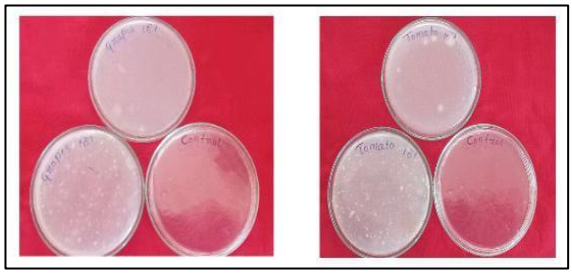


Sapota Apple

control and dilution 10^{-1} control and dilution 10^{-1}

and 10^{-7} colony count and 10^{-7} colony count

dilution 10^{-1} = 374 dilution 10^{-1} = 231



Grapes Tomato

control and dilution 10-1 control and dilution 10-1

and 10-7 colony count and 10-7 colony count

dilution 10-1 = 386 dilution 10-1 = 467

dilution 10-7 = 72 dilution 10-7 = 103

Fig 1 Microbial load assessment of fruits and vegetables

B. Gram staining:

The bacterial strains were characterized on the basis of ability of bacteria to retain primary stain (crystal violet dye) during decolourisation with alcohol.

The results of the gram staining are shown in table below.

Table 2 Gram staining

Sample	Isolates	Slide 1	Slide 2	Slide3
Tomato	10^{-1}	+(rods)	+(bacillus)	+(rods)
	10^{-2}	+(rods)	-(bacillus)	-(bacillus)
	10^{-3}	-(rods)	+(bacillus)	+(rods)
Spinach	10^{-1}	+(bacillus)	+(rods)	+(rods)
	10^{-2}	-(rods)	+(bacillus)	+(rods)
	10^{-3}	-(cocci)	-(rods)	+(rods)
Radish	10^{-1}	+(rods)	-(cocci)	-(rods)
	10^{-2}	-(rods)	-(rods)	+(bacillus)

Sample	Isolates	Slide 1	Slide 2	Slide3
	10^{-3}	+(rods)	-(rods)	+(rods)
Apple	10^{-1}	+(rods)	+(rods)	+(bacillus)
	10^{-2}	+(bacillus)	-(cocci)	-(cocci)
	10^{-3}	+(bacillus)	-(rods)	+(bacillus)
Grapes	10^{-1}	-(cocci)	-(cocci)	+(bacillus)
	10^{-2}	-(rods)	-(rods)	-(cocci)
	10^{-3}	-(cocci)	-(rods)	-(cocci)
Sapota	10^{-1}	-(rods)	+(bacillus)	+(bacillus)
	10^{-2}	+(bacillus)	+(bacillus)	+(bacillus)
	10^{-3}	+(bacillus)	+(bacillus)	+(bacillus)

C. Phytochemical screening:

Preliminary phytochemical screening of the extracts of prepared formulation. Revealed the presence of saponins, Alkaloids, Flavonoids, glycosides and Tannins as shown in Table below.

Table 3 Photochemical analysis

Test	Observations	Inference
Tannins	Formation of gelatinous precipitate	Present
Alkaloids	Orange red precipitate	Present
Flavonoids	Brown color appearance	present
Terpenoids	Reddish brown color precipitate	present
Phenols	Black color precipitate	present
Quinones	yellow precipitate	Present
Glycosides	Brownish ring formation	Present
Saponins	Emulsion formation	Present

D. Evaluation of antimicrobial property:

The efficacy of the formulation was observed by comparing the microbiological contamination of the samples before and after its disinfection, expressed as total colony count. Collected samples are treated with three different treatments (Formulation 1, formulation 2, and formulation 3) for 2 mins. Fig.1 shows that the reduction observed in the number of colonies among the vegetables and fruits with different formulations. Maximum difference in colonies before and after disinfection was found when the fruits and vegetables were soaked in formulation for 2 mins.

Conclusion:

From the present study we demonstrate that, out of four formulations prepared (from method l and method 2), formulation four was found to be more effective in terms of both antimicrobial activity and economic feasibility Thus, formulation four prepared by method 2 can be considered as effective herbal cleanser for fruits and vegetables.

Our formulation is basically a combination of natural extracts, the components used in our formulation can remove surface contaminants from fruits and vegetables. Presently available fruits and vegetables cleansers are chemical based and are not cost effective. But our product is purely herbal based. Thus, we could claim that it is safe to use and it will not deplish any nutritional value of fruits and vegetables.

Acknowledgement:

We are thankful for the support extended by the Department of Biotechnology Basaveshwar Engineering college, Bagalkote to carry out the research work.

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21. Enhancement of Nutrients in Wheat *(Triticum aestivum)* Grass by Hydrophonic Technique

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ABSTRACT

Wheatgrass is an affordable and effective source of essential nutrients and medicinal benefits for a healthy, rejuvenated body. This research focused on two objectives. The first was to explore hydroponics, an innovative and highly successful soilless agricultural technology [17]. Wheatgrass is a nutritional powerhouse for humans. Hydroponically grown wheatgrass is ready for harvest in seven days, whereas conventionally grown wheatgrass takes 21 days to reach the same stage.[22]. Wheatgrass is grown hydroponically using nutrient water with an NPK ratio of 19:19:19 [2]. Wheatgrass is grown hydroponically using nutrient water with an NPK ratio of 19:19:19. A comparative study shows that hydroponically grown wheatgrass has 113.36% nutrients, compared to 109.2% for soil-grown wheatgrass. This makes the nutrient content of hydroponically grown wheatgrass 4.16% higher than that of soil-grown wheatgrass.[18]. Therefore, nutrient water provides a higher percentage of essential nutrients needed for wheatgrass growth compared to soil [3].

KEYWORDS:

Wheat grass, Nutrient water, N P K 19:19:19, Hydroponic.

I. INTRODUCTION

A. About wheat grass: Wheatgrass, the young shoots of the wheat plant (Triticumaestivum), is consumed fresh or as a powdered supplement for its nutritional benefits. Rich in chlorophyll, amino acids, minerals, vitamins, and enzymes, it belongs to the Gramineae family. Despite being considered a simple weed, wheatgrass offers significant health benefits [1]. Wheatgrass, derived from the cotyledons of Triticum aestivum, is considered a nutrient-rich superfood with benefits unmatched by other foods. Historically used to address various health issues, it is now widely available in India through home delivery services. People use it as a health tonic for conditions like fatigue, anemia, asthma, eczema, hemorrhoids, skin problems, bad breath, body odour, and constipation [4].

B. Nutrients in wheat grass: Selenium and laetrile in wheatgrass have anti-cancer effects. Selenium strengthens the immune system and might reduce cancer risk [6]. Wheatgrass is rich in at least 13 vitamins, including B12 and abscisic acid, and contains beneficial compounds like superoxide dismutase (SOD) and cytochrome oxidase. Common wheat (Triticum aestivum) offers antimutagenic and antioxidant benefits through redox enzymes such as catalase and peroxidase, along with antioxidant substances like phenolic acids and alkyresorcinols. It is also a valuable source of essential minerals [2]. Wheatgrass is rich in iron, phosphorus, magnesium, manganese, copper, and zinc, and provides a high concentration of vitamin E through tocopherols. It is packed with chlorophyll, essential minerals like magnesium, selenium, zinc, and chromium, and antioxidants such as beta-carotene, vitamin E, and vitamin C.

Additionally, it includes anti-anaemic nutrients like vitamin B12, iron, folic acid, and pyridoxine, along with various minerals, amino acids, and enzymes, enhancing its nutritional and medicinal value [3]. The NPK fertilizer, which includes Nitrogen, Phosphorus, and Potassium, is mixed with water to dissolve its salts. This complex fertilizer supports leaf growth (Nitrogen), fruit and flower production as well as root development (Phosphorus), and overall plant health (Potassium). The mixture is filtered to prepare the organic nutrient solution, and heat treatment at 20-22°C helps keep the root zone pathogen-free [23]. NPK represents nitrogen, phosphorus, and potassium, key nutrients for plant growth. Maintaining the right NPK ratio ensures plants get the nutrients they need [22]. When buying fertilizers, each brand lists its NPK ratio, showing the percentages of nitrogen, phosphorus, and potassium. Different ratios can greatly impact hydroponic success. For example, a 7:9:5 NPK means seven percent nitrogen, nine percent phosphorus, and five percent potassium. Fertilizers can contain up to twenty nutrients, so a nine percent phosphorus content is noteworthy [31].

C. Medicinal uses of wheat grass juice: Wheatgrass juice provides various health benefits, including aiding digestion, treating anemia, purifying the blood, and enhancing immunity. Safe for oral consumption or as a colon implant, it is rich in chlorophyll, which has antibacterial properties and rejuvenates the bloodstream. Studies indicate that chlorophyll is non-toxic to animals [5]. Chlorophyll in wheatgrass juice acts as a potent antioxidant and may help prevent cancer. Although its anti-cancer effects are not fully understood, wheatgrass juice supports energy levels by addressing nutritional deficiencies and clearing waste from cells, blood, and organs. It also aids in blood purification, liver detoxification, and colon cleansing, thanks to its high content of vitamins A, B, C, E, K, calcium, potassium, iron, magnesium, sodium, sulfur, and 17 amino acids [9]. Wheatgrass juice is rich in vitamins A, C, E, and B complex, and contains various minerals such as calcium, phosphorus, magnesium, potassium, zinc, boron, and molybdenum [7].

D. Nutritional benefits of wheat grass: Wheatgrass, the young shoots of the wheat plant, is a cost-effective source of essential nutrients and medicinal benefits. In Asia and Europe, it is consumed in juices, powders, and extracts to enhance health [10]. Fifteen pounds of wheatgrass are nutritionally equivalent to 350 pounds of standard vegetables, thanks to its amino acids, vitamins, minerals, chlorophyll, and enzymes. Limited studies suggest wheatgrass extracts can prevent DNA damage and reduce harmful superoxide radicals. Although wheatgrass is available as supplements and medicines, its use remains limited and mainly among those with health issues [17].

Strict growing conditions, low sensory appeal, and poor shelf-life limit wheatgrass's popularity. In India, expensive wheatgrass drinks are sold at few outlets. This research seeks to address these issues and boost wheatgrass juice acceptance [12].

Fresh wheatgrass juice, rich in chlorophyll, enzymes, vitamins, and nutrients, is gaining recognition in India, though its benefits have been known in the West for years. Modern science views herbs as sources of new bioactive compounds. The wheat plant, originating from southwest Asia and the Mediterranean, has a compressed stem and narrow leaves in its early growth stages and is now widely cultivated, with 15-20 recognized species [11].

Wheatgrass contains 70% chlorophyll, similar to haemoglobin but with magnesium instead of iron. It enhances metabolism, restores blood alkalinity, and reduces acidity with its alkaline minerals. Additionally, it detoxifies and supports healthy cell restoration [14].

Wheatgrass, the young shoots of wheat, is consumed fresh or as dried powder by humans and animals. It offers chlorophyll, 17 amino acids (including 8 essential ones), minerals, vitamins, and enzymes. Wheatgrass juice (WGJ), made from mature sprouts, is well-documented in scientific studies [15].

Wheatgrass extracts are clinically effective in treating anaemia, thalassemia major, cancer, and bacterial infections. Often called "green blood" for its 70% chlorophyll content, it contains therapeutic enzymes like protease, amylase, lipase, cytochrome oxidase, transhydrogenase, and superoxide dismutase (SOD), as well as amino acids such as aspartic acid, glutamic acid, arginine, alanine, and serine [17].

D. Hydroponic Technique: Hydroponics, a soil-free growing method, could play a key role in future food production. It optimizes space use, is cost-effective, and environmentally friendly, allowing for larger yields in limited spaces [16]. Hydroponics enables indoor gardening with full control over temperature, humidity, nutrition, and climate. With enthusiasm and basic gardening skills, anyone can build a successful hydroponic farm. As land becomes scarce, hydroponics provides a sustainable solution for growing food without relying on dwindling land resources [20].

II. Materials and methods:

A. Preparation of Nutrient water:

During the vegetative stage, a 7:9:5 NPK ratio is ideal, promoting dark green leaves and abundant foliage. These fertilizers are known as grow fertilizers [32]. The increased nitrogen in this NPK ratio enhances the vegetative stage and overall plant growth. Hydroponic solutions or fertilizers labeled "vegetative" or "grow" are perfect for accelerating healthy maturation until harvest [30].

This fertilizer contains a minimum of 19.00% total nitrogen, with nitrate nitrogen not exceeding 4.00%. It includes at least 4.50% ammoniacal nitrogen and a minimum of 10.50% urea nitrogen. Additionally, it provides at least 19.00% water-soluble phosphates (as P2O5). The product is available in a 1-kilogram packaging size.

B. Growing Wheat grass in Nutrient water:

NPK 19:19:19 fertilizer is water-soluble and provides all essential nutrients, making it suitable for hydroponics. It supports optimal plant functions by ensuring adequate calcium and phosphorus. To plan an effective fertilizer program, consider crop nutritional needs, soil type, water quality, environmental conditions, and irrigation system type [35]. A hydroponic nutrient solution is a water-based mixture of inorganic ions from soluble salts, providing essential elements for higher plants [21].

NPK 19:19:19 fertilizer is essential for early vegetative growth and later seed and flower formation. It supplies the critical nutrients nitrogen (N), phosphorus (P), and potassium (K). If plants appear pale, increase the NPK 19:19:19 dosage, especially during the flowering stage. Our tested, premium imported NPK 19:19:19 fertilizer is water-soluble and optimized for plant growth [22]. Growing wheat grass by hydroponic method. The wheat seeds were washed to clean the dust then soaked for about 12 hours to develop sprouts figure 1.

Fig:1 Soak wheat grains in water for 8-12 hours.

The soaked seeds are tied in a muslin cloth for the development of sprouts overnight figure 2.

Fig:2 Seeds are allowed to sprout overnight

The sprouted seeds of wheat are ready for the spread on the turkey cloth which is used as a media for the nutrient holding figure 3

Fig:3 Sprouted wheat seeds

The sprouted wheat seeds are spread in the tray containing the nutrients

Fig;4 Transfer sprouted seeds to a tray with nutrient water.

The seeds develop into 7 to 10 cm grass over a period of 10 t0 14 days which will be a proper time to harvest the grass which contains all the nutrients

Fig:5 Wheatgrass grows to 7-10 cm in length after 10-14 days in nutrient water.

C. Comparison of nutrients in wheatgrass grown hydroponically versus in soil:

1. ESTIMATION OF PROTIEN BY LOWRY'S METHOD:

Principle: The Lowry method measures protein concentration by reacting peptide nitrogen with copper ions in an alkaline environment, reducing Folin-Ciocalteu reagent to heteropolymolybdenum blue. It requires a pH of 10-10.5 and works for protein concentrations between 0.10 - 2 mg/ml and 0.005 - 0.10 mg/ml. The method's narrow pH range can be a limitation, but small sample volumes minimize this issue. Substances like amino acid derivatives, buffers, drugs, lipids, sugars, salts, nucleic acids, and sulfhydryl reagents can interfere and should be removed or diluted beforehand.

Procedure: 0.2 ml of BSA working standard in 5 test tubes and makeupto1ml using distil edwater.The test tube with 1 ml distilled water serve as blank. Add 4.5 ml of Reagent I (2% Na2CO3 in 0.1 N NaOH,1% NaK Tartrate in H2O,0.5% CuSO4.5 H2O) in H2O and incubate for 10minutes. After incubation add 0.5 ml of reagent I and incubate for 30 minutes Measure the absorbance at 660 nm and plot the standard graph. Estimate the amount of protein present in the given sample from the standard graph.

2. ESTIMATION OF IRON BY WONG'S METHOD:

PRINCIPLE:

Ferric ions react with potassium thiocyanate to produce a red color, with intensity proportional to the iron concentration. The red color is measured at 540 nm.

PROCEDURE:

Pipette 1-5 ml of $FeCl_3.6H_2O$ standard solution into test tubes and dilute to 5 ml with distilled water. Add 1 ml of 30% sulfuric acid to each tube to make a total volume of 6 ml, then add 1 ml of potassium persulphate solution and 1.5 ml of potassium thiocyanate solution. Incubate for 20 minutes at room temperature and measure the intensity at 540 nm against the blank. For the blank, add 5 ml distilled water, 1 ml of 30% sulfuric acid, 1 ml of potassium persulphate, and 1.5 ml of potassium thiocyanate to a test tube, and incubate for 20 minutes at room temperature.

BLANK:

Prepare the blank by adding 5 ml distilled water to a test tube. Add 1 ml of 30% H_2SO_4, 1 ml of potassium persulphate, and 1.5 ml of potassium thiocyanate. Incubate for 20 minutes at room temperature. This serves as the blank.

TEST:

Add 1 ml of the test solution to a test tube and dilute with 4 ml of distilled water. Then, add 1 ml of 30% sulfuric acid, 1 ml of potassium persulfate, and 1.5 ml of potassium thiocyanate. Incubate at room temperature for 20 minutes. Measure the intensity at 540 nm against the blank.

III. RESULT AND DISCUSSION:

Nutrients support plant growth, reproduction, and health, similar to their role in people and animals. Plants have specific nutrient needs based on their age and development, which are the same for both hydroponic and soil growth. The main difference is in nutrient delivery and the energy plants use to absorb them [1].

Macronutrients are essential elements that plants need in large quantities, including magnesium, sulfur, oxygen, phosphorus, carbon, hydrogen, potassium, calcium, and nitrogen.

Each plays a crucial role in plant health and must be evaluated individually for its impact when applied to soil or dissolved in water. For instance, nitrogen can be washed away by heavy rain, especially when applied as a surface dressing on slopes [2]. Phosphorus binds to the soil and stays in place, but plants can't use it unless it's mixed into the soil. In hydroponic solutions, both phosphorus and nitrogen are fully accessible to plants [7].

Micronutrients, needed by plants in very small amounts, include cobalt, iron, chlorine, zinc, molybdenum, manganese, boron, and copper. They support growth and development, and deficiencies can cause symptoms like poor development, yellowing leaves, leaf drop, or stunted growth.

These elements must be present in trace amounts in soil or hydroponic solutions to ensure plant health. The result suggests that the plants grown by the hydrophonic method showed much healthier grass

Soil nutrients is challenging and typically requires a professional analysis, which determines the nutrient levels and provides fertilizer recommendations. For instance, if soil lacks copper or calcium, these must be added for optimal plant growth.

However, it's hard to confirm if the balance is right without further testing. Soil testing is often done only when plants show poor growth, which may be due to high or low pH or salt buildup rather than nutrient deficiencies. To address such issues, growers might need to adjust pH or add amendments through tilling.

In **hydroponics**, the nutrient balance is managed by the gardener, who regularly monitors the system. Since plants get all their nutrition from the added nutrient solution, any imbalances can be corrected by replacing the nutrient solution with a freshly balanced formula, addressing pH and salt levels.

Problems can arise with insoluble nutrients or improperly balanced solutions. As plants absorb nutrients daily, the balance shifts and needs frequent monitoring. If the nutrient balance is off, plants can quickly become sick and die if not corrected. The imbalance of nutrients are managed by the nutrients at smaller quantities in hydrophonic technique.

ESTIMATION OF PROTIEN BY LOWRY'S METHOD:

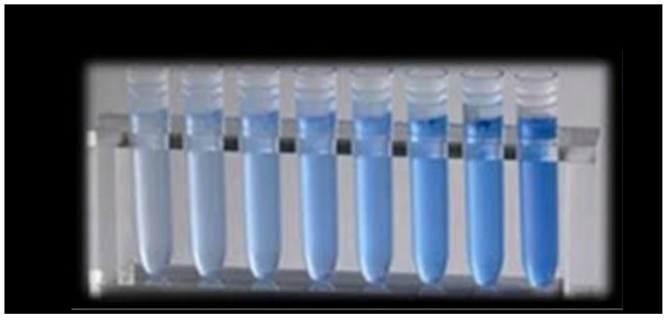

Fig: 6 Protein estimation by Lowry's method

Table 1: Comparison of protein between soil grown and nutrient water grown grass

NUTRIENTS AND MINERALS	CONTENTS OF WHEAT GROWN IN SOIL	CONTENTS OF WHEAT GRASS GROWN IN NUTRIENT WATER
PROTEIN	31.0%	33.36%

ESTIMATION OF IRON BY WONG'S METHOD:

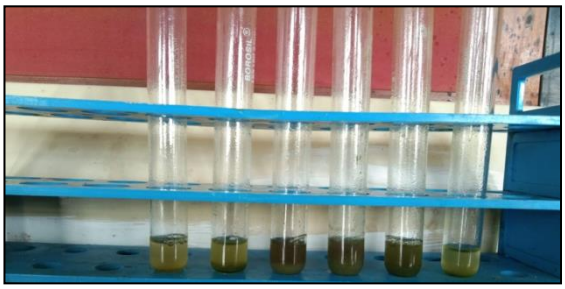

Fig: 7 Test tubes showing the presence of iron

Table 2: Comparison of iron between soil grown and nutrient water grown grass

NUTRIENTS AND MINERALS	CONTENTS OF WHEAT GROWN IN SOIL	CONTENTS OF WHEAT GRASS GROWN IN NUTRIENT WATER
IRON(Fe)	78.21mg	80.0mg

IV. CONCLUSION:

NPK 19:19:19 fertilizer is water-soluble and provides essential nutrients, including calcium and phosphorus, for plant health, making it suitable for hydroponic systems.

Effective fertilizer planning requires knowledge of crop needs, soil type, water quality, and environmental conditions.

Hydroponic wheatgrass cultivation offers a sustainable alternative to soil growing, requiring attention to macronutrients like nitrogen, potassium, and phosphorus. Coco coir is often sufficient but low in nitrogen and phosphorus, so adding coffee grounds and micronutrients like liquid kelp can enhance growth.

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22. Green Synthesis of Copper Nanoparticles Using *Ficus Carica*

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ABSTRACT

Nanotechnology has opened up novel dimensions, engineered for various applications in the field of biotechnology and medicine specifically for the drug delivery. Green synthesis of copper nanoparticles (CuNPs) is cost effective and non-toxic over synthetic methods which is estimated to be rich with bioactive components. Copper nanoparticles exhibit catalytic activity and antimicrobial activity. CuNPs are synthesized and optimized from Ficus carica leaf dried under microwave, distilled water was added to the crushed powder and kept for incubation and extract was filtered to get the CuNPs. The synthesized nanoparticles were characterized under ultraviolet-visible spectrometer and scanning electron microscope. the screening of nanoparticles resulted in thestrong antimicrobial activity which has abundant application in biomedical and also defined the presence of phytochemicals.

KEYWORDS:

Green synthesis, antimicrobial, phytochemicals, scanning electronic microscope

INTRODUCTION

Nanotechnology is a scientific discipline that deals with the production of matter at the nanoscale, typically ranging from 1 to 100 nanometers. nanomaterials exhibit uniqueproperties that differ from their macroscale counterparts. Nanotechnology finds applications in various fields such as materials science, electronics, medicine, energy production, and environmental science. It offers solutions to challenges in areas like drug delivery, water purification and electronics miniaturization.in the production of CuNPs Plant extract are involved in redox reactions, which reduce metal ions to form nanoparticles. Metabolites such as sugar, terpenoids, polyphenols, alkaloids and proteins play essential role in reduction of metal ions to nanoparticles [2]. The leaf extract of medicinal plants serveas reducing agent as well as capping agent in the process of synthesis of nanoparticles which are ecofriendly green nanoparticles (GNPs) can be characterizedby various

techniques, such as X-ray diffraction (XRD), Fourier transform infrared spectrum analysis (FT-IR), UV-visible absorption spectrum, scanning electron microscope (SEM), transmission electron microscope (TEM) and atomic force microscopy (AFM) [14].

The synthesis of nanoparticles using plant extracts having antimicrobial properties the process is termed as green synthesis. In this study, the aim is to synthesize and optimize the copper nanoparticles of Ficus carica leaf extract.[1]

MATERIALS AND METHODS:

Preparation of leaf extract:

Ten grams of leaves of *Ficus carica* were washed, dried and crushed finely using pestle mortar. The 10g powdered leaves were weighed and 100ml of distilled water was added and kept at room for 1hour and extract was filtered to obtain phytochemicals for the reaction.

Phytochemical Analysis:

Phytochemicals in *Ficus carica* are as follows phytosterols, anthocyanins, amino acids, organic acid, fatty acids, phenolic components, hydrocarbons, aliphatic alcohols, volatile components, and few other classes of secondary metabolites.[8]The phytoconstituents of *Ficus carica* has remarkable pharmacological properties such as antioxidant, anticancer, cytotoxic, anti-inflammatory, and hypolipidemic activities [9].

Test for Phenolic Compound:

Two to three drops of 1% solution was added into 1mL sample. Phenolic compounds produce a deep violet black precipitate with ferric ions. Formation black precipitation indicates the presence of Phenols. [10,11]

Test for Flavonoid Compound:

One mL of sample was dissolved in methanol by heating. Then metal magnesium and 5-6 drops of concentrated HCL is added. The solution turn intoRed colour indicates the presence of Flavonoids. [10,11]

Test for Anthocyanins:

20mL extract + 2ml 2NHCl + small amount of ammonia. Pink Red solution turns violet - blueafter ammonia addition indicates the presence of Anthocyanin [12].

Synthesis of Copper Nanoparticles:

Preparation of 1 mm copper sulphate (CuSO4) solution:

To prepare 1 mm of CuSO4 solution, 15.96mg of CuSO4 is added to 100ml distilled water.

Synthesis of Copper Nanoparticles:

Freshly prepared leaf extract of 1ml is added to 10 ml of CuSO4 [13]. Mix the composition thoroughly and keep for incubation in a dark room for 24 hours at room temperature and the color change is observed as in Fig:1.

Fig 1: Change in colour shows nano particle synthesized

Results:

Analysis of Copper Nanoparticles:

UV-Visible Spectrophotometry:

The reduction of CuSO4 to CuNPs using aqueous leaf extract was observed by measuring the UV-visibleSpectrum of the resultant mixture. The measurements are recorded on CORBET UV-Visible spectrophotometer. In studies it has been mention that the absorption peak of copper nanoparticles ranges from 300nm to 800nm. However, in our work the peak was observed at 517nm as seen in the Fig: 2.

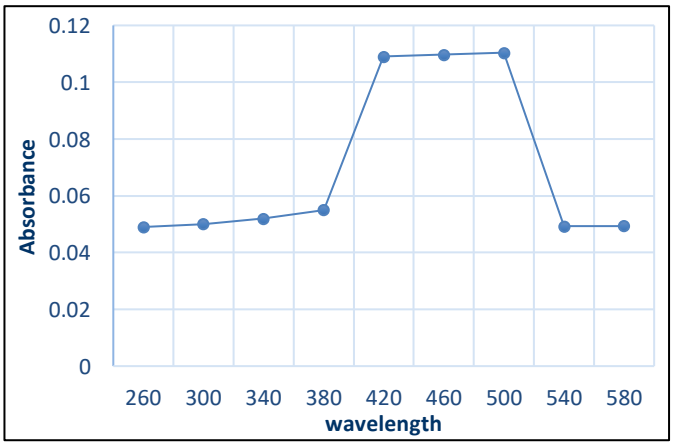
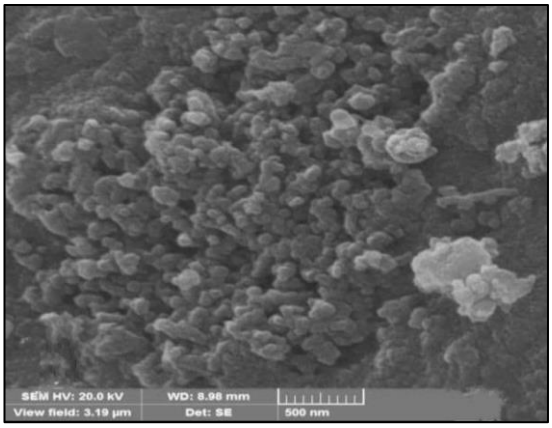


Fig:2 The peak was observed at 517nm in UV-Visible spectrophotometer.

SEM:

Collect the CuNPs and wash them to remove impurities. Dry the CuNPs to obtain a fine powder. Place the CuNPs on the carbon coated copper grid. Insert the sample into the SEM chamber which is operated at 20kv. Capture SEM micrographs at different magnifications to study the surface morphology and size of the CuNPs. The size of nano particles is observed at range of 100-500 nm as in Fig: 3.



Efficacy of CuNPs against antimicrobial activity:

Synthesized CuNPs were analyzed for their antimicrobial activity against E. coli disk on the plate as shown in the Fig. 4. When 1mg/ml of CuNPs is used it showed zone of inhibition. It was observed that the growth of E. coli was directly proportional to the concentration of CuNPs and compared to reference drug (pencilin G). The zone of inhibition range was 5mm for 30microliter, 12mm for 60microliter and 18mm for 90microliter. These results indicated that the CuNPs synthesized have strong antibacterial effect compared to reference drug.

Fig: 4 zone of inhibition shows the antimicrobial activity of CuNPs

Conclusion:

Green synthesis of copper nano particles is a cost effective and non-toxic method to synthesis nano particles which has a wide application. UV visible Spectrophotometry and SEM confirms the synthesis Of CuNPs.

The copper nanoparticles have antimicrobial activity due to the presence of antioxidants in Ficus carica leaves against E. coli.

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23. Antimicrobial Analysis for Fabrics

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ABSTRACT

Antimicrobial textiles are fabrics designed to either kill microorganisms or prevent their growth. Antimicrobial textiles find applications across a wide range of areas, including household items, commercial products, air filters, food packaging, healthcare, hygiene, medical, sportswear, storage, ventilation, and water purification systems. There has been a growing public awareness and commercial interest in antimicrobial textiles in recent years. These textiles are generally made by incorporating antimicrobial agents into the textile fibers or applying them to the fiber surfaces. Antibiotics such as triclosan or silver-based compounds are applied to textiles to inhibit microbial growth, reducing odor and potential infections.

These treatments are often used in medical uniforms, hospital linens, and sportswear. It is crucial that any antimicrobial treatment used in textiles is effective against microorganisms while also being safe for both consumers and the environment. Here the antimicrobial testing was done using different techniques with the six different textile samples. Although some cloth samples exhibited minimal antimicrobial activity with E. coli and tetracycline is used as reference to check the activity. Notably, cloth samples 4A, 4B, 4C, 6A, 23 PLKBT 2%, and 10KBBTR showed a significant 2mm to 4 mm inhibition zone. Clothes of 4mm inhibition are more effective as good antimicrobial property As the use of antimicrobial textiles increases, there is a pressing need to develop regulations and international testing standards to ensure safety.

KEYWORDS:

MHA- Muller Hington Agar, PCA- plate Count Agar,

I. Introduction:

Functional fabrics with antimicrobial properties are increasingly important in the textile industry due to their ability to combat microbial growth, which can cause odor, infections, and fabric deterioration. Legal guidelines and regulations for antimicrobial agents are crucial to address these issues.

Standard methods for evaluating antimicrobial effectiveness include both qualitative and quantitative approaches. Qualitative methods, like the JIS L 1902:2008 Halo method, are simple and quick, involving placing textile samples on nutrient agar plates with bacteria to observe activity.

The AATCC 147 method places samples on pre-inoculated nutrient agar, while the ISO 20645 method uses layered agar plates. These methods assess bacterial activity by observing halos, indicating areas where bacteria cannot grow.

Despite various standards, no comprehensive studies compare their effectiveness. Historically, treatments like antimony salts and copper, though effective, caused stiffness and odor. Following Rachel Carson's "Silent Spring" (1962), the focus shifted to safer, eco-friendly antimicrobial compounds.

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Following Rachel Carson's "Silent Spring" (1962), the focus shifted to safer, eco-friendly antimicrobial compounds.

Methodology:

A. Media preparation:

Preparation of Muller Hington Agar (MHA) media Dissolve 38g of dehydrated MHA media in 1 liter of distilled water. Shake and heat to dissolve completely Close the lid of the flask with cotton plugs to avoid contamination Autoclave the media at 121°C temperature and 15 lbs pressure for Allow to cool the media and add the media into Petri plates under the laminar air flow and solidify.

Lastly check for the contamination before use. Lastly check for the contamination before use.

Fig.1Muller Hinton agar media preparation

B. Bacterial sub-culture:

The E. coli bacterial sub culture is used against the cloth samples. Take an agar plate with E. coli bacteria and with the help of inoculation loop take a loop full of smear and mix with the nutrient broth in laminar air flow Put a cotton plug on the lid of the inoculated flask media. Keep the flask of broth containing E. coli in incubator for 24 hours at 37°C.

C. Inoculation of culture plates:

Methods used:

1. Pour plate technique.
2. Spread plate technique.
3. Streak plate technique.

Pour plate Technique:

1)To perform the pour plate technique, begin by preparing the materials: an antimicrobial cloth sample, a tetracycline disc, and plate count agar (PCA) or nutrient agar. First, sterilize the neck of the agar bottle by passing it through a flame, then carefully pour the melted agar into a sterile Petri dish while slightly lifting the lid. After pouring, close the lid and flame the bottle neck again before reattaching the cap. Gently swirl the Petri dish on the bench to distribute the agar evenly and allow it to solidify undisturbed for about 10 minutes. Place the cloth sample and the tetracycline disc on the solidified agar, ensuring proper placement. Cover the plate and incubate it upside down at 37°C for 24 to 48 hours to observe the antimicrobial effects.

2)To perform the spread plate technique, begin with serial dilution. Prepare six sterile test tubes, each with 9 mL of distilled water. Using a sterile pipette, add 1 mL of the sample to the first tube and label it as 10^-1. Mix the contents thoroughly by swirling the tube. Transfer 1 mL from the first tube to the second tube, labelling it as 10^-2, and repeat this process for the remaining tubes, sequentially labelling up to 10^-6. For plating, melt Plate Count Agar (PCA) or Nutrient Agar in a hot water bath at 45°C. Pour the agar into sterile Petri dishes and allow it to solidify. Then, use a sterile pipette to transfer 0.1 mL from each dilution tube onto separate agar plates. Spread the sample evenly using an L-shaped glass rod. Incubate the plates at 37°C for 24 to 48 hours and observe the microbial growth.

3)Streak Plate *Technique*:To perform the spread plate technique, start by preparing all materials and ensuring sterility. Heat the water bath to 45°C and have sterile Petri dishes ready. Using a sterile pipette, transfer a small amount of the test sample onto the surface of a Plate Count Agar (PCA) or nutrient agar plate. Flame the inoculating loop or streaking tool to ensure sterility, then gently streak the sample across the agar in a pattern to spread it evenly. Incubate the plate inverted at 37°C for 24 to 48 hours. After incubation, use a colony counter and magnifying glass to inspect and count the colonies that have developed. This method helps in quantifying microbial growth and assessing the effectiveness of antimicrobial agents.

III. Result and Discussion:

Examine the inhibition zones around the antibiotic and the samples. The sample produced a very small inhibition zone, whereas the antibiotic disk produced a significantly larger one. Cloth samples such as 4A, 4B, 4C, 6A, 23PLKBT2%, and 10KBBTR demonstrated notable antimicrobial properties against E. coli, showing no bacterial growth on these samples.

Plate technique result:

In the pour plate technique, some cloth samples exhibited notable antimicrobial properties, evidenced by a 6 mm zone of inhibition around the samples. In the pour plate technique, some cloth samples displayed antimicrobial properties, with a 6 mm inhibition zone around them. However, other cloth samples showed no antimicrobial effect, allowing E. coli to grow on and around them. Regular cloth allowed E. coli to spread completely across the sample. The tetracycline disc demonstrated the highest level of E. coli inhibition compared to the other samples.The results are indicated in the Figures 2,3,4.

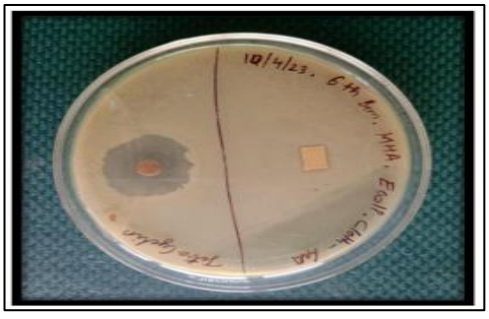

Fig. 2 Cloth sample – 4A

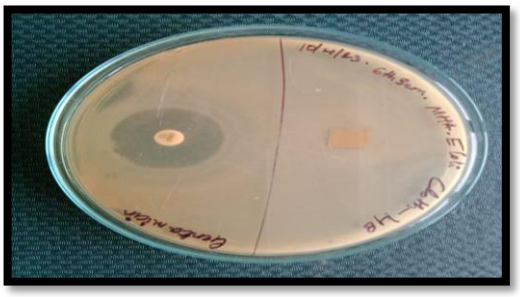

Fig. 3 Cloth sample -4B

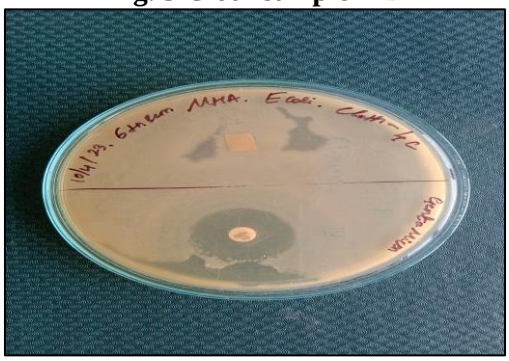

Fig. 4 Cloth sample 4C

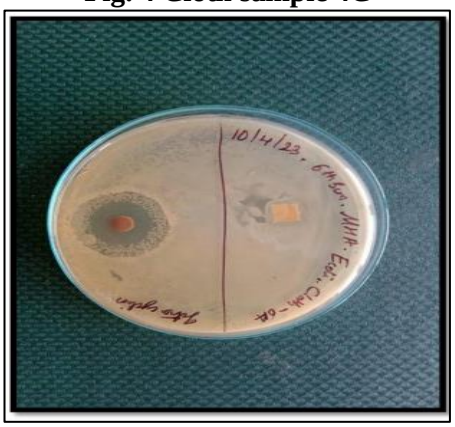

Fig. 6 Cloth sample 6A

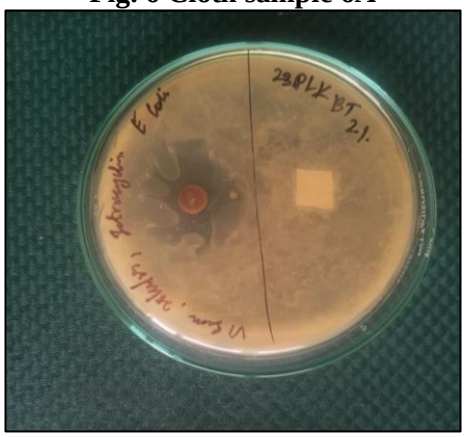

Fig. 7 Cloth sample-23PLKB2%

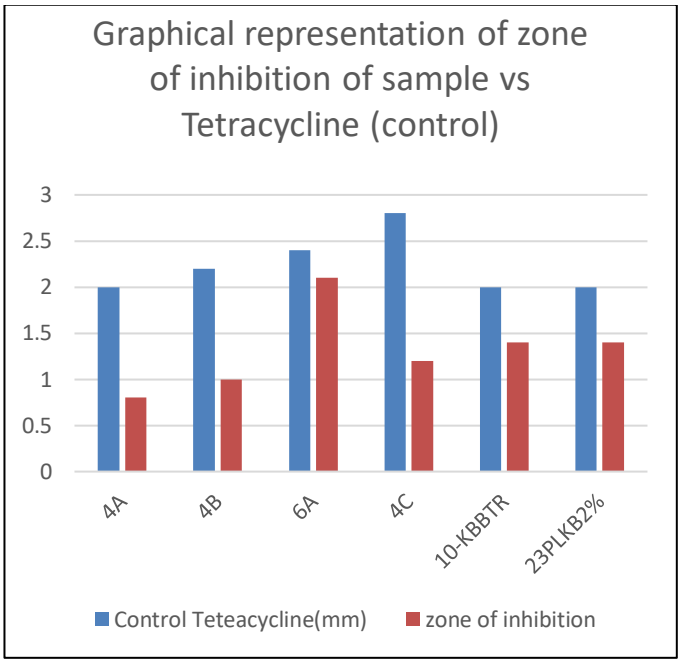

Fig.8: Graphical representation of zone of inhibition of sample vs Tetracycline (control)

Table 1: Zone of inhibition of sample and control (Tetracycline).

Sample	Control Tetracycline(mm)	zone of inhibition(mm)
4A	2	0.8
4B	2.2	1.6
6A	2.4	2.1
4C	2.8	1.2
10-KBBTR	2	1.4
23PLKB2%	2	1.4

The above table 1 and Figure 8 indicates zone of inhibition of different types of cloth samples named as 4A,4B,4c,10-KBBTR,6A, 23PLKB2%. The zone of the inhibition was compared with tetracycline a standard antibiotic and the results indicates that all the 6 samples show some amount of inhibition while 6A sample shows the maximum amount of inhibition which indicates this cloth is having good antimicrobial property and can be used to control microorganisms.

Conclusion:

The study aimed to assess the range of antimicrobial inhibition against E. coli. Results indicated that the inhibition zones created by the cloth samples were smaller compared to those created by tetracycline.

Although some cloth samples exhibited minimal antimicrobial activity, tetracycline demonstrated high effectiveness. Notably, cloth samples 4A, 4B, 4C, 6A, 23PLKBT2%, and 10KBBTR showed a significant 2 mm inhibition zone. These results suggest that these cloth samples have potential antimicrobial properties suitable for applications in the food and medical industries.

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24. Statistical Optimization of Immobilization Process to Enhance the Lipase Activity

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ABSTRACT

Biodiesel produced through the enzymatic process, plays a crucial role in reducing carbon emissions and dependence on fossil fuels. This sustainable alternative promotes cleaner air quality, supports renewable energy sources, and contributes to a more environmentally friendly future. Immobilized enzymes were used as catalyst. To enhance the activity of lipase, optimization of immobilization plays crucial role. Optimization studies was performed by statistical methods such as RSM (Box-Behnken design). The variables considered for optimization are sodium alginate concentration (1-5%), calcium chloride concentration(50-250mM), and ratio of Sodium Alginate to Lipase (1:1-1:5). The results of the optimization revealed that the greater lipase activity was gained with a more level of sodium alginate (5%), a low concentration of calcium chloride(50mM), and ratio of sodium alginate to lipase(1:3). The implementation of the Box-Behnken design enabled the identification of the optimal conditions to maximize lipase activity. The project's outcomes demonstrated a significant improvement in lipase activity, with an increase from 6.5 U/ml to 9.8 U/ml. Moreover, the efficiency of immobilization was substantially enhanced, rising from 52% to 82%. These findings underscore the remarkable increase in immobilization efficiency which are crucial factors in enhancing biodiesel production attained through the statistical optimization of immobilization process. Further the produced immobilized lipase was used for biodiesel production and it was observed that the conversion efficiency was enhanced.

KEYWORDS:

Immobilization, lipase, optimization, RSM.

I. INTRODUCTION

Bio-diesel, a renewable and environmentally friendly alternative to conventional fossil fuels, has gained significant attention in recent years. Vegetable oils, animal fats, and algae, bio- diesel offers a promising solution to reduce greenhouse gas emissions and mitigate climate change impacts.

The Intergovernmental Panel on Climate Change (IPCC) states that the burning of fossil fuels contributes to approximately 75% of total greenhouse gas emissions (IPCC, 2021). In contrast, bio-diesel is considered a carbon-neutral fuel, as the CO2 released is offset by the CO2 absorbed during its production. [1].

Additionally, bio-diesel exhibits favorable properties such as high lubricity, low sulphur content, and reduced particulate matter emissions compared to conventional diesel [2]. This makes it an attractive option for improving air quality and reducing health risks associated with diesel exhaust emissions [3].

Moreover, bio-diesel production offers economic advantages by reducing dependence on imported fossil fuels and creating opportunities in the agricultural sector [4].

Biodiesel produced via enzymatic and chemical methods. Enzymatic method advantages over traditional chemical transesterification processes. Enzymatic transesterification is a bioconversion process that involves the use of enzymes to catalyze the conversion of triglycerides into biodiesel through the exchange of ester groups.

Firstly, enzymatic transesterification performed at lower temperatures and pressures, which reduces energy consumption and operational costs [5].

Secondly, enzymes are highly specific catalysts, enabling high conversion rates and selectivity, resulting in a higher yield of biodiesel with less production of unwanted byproducts [6]. Lastly, enzymatic transesterification utilizes renewable resources and produces lower levels of pollutants, making it an environmentally friendly and sustainable option for biodiesel production [7].

Lipase is a potential enzyme for biodiesel production due to its ability to catalyze the transesterification reaction efficiently. Lipases are produced by various organisms, including bacteria, fungi, and plants, making them widely available for industrial applications. These enzymes exhibit high specificity and selectivity, enabling them to effectively convert triglycerides into biodiesel.

Additionally, microbial lipases from bacteria such as Pseudomonas, Bacillus, and Candida species have been extensively studied for their biodiesel production potential [8].

Enzyme immobilization is a technique employed in biocatalysis to enhance enzyme stability, reusability, and efficiency. It involves attaching or confining enzymes onto a solid support or matrix while retaining their catalytic activity. Immobilization is necessary to overcome limitations associated with free enzymes, such as enzyme deactivation, loss, and difficulty in recovery.

The choice of method depends on factors like enzyme stability, activity, reaction conditions, and application. For instance, covalent binding provides high stability and reusability, as shown in studies on lipase immobilization [9]. Encapsulation in alginate beads improves enzyme stability and reusability, demonstrated in research on α-amylase immobilization [10].

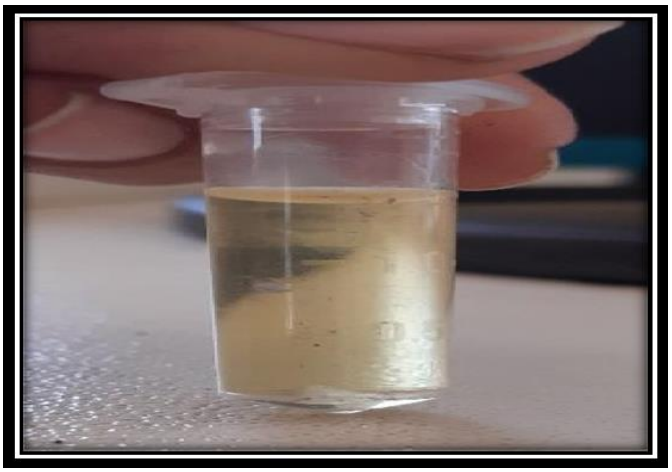

Fig. 1: Innoculated media

Statistical optimizing tools play a crucial role in biotechnology experiments by enabling researchers to optimize and fine-tune various parameters for improved process efficiency and yield. These tools, such as Design of Experiments (DOE) and Response Surface Methodology (RSM), provide systematic approaches for experimental design, data analysis, and optimization of complex bioprocesses [11]. This allows for efficient resource utilization, save time and cost, and improved process understanding. Additionally, statistical optimizing tools helps to know critical process parameters and their effects on product quality, leading to enhanced process control and reproducibility. Overall, these tools enable researchers to optimize bioprocesses, maximize productivity, and accelerate the development of biotechnological applications.

II. MATERIALS AND METHODOLOGY

A. Lipase production:

Lipase production was carried out by inoculating *Lysinibacillus macroides* FS1in production media [12]. Production media is prepared as per Table 1.

Table I: Production media

Sr. No.	Ingredients	Quantity(g/l)
1	Beef Extract	30
2	Galactose	30
3	Ammonium Chloride	30
4	CaSO4	0.1
5	KH2PO4	0.5
6	MgSO4	0.1
7	Honge Oil	10

Fig. 2: Crude lipase

The flasks were incubated at 37°C for 24-48hours with shaking speed of 120rpm [12]. After incubation crude lipase was extracted by centrifugation at 10000rpm at 4°C for 30min, as lipase is produced extracellularly, supernatant is considered as crude lipase source (Fig.2).

B. Lipase assay by titrimetric method: The lipase activity assay is carried by the titrimetric method using olive oil as the substrate. In flask mix 1ml of the supernatant, 2ml of phosphate buffer pH, and 1ml of olive oil. then incubated at 37°C for 60 minutes [13]. After the incubation period, 1ml of a solution consisting of acetone and ethanol in a 1:1 ratio is added to the reaction mixture to halt the reaction. The mixture is further titrated using 0.05M NaOH, with a few drops of phenolphthalein serving as an indicator, until the pH of the reaction mixture reaches 10.5. The quantity of NaOH taken during titration is recorded.

Lipase activity is calculated by using below Eq.1

Lipase Activity (U/ml) = Volume of alkali consumed x Strength of alkali x 1000/ (Volume of sample x Time in min) Eq.1

C. Partial Purification of Lipase: For the purification of the lipase, ammonium sulfate precipitation is employed within the range of 0-30%. The purification process involves the gradual addition of solid ammonium sulfate to 100ml of the supernatant while stirring constantly at 4°C. The complete dissolution of 3g of ammonium sulfate is carefully recorded, and the flask is then incubated at 4°C for 30 minutes followed by centrifugation at 10,000 rpm for 30 minutes at 4°C to collect partially purified lipase. Subsequently, the pellet is dissolved in 0.05M phosphate buffer with a pH of 7 then subjected to testing for lipase assay using the titrimetric method.

Fig.3: Partially purified crude lipase

D. Immobilization by Entrapment: In this study, entrapment method was applied. 4% sodium alginate was dissolved in 0.05 M Tris HCl buffer of pH 7 boiled for 5 minutes to ensure uniformity, and then allowed to cool. Alginate lipase mixture was prepared by adding equal proportions (1:1) of alginate and extracted lipase with stirring. Then this mixture slowly added to a cold solution of 200 mM CaCl2 using a 5ml syringe without a needle and preserved for 1 hour at 4°C for curing [14]

After the curing process, the beads, approximately 3mm in diameter as shown Fig. 4, beads were filtered using Whatman filter paper 1.

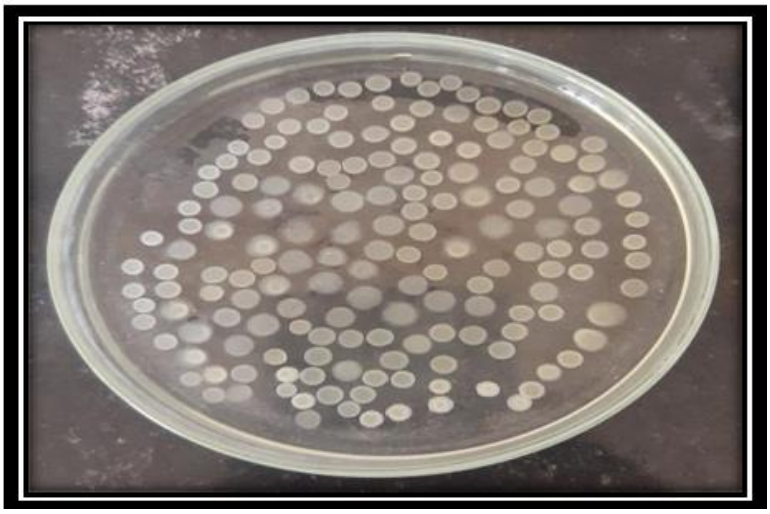

Fig. 4: Immobilized Beads

Determination of immobilization efficiency

The immobilization efficiency is a measure of lipase activity after immobilization. Immobilization efficiency is calculated using the below Eq.2.

Beads Activity (U/ml) = Volume of alkali consumed X Strength of alkali x 1000/(Volume of sample x Time in min)

Immobilization efficiency % = Activity of immobilized lipase/Activity of free lipase –Wash water activity×100 Eq.2

E. Optimisation of immobilization Statistical design:

Statistical optimization is used to optimize or improve various aspects of a system, process, or model. Response Surface Methodology (RSM): RSM builds upon DOE and uses mathematical models to describe the relationship between the input variables and the response variable. It aims to find the optimal combination of variables by fitting response surfaces and performing optimization based on these models. In this study, RSM is proves to be more advantageous compared to conventional methods as it reduces the number of experiments required, saving consumables, time, and labor. RSM is a novel and effective

statistical technique used to evaluate the relationships between independent variables and the response. Its objective is to identify the optimal process variables that result in the optimum response. By employing RSM, the optimized parameters for immobilization process can be determined, ensuring the highest possible efficiency [15].

Box Behnken Design

The Box-Behnken Design (BBD) is chosen as it is highly suitable for optimizing processes involving three variables. A three-level three-point design, known as the Box-Behnken design, is implemented, consisting of 15 trials.

The BBD design considers three factors with three levels each: low (-1), central (0), and high (+1). The factors considered are:

1. Concentration of Sodium Alginate
2. 2.Concentration of CaCl2
3. 3.Ratio of Sodium Alginate to Lipase

Table. 2: Process variables for BB design

Variables	Levels		
	Low	**Middle**	**High**
Concentration of sodium alginate	1%	3%	5%
Concentration of CaCl2	50mm	150mm	250mm
Ratio of Sodium Alginate to Lipase	1:1	1:3	1:5

The experimental design used in this study is the Box-Behnken Design (BBD), which includes 3 factors with 3 levels each. In total, there are 15 base runs along with three center points, one replicate, one block, resulting in a total of 15 runs. The first factor, concentration of sodium alginate, has a high value of 5%, a central value of 3%, and a low value of 1%. The second factor, concentration of CaCl2, has a high value of 250mM, a central value of 150mM, and a low value of 50mM. The third factor Ratio of Sodium Alginate to Lipase is represented by a high 1:5 ratio, a central value of 1:3 and a low value 1:1. According to the Box-Behnken layout, a total of 15 experimental setups are prepared, allowing for comprehensive exploration and optimization of the biodiesel production process.

Table. 3: Experimental layout Box-Behnken (BB) Design

Trial no.	Concentration of sodium alginate	Concentration of calcium chloride	Ratio of sodium alginate to lipase
T1	5	250	1:3
T2	3	150	1:3
T3	3	150	1:3
T4	3	250	1:1
T5	1	150	1:1

Trial no.	Concentration of sodium alginate	Concentration of calcium chloride	Ratio of sodium alginate to lipase
T6	1	150	1:5
T7	1	250	1:3
T8	3	150	1:3
T9	3	50	1:1
T10	3	50	1:5
T11	3	250	1:5
T12	5	150	1:1
T13	5	150	1:5
T14	5	50	1:3
T15	1	50	1:3

Fig. 5: Experimental set up

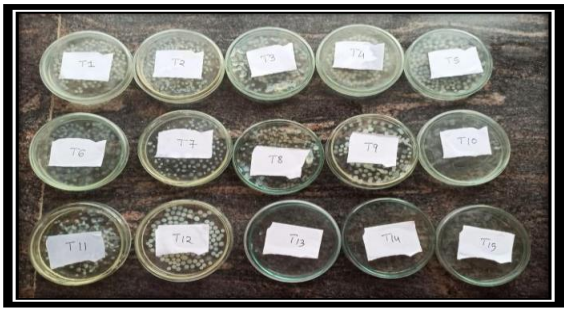

Fig. 6: Immobilized lipase Beads

BB Design is used in the present study to know the effect of three factors such as concentration of sodium alginate, concentration of calcium chloride, ratio of sodium alginate to lipase on immobilization efficiency.

The experimental layout of BBD is designed using the three variables at three levels which give out 15 experimental trials which are performed and lipase activity is recorded as response. The experimental layout and corresponding response of BBD is presented in the Table 3. Experiments were performed as per the Table 3 and produced immobilized beads were analysed for lipase activity (Fig. 6)

III. RESULTS AND DISCUSSION

A. Lipase production:

The source of Lipase is *Lysinibacillus macroides* FS1. More than 95% of crude lipase was obtained.

A lipase assay is a laboratory test used to measure the activity of the enzyme lipase in biological samples.

The lipase assay results are reported as units per liter (U/L) or international units per liter (IU/L), representing the amount of lipase activity present in the sample. The reference range for lipase activity may vary depending on the laboratory and the specific assay used. It's important to note that lipase assays should be interpreted in conjunction with other clinical information and diagnostic tests to make an accurate diagnosis and determine appropriate treatment options [13].

Lipase activity of immobilized lipase beads is evaluated by titrimetric method by the Eq 1 i.e.,

Lipase Activity (U/ml) = Volume of alkali consumed X Strength of alkali x 1000/Volume of sample x Time in min

= 15 X 0.05 X 1000/60

= 12.5U/ml

B. Partial Purification of Lipase:

Ammonium sulfate is commonly used for the purification of lipase due to its high solubility in water, cost-effectiveness, and minimal impact on the enzyme structure. The precipitation method is a preferred technique, where the addition of salts modifies the solubility of proteins, causing them to form aggregates or clumps. A 30% saturation level of ammonium sulfate is typically optimal for recovering a significant number of lipases during the purification process.

C. Immobilization by Entrapment

Immobilized lipase offers significant advantages in biodiesel production. Firstly, it provides enhanced catalytic efficiency, stability, and reusability compared to free lipase. Immobilized lipase exhibits high substrate tolerance, reducing the need for extensive

feedstock pretreatment. Its easy separation from the reaction mixture simplifies downstream processing and purification. The immobilization matrix protects the lipase from denaturation or degradation, ensuring long-term stability

Determination of immobilization efficiency:

The immobilization efficiency was calculated and activity recoreded is 6.25 U/ml and efficiency was 52%.

Beads Activity (U/ml) = Volume of alkali consumed X Strength of alkali x 1000/Volume of sample x Time in min

Beads Activity (U/ml) = 7.5x0.05x1000/60

= 6.25 U/ml

Immobilization efficiency % = Activity of immobilized lipase/ Activity of free lipase−Wash water activity × 100

= 6.25/12.5- 0.6x100

= 52%

D. Optimisation of immobilization Statistical design:

RSM allows for the development of mathematical models that describe the process behavior, enabling the prediction and optimization of biodiesel production under different conditions. Statistical optimization techniques also facilitate the identification of critical process parameters and their optimal ranges. By conducting sensitivity analysis and generating response surface plots, it becomes possible to determine the key factors influencing biodiesel production and the ranges within which they should be maintained for optimal performance. It supports informed decision-making, reduces experimental efforts.

F-value: The F-value is a statistic calculated in ANOVA (analysis of variance) tests, which compares the variation between groups with the variation within groups. Minitab calculates the F-value as part of ANOVA analysis, where it tests whether there are significant differences between the means of multiple groups. A larger F-value indicates a higher likelihood of significant differences between the groups. R-squared (R2) value: In regression analysis, the R-squared value represents the proportion of the variation in the dependent variable that can be explained by the independent variables. Minitab calculates the R-squared value when performing regression analysis. It ranges from 0 to 1, where 0 indicates that the independent variables explain none of the variation, and 1 indicates a perfect fit. A higher R-squared value indicates a stronger relationship between the variables. These variables, p-value, F-value, and R-squared value, are essential statistical measures that help in interpreting the results of various analyses and making informed decisions. Minitab provides these values as part of its output to assist users in understanding the statistical significance and strength of relationships in their data.

Box-Behnken Design

In the present study, the Box-Behnken Design (BBD) was chosen as the optimal experimental design for the optimization of enzymatic biodiesel production. This design was preferred due to its superiority in handling three variables simultaneously. A total of 15 trials were conducted using a three-level three-point design, where the factors were assigned low (-1), central (0), and high (+1) levels, as described in Table 3 in the materials and methods section.

Upon analyzing the obtained results, it was observed that the yield of biodiesel exhibited considerable variation under different conditions. Trial number 14 demonstrated the highest lipase activity, suggesting that the optimized condition for maximum lipase activity involved the highest concentration of sodium alginate, the lowest concentration of calcium chloride, and a moderate value of lipase concentration.

These findings indicate that the combination of these specific factors (T14) resulted in the highest lipase activity, thus representing the optimal condition for enzymatic biodiesel production. The use of the Box-Behnken Design allowed for the identification of the ideal parameter values, leading to enhanced lipase activity and potentially improving the efficiency of biodiesel production.

Table 4: BBD response

Trials No.	concentration of sodium alginate (%)	Concentration of calcium chloride(mm)	Ratio of sodium alginate to lipase	Lipase activity(U/ml)	Predicted Lipase Activity(U/ml)
T1	5	250	3	7.00	7.388
T2	3	150	3	6.10	6.790
T3	3	150	3	7.25	6.790
T4	3	250	1	6.60	6
T5	1	150	1	6.00	6.013
T6	1	150	5	7.00	6.787
T7	1	250	3	7.00	7.586
T8	3	150	3	7.02	6.790
T9	3	50	1	6.30	6.675
T10	3	50	5	6.90	7.5
T11	3	250	5	8.20	7.825
T12	5	150	1	7.10	7.312
T13	5	150	5	9.20	9.188
T14	5	50	3	9.80	9.613
T15	1	50	3	6.10	5.713

Table 5 ANOVA for lipase activity

Source	DF	Seq SS	Adj SS	Adj MS	F value	P value
Regression	9	16.4617	16.4617	1.8291	3.24	0.104
Linear	3	10.4175	10.4175	3.4725	6.15	0.039
Square	3	1.2892	1.2892	0.4297	0.76	0.562
Interaction	3	4.7550	4.7550	1.5850	2.81	0.148
Residual Error	5	2.8231	2.8231	0.5646		
Lack-of-Fit	3	2.0825	2.0825	0.6942	1.87	0.366
Pure Error	2	0.7406	0.7406	0.3703		
Total	14	19.2824				

The regression models used for optimization demonstrate a well- fitted relation. Table 6 presents the p-values, which indicate the significance of each term. In this case, the p-value represents the probability of error at a 85% confidence interval (p=0.05).

The results, as summarized in Table 6 and Table 5, reveal that the model's p-value is 0.005, and the F-value is 3.24. These values suggest that the model is both satisfactory and significant, validating its usefulness.

The lack of fit, indicated by a p-value of 0.366, is insignificant, further supporting the model's reliability. Furthermore, the high values of R-squared (85%) and adjusted R-squared (59%) indicate a strong correlation between the response and the variables.

This suggests that the model accurately represents the actual relationship between the variables and the lipase activity. The significance of each coefficient in the model is determined based on the p-value [15,16].

The optimized conditions for immobilization is 5% sodium alginate, 50mM CaCl2 and 1:3 ratio of sodium alginate and lipase were observed in trial T14 and under these conditions the lipase activity of immobilized beads observed is 9.6U/ml which is higher compared to other trials [17,18].

Immobilization efficiency % = Activity of immobilized lipase/ Activity of free lipase−Wash water activity × 100

= 9.80/12.5- 0.5x100

= 82%

Immobilization efficiency was enhanced indicates that the factors which are used in statistical optimization were proved to be effective.

Table 6. Estimated Regression Coefficients for lipase activity

Term	Coefficient	SE Coefficient	T value	P value
Constant	6.79000	0.4338	15.651	0.000
concentration of sodium alginate	092500	0.2657	3.482	0.18
concentration of calcium chloride	0.08750	0.2657	-0.329	0.755
Ratio of sodium alginate to lipase	0.66250	0.2657	2.494	0.055
concentration of sodium alginate* concentration of sodium alginate	0.555000	0.3910	1.419	0.215
concentration of calcium chloride*concentration of calcium chloride	0.23000	0.3910	0.588	0.582
Concentration of lipase* Concentration of lipase	-0.02000	0.3910	-0.051	0.961
concentration of sodium alginate* concentration of calcium chloride	-1.02500	0.3757	-2.728	0.041
concentration of sodium alginate*Concentration of lipase	0.275000	0.3757	0.732	0.497
concentration of calcium chloride*Concentration of lipase	0.25000	0.3757	0.665	0.535

S = 0.7514 R-Sq = 85.4% R-Sq(adj) = 59.0%

IV. CONCLUSIONS

The efficient immobilized lipase has demonstrated its ability to catalyze the transesterification. Optimization of immobilization process has great significance to improve the catalytic activity of immobilized lipase.

Response Surface Methodology (RSM) was employed to investigate the effects of sodium alginate concentration, calcium chloride concentration, and ratio of sodium alginate to lipase on immobilized lipase activity.

These variables were optimized using a Box-Behnken Design (BBD), optimized conditions revealed that the highest lipase activity of immobilized beads of 9.6U/ml was achieved with a high concentration of sodium alginate (5%), a low concentration of calcium chloride(50mM), and 1:3 ratio of sodium alginate and lipase.

As a result of these optimized studies, the lipase activity increased from 6.5 U/ml (Innate activity) to 9.8 U/ml. Additionally, the efficiency of immobilization significantly improved, increasing from 52% to 82%. These findings highlight the substantial increase in the efficiency of immobilization achieved through the optimization studies.

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INTERNATIONAL JOURNAL OF RESEARCH AND ANALYSIS IN SCIENCE AND ENGINEERING

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25. Enhancement of Sustainability from Concept to Completion by Project Implementation Team: A Review of Green Residential Building Construction Project

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ABSTRACT

Residential buildings constitute a significant proportion of the building stocks in India and elsewhere. Various rating tools have been developed to foster green residential building construction project. Different stakeholders adopting these tools to showcase their efforts in sustainable habitat and development. This paper examines the role of project implementation team in enhancing sustainability in green building construction projects. To meet this, survey check list from the few certified residential buildings have been collected and critically analysed. Further, through a review of existing literature and case studies, the paper highlights the importance of regular site level briefing and understanding of green concepts from initial design to completion of the project, close co-ordination among the team members of the project, meticulously follow-up of method statements and schedules, and close supervision and monitoring in achieving sustainability goals. The findings suggest that a structured approach to sustainability implementation can significantly enhance the environmental, social, and economic sustainability outcome. It is concluded that the study provides a useful reference and inputs to the Owners, Contractors, Engineers and Policy makers for implementation of green building construction projects in the future.

KEYWORDS:

Sustainability, green concepts, method statements and schedules, implementation team, structured approach.

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26. MHD Casson Nanofluid with Non-uniform Heat Source/Sink and Viscous Dissipation Effects

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ABSTRACT

This study explores the magneto-hydrodynamic fluid flow and heat exchange of a Casson nano particles with a non-uniform heat source or sink and viscous dissipation. The concerned boundary layer equations are deformed into set of nonlinear differential equations using appropriate similarity transformations. The Runge-Kutta method combined with the shooting technique is used to obtain numerical results for velocity and temperature within the boundary region. The impacts of key parameters, including the Casson liquid parameter, Eckert number, magnetic parameter, Prandtl number, porosity parameter, non-uniform heat source or sink parameter, on the flow field are analyzed, with numerical results presented graphically. The findings indicate that increasing the Casson parameter decreases the velocity field while increasing the temperature profile.

KEYWORDS:

Casson parameter, nanofluids, porous medium, viscous dissipation, magneto hydrodynamic, non-uniform heat source/sink.

I. INTRODUCTION

Due to its practical applications in industries like polymer production, crystal growth, paper manufacturing, glass blowing, aerodynamic extrusion of plastic sheets, and food processing, the study of boundary layer movement and transfer of heat in non-Newtonian viscous fluids has been conducted extensively.

The initial challenge was precisely solved by Crane [1], who was the first to examine the flow of the boundary layer past a stretched plate. Many scholars, notably Cortell [2], Bhattacharyya et al. [3], Mukhopadhyay [4], Rashidi and Pour [5], and Pal [6], have since shown a great deal of concern in the boundary layer flow across both linear and nonlinear stretching sheets. A boundary layer stream including magnetohydrodynamics (MHD) atop an exponentially extending surface with radiation effects has been considered by Ishak [7]. The properties of the steady two-dimensional laminar flow through the boundary layer of a viscous, incompressible liquid past a moving wedge with suction or injection were theoretically studied by Falkner and Skan [8]. Heat and mass transport in a two-dimensional viscous fluid radial flow through a saturated porous wedge-shaped zone with confining walls was investigated by Goyal and Kassoy [9].

The Falkner-Skan equation for flow beyond a stretching boundary was summarised by Stewartson, Riley [10], and Weidman [11], while MHD Casson fluid flow with temperature-dependent characteristics over an exponentially stretching surface was investigated by Animasaun et al. [12]. In order to analyse heat and mass transmission in hydromagnetic flow, Mabood [13] used the HAM method, while Mushtaq et al. [14] investigated radiation effects in the stagnation-point flow of viscous nanofluid while taking into account a variety of methods for transferring heat.

Recently, Many Researchers ([15]-[22]) have studied the various effects of non-dimensional parameters on the Newtonian and non-Newtonian fluid flow and heat stream with the help of different analytical and numerical methods. Keeping the importance and several industrial applications in mind, the present study is carried out with the combination of viscous dissipation and non-uniform heat source/sink for the MHD Casson nanofluid over permeable stretching sheet

II. FORMULATION OF THE PROBLEM

On a heated stretched surface lying in the plane of the flow, consider the two-dimensional, steady stream of a Casson liquid approaching the stagnation point, where (y) is the coordinate perpendicular to the surface. When two equal and opposing forces are applied along the surface's x-axis, the surface stretches while the origin remains fixed. The following are the boundary layer equations that control heat transport and Casson fluid flow:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \qquad (1)$$

$$u\frac{\partial u}{\partial x}+v\frac{\partial v}{\partial y}=\nu_{nf}\left(1+\frac{1}{\gamma}\right)\frac{\partial^2 u}{\partial y^2}-\left(\frac{\sigma {B_0}^2}{\rho_{nf}}+\frac{\nu_{nf}}{k_0}\right)u \qquad (2)$$

$$u\frac{\partial T}{\partial x}+\frac{\partial T}{\partial y}=\alpha_{nf}\frac{\partial^2 T}{\partial y^2}+\frac{\nu}{\rho C_p}\left(1+\frac{1}{\gamma}\right)\left(\frac{\partial u}{\partial y}\right)^2+\frac{q'''}{\rho C_p} \qquad (3)$$

where the components of velocity in the x and y directions are denoted by u and v, respectively. Here σ is the electrical conductivity of the liquid, C_p is specific heat, α_nfis thermal diffusivity, ν_nfis kinematic viscosity, ρ〗_fis base fluid density,

$\rho_{nf}$is Casson fluid density, and $\gamma = \mu_B \frac{\sqrt{2\pi_c}}{P_y}$ non-

Newtonian (Casson) parameter, T is the temperature, $k_0$permeability of the porous medium. The model for the non-uniform heat source or sink q''' from equation (3) is

$$q''' = \frac{ku_w(x)}{x\upsilon}[A^*(T_s - T_0)f' + (T - T_0)B^*], \tag{4}$$

Where A^* and B^* are the coefficients of space and temperature dependent heat source/sink respectively. Here we make a note that the case $A^* > 0,\ B^* > 0$ corresponds to internal heat generation and that $A^* < 0,\ B^* < 0$ corresponds to internal heat absorption. Further it is assumed that the induced magnetic field is negligibly small. The boundary conditions given below are subjected to the governing equations

$$u = u_w(x) = bx, \quad v = 0,$$

$$T = T_w = T_\infty + A\left(\frac{x}{l}\right)^2 \quad at \quad y = 0 \tag{5}$$

$$u \to 0, \quad T \to T_\infty \quad as \quad y \to \infty$$

In this case, l is the characteristic length, T is the fluid's temperature, and $T_w$is the temperature of the fluid both at the stretching surface (shear stress) and T_∞at a distance from it (free stream temperature). The stretching sheet velocity is represented by $u_w = bx, \quad b > 0$, and A is a constant.

We introduce the following suitable similarity variables

$$\psi = x\sqrt{b\upsilon}\, f(\eta), \quad \theta(\eta) = \frac{T - T_\infty}{T_w - T_\infty}, \quad \eta = \sqrt{\frac{b}{\nu_f}}\, y \tag{6}$$

Where ψ is the stream function which is defined in the usual way as

$$u = \frac{\partial \psi}{\partial y} \text{and } v = -\frac{\partial \psi}{\partial x}$$

Where η is the dimensionless similarity variable, θ is the dimensionless temperature, substituting (6) in equations (2) and (3), the set of ordinary differential equations results in

$$\left(1 + \frac{1}{\gamma}\right)f''' + \phi_1\left(ff'' - f'^2 - \frac{M}{\phi_2}f'\right) - kf' = 0 \tag{7}$$

$$\theta'' + \left(\frac{k_f}{k_{nf}} Pr\phi_3\right) f\theta' + \left(1 + \frac{1}{\gamma}\right) Ec\, f''^2 - (A^* f' + B^*\theta) = 0 \text{.....(8)}$$

And the conditions in (5) becomes

$$f = 0, \qquad f' = 1, \ \theta = 1 \ \ as \ \ \eta \to 0$$

$$f' \to 0, \ \theta \to 0 \quad as \quad \eta \to \infty \qquad (9)$$

Here $M = \frac{\sigma B_0^2}{b\rho_f}$ is the magnetic parameter, γ is the Casson parameter,$k = \frac{\nu_f}{k_0 b}$is the porosity

Parameter, ϕ is the nanoparticle volume fraction (where

$\phi_1 = \frac{\nu_f}{\nu_{nf}}, \phi_2 = \frac{\rho_{nf}}{\rho_f} and\ \phi\ 3 = \frac{\rho_{nf}}{\rho_f}$) , $Pr = \frac{\nu_f}{\alpha_f}$ is the Prandtl number and $Ec = \frac{u_w}{C_p[T_w - T_\infty]}$ is the constant Eckert

number, and the prime denotes differentiation with respect to η.The physical quantities of interest are the skin friction coefficient C_f and the local Nusselt number Nu_x, which are defined as

$$C_f = \frac{\tau_w}{\rho_f {u_w}^2} \text{and} \quad Nu_x = \frac{x q_w}{k(T_w - T_\infty)} \qquad (10)$$

Where τ_w is the skin friction or the shear stress along the stretching surface and q_w is the heat flux from the surface, which are given by

$$\tau_w = \left(\mu_B + \frac{P_y}{\sqrt{2\pi_c}}\right)\left(\frac{\partial u}{\partial y}\right)_{y=0} \text{ and } q_w = -k\left(\frac{\partial T}{\partial y}\right)_{y=0} \qquad (11)$$

Substituting the transformations in (6), (10) and (11), we obtain

$$Re_x^{\frac{1}{2}} C_f = \left(1 + \frac{1}{\gamma}\right) f''(0), \quad \text{and } Re_x^{-\frac{1}{2}} Nu_x = -\theta'(0) \quad (12)$$

Where $Re_x = \frac{{u_w}^2}{\nu}$is the local Reynolds number.

III. NUMERICAL SOLUTION

The combined ordinary differential equations (7) and (8) are highly non-linear with the suitable boundary conditions (9) are solved numerically by the competent fourth order Runge-Kutta method along with the numerical shooting method. Set of these nonlinear differential equations are of third order in f second order in θreduced into a set of simultaneous ordinary equations as shown below,

$$\frac{df_0}{d\eta} = f_1,$$

$$\frac{df_1}{d\eta} = f_2,$$

$$\left(1+\frac{1}{\gamma}\right)\frac{df_2}{d\eta} = \phi_1\left(f_0 f_2 - {f_1}^2 - \frac{M}{\phi_2} f_1\right) - k f_1 \qquad (13)$$

$$\frac{d\theta_0}{d\eta} = \theta_1,$$

$$\frac{d\theta_1}{d\eta} = -\left(\frac{k_f}{k_{nf}} Pr\, \phi_3 \theta_1 f_0\right) - (A^* f_0 + B^* \theta_0) -$$

$$Ec\left(1+\frac{1}{\gamma}\right){f_2}^2 \qquad (14)$$

The related Boundary conditions reduce to the form,

$$f_0(0) = 0, \quad f_1(0) = 1, \quad \theta_0(0) = 1 \qquad (15)$$

$$f_1(\infty) = 0, \quad \theta_0(\infty) = 0, \qquad (16)$$

Here $f_0(\eta) = f(\eta)$ and $\theta_0(\eta) = \theta(\eta)$.

This requires the initial values $f_2(0)$ and $\theta_1(0)$ and hence suitable guess values are chosen and later integration is performed. A step size of $\Delta\eta=0.001$ is chosen with an error of tolerance 10^(-6).

In order to solve this system of equations using Runge-Kutta method with shooting technique. In order to get the desired values, one should need three more missing initial conditions. However, the values of f^ (‘) (η) and θ(η) are known when η→∞, these end conditions are used to obtain an unknown initial conditions at η=0 by using suitable shooting technique.

IV. ANALYSIS OF THE RESULT

This work examines viscous dissipation & Casson nanofluid flow under magneto-hydrodynamics with non-uniform heat sources and sinks. The coefficient of skin friction, local Nusselt number, and numerically velocity and temperature profiles were calculated for various parameter values. The objective is to evaluate the impact of various parameters on these profiles, as seen in Figs. [1–11]. The effects of the porosity parameter, magnetic parameter (M), and Casson parameter on the velocity profile are depicted in Figs. [1-3]. Higher Casson parameter values, according to Fig. [1], reduce fluid velocity because they

lower yield stress, which lessens the fluid's flexibility. The authors' observations [20] are in line with this tendency. Figure [2] illustrates how fluid velocity is affected by the magnetic parameter (M). Naturally, a rise in (M) results in a fall in fluid velocity. This happens when a magnetic field is introduced to an electrically conducting fluid, acting on it to produce the Lorentz forcea resistive force comparable to drag. In the boundary zone, this force causes the fluid flow to slow down.

As seen in Figure [3], fluid velocity close to the stretched sheet sharply decreases as the porosity parameter is increased. In terms of physics, this indicates that the fluid velocity next to the porous sheet is less than that of a stretching sheet that is not porous.The effect of Casson nanofluid on temperature profiles across a horizontal stretched sheet is depicted in Figures 4–12.

Figure 4 shows that a thicker thermal boundary layer results the temperature of the nanofluid raises with an increase in the Casson nanofluid parameter. As the magnetic field raises the fluid's temperature inside the boundary layer,

Figure 5 shows that an increase in the magnetic parameter (M) likewise increases the thermal boundary layer thickness. This could be because current flows through moving fluids at a decreasing temperature, which increases the thickness of the thermal boundary layer. Figure 6 illustrates how the fluid's temperature rises as the porosity parameter (k) increases.

As the nanoparticle volume fraction () increases, Figure 7 illustrates that the fluid temperature rises as well. Figure 8 shows that a reduction in the temperature profile is caused by a rise in the Prandtl number (Pr). According to Figure [9], the fluid temperature rises in tandem with the viscous dissipation parameter (Ec).

The non-uniform heat source/sink parameters (A*) and (B*) increase the temperature in the boundary region, as Figures 10 and 11 demonstrate. Positive values of these parameters typically result in the production of heat, whilst negative values cause the boundary layer to absorb heat.

The skin friction coefficient increases as the nanoparticle volume fraction () increases, as Figure 12 illustrates. Similar to this, Figures 13 and 14 show that rising Eckert (Ec) and Prandtl (Pr) numbers result in.

V. CONCLUDING REMARKS

Taking into account the impacts of a non-uniform heat source/sink, this work examines the velocity and characteristics of heat transfer of a two-dimensional Casson nanofluid flow over a porous stretched sheet. Graphs are used to discuss and show how different non-dimensional controlling parameters affect the velocity distribution and heat transfer rate.

The following findings were noted. The velocity profiles progressively decrease as the Casson parameter increases.

- The skin friction –f^" (0) increases as both the nanoparticle volume fraction (ϕ) and the porosity parameter (k) increase.
- The presence of a non-uniform heat source/sink affects the temperature profile. Positive values of the non-uniform heat source/sink parameter act as heat generators, while negative values cause heat absorption from the boundary layer.
- Considering the Eckert number causes the temperature to increase in the boundary region.

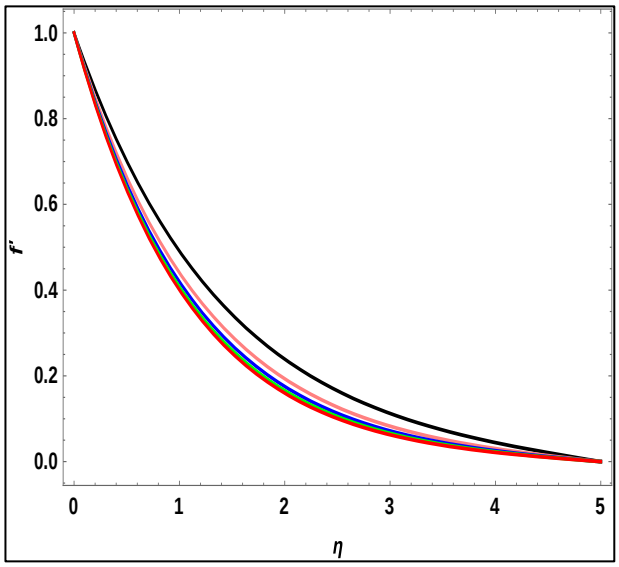

Figure.1. Velocity profile $f'(\eta)$for ascending values of γ.

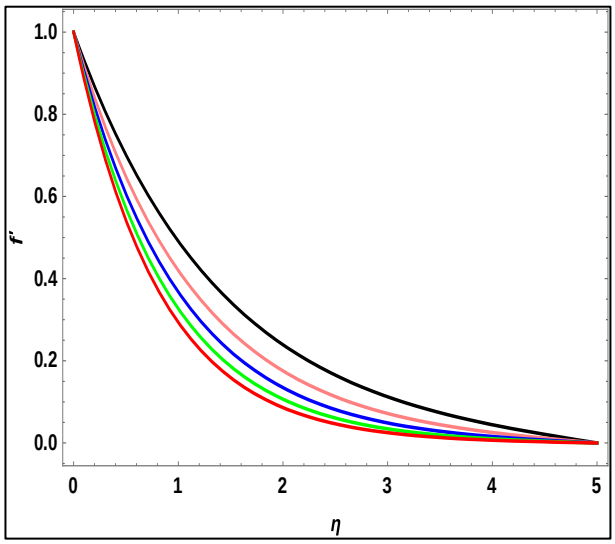

Figure.2. Velocity profile f'(η) for variousvalues of M

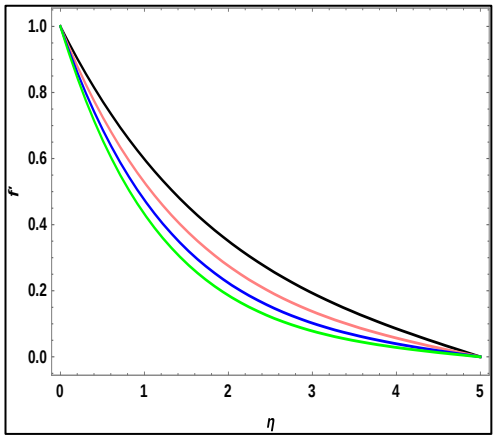

Figure.3. Velocity profile f'(η) for various values of Porosity parameter k

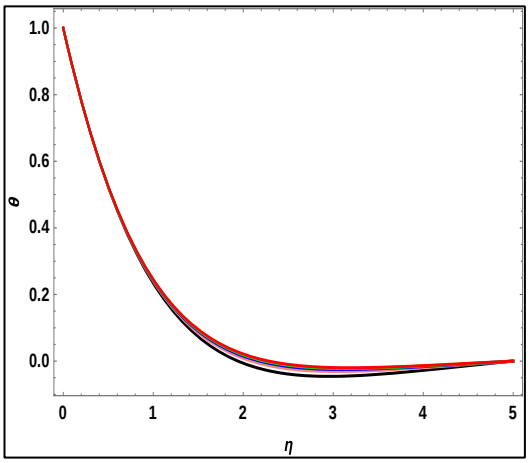

Figure.4. Temperature profile θ(η) for different values of γ

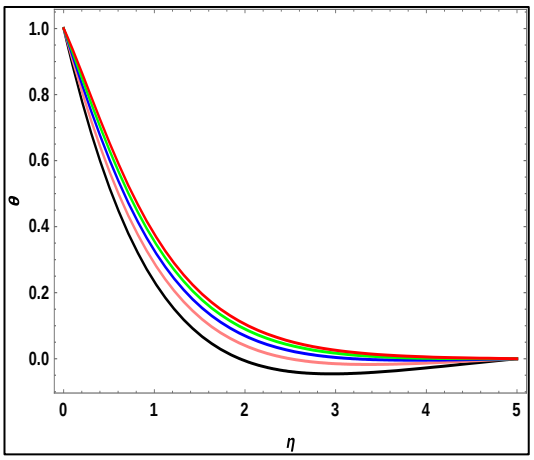

Figure.5. Temperature profile θ(η) for the incresing values of M

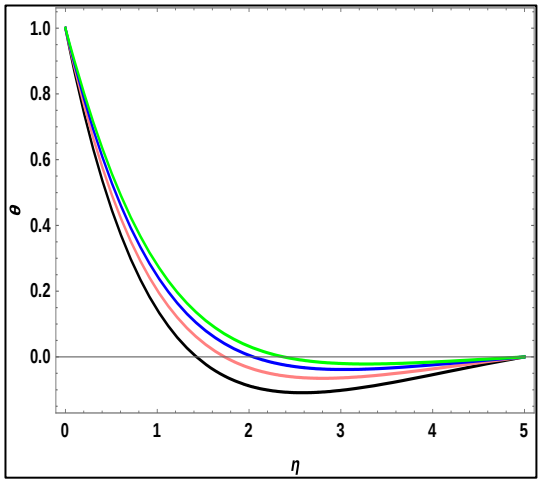

Figure.6. Temperature profile $\boldsymbol{\theta(\eta)}$ for different values of $\boldsymbol{k}$

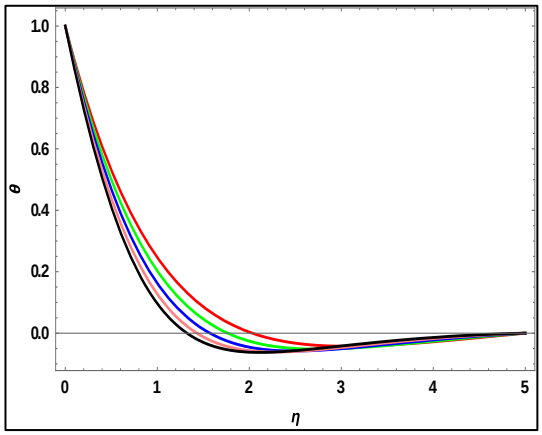

Figure.7. Temperature profile θ(η) for distinct values of ∅_3

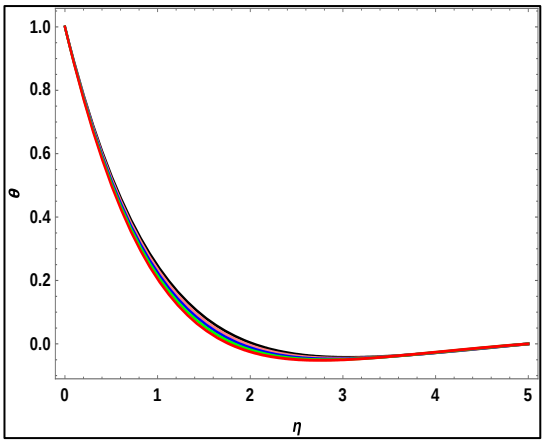

Figure.8. Temperature profile θ(η) for distinct values of Pr

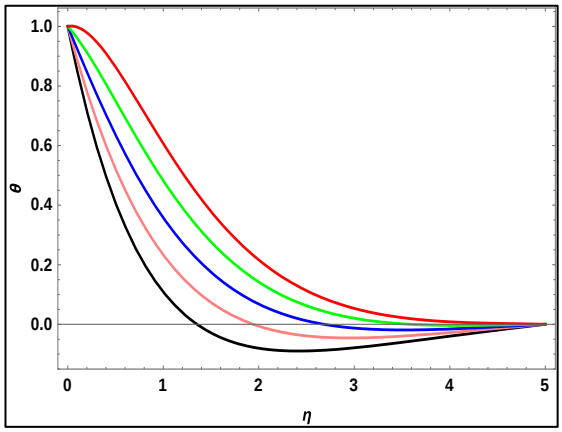

Figure.9. Temperature profile θ(η) for different values of Ec

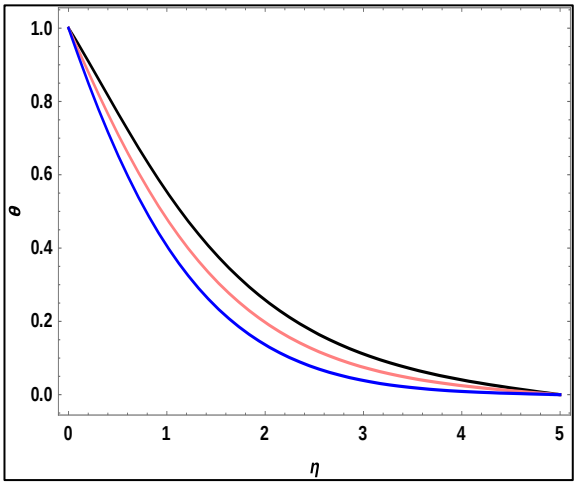

Figure.10. Velocity profile θ(η) for various values of A*

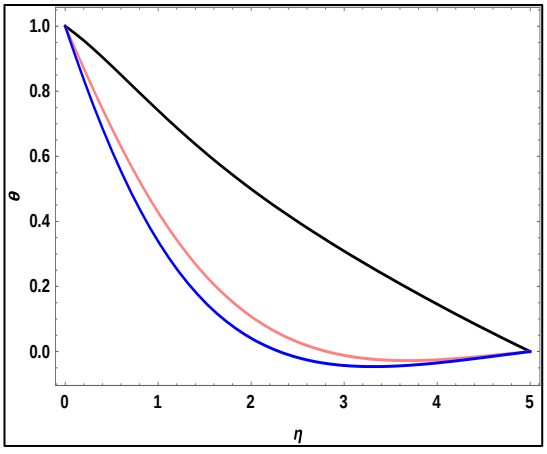

Figure.11. Temperature profile θ(η) for various values of B*

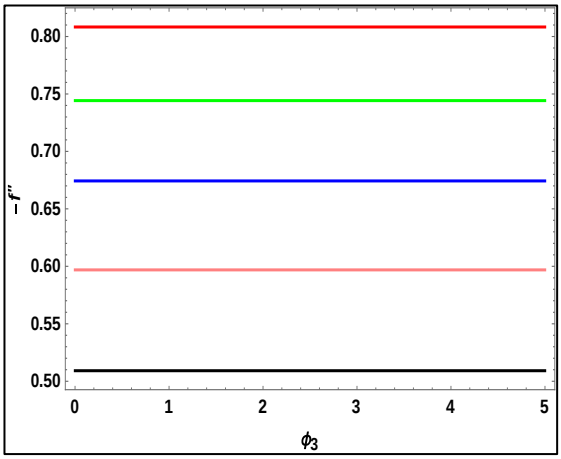

Figure.12. Skin friction –f''(0) with nanoparticle volume fraction ϕ_3for various values of porosity parameter k

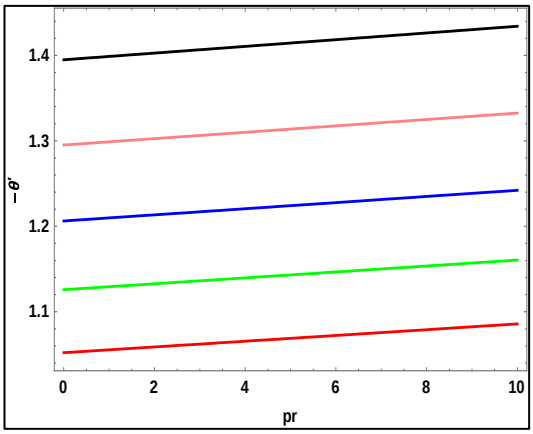

Figure.13. (–θ'(0)) temperature gradient nature with Pr for different values of k.

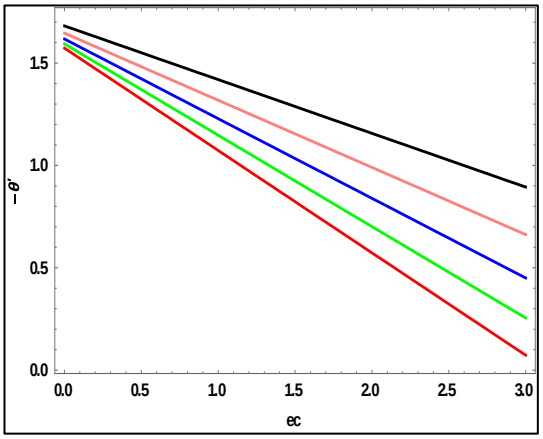

Figure.14. Temperaure gradient –θ'(0) nature with Ec for different values ofk.

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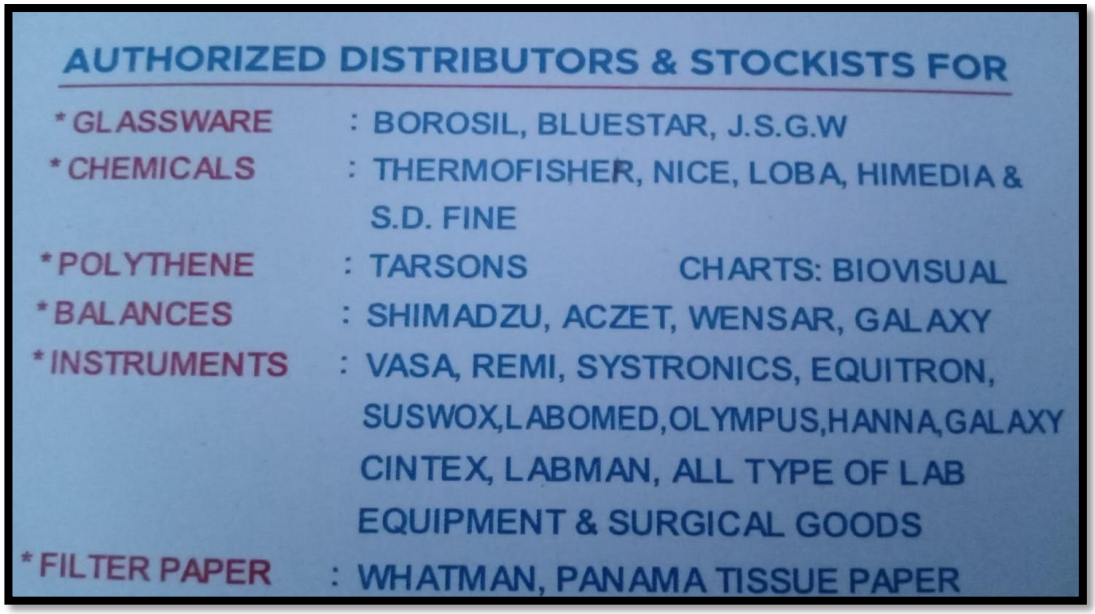

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