4th International Conference on

"Advances in Water Treatment and Management"

(ICAWTM-25)

March 01-02, 2025

Editor

Prof. Anurag Mudgal

Publisher

Pandit Deendayal Energy University (PDEU)
Gandhinagar, Gujarat, India

ISBN: 9789334235845

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Formerly Pandit Deendayal Petroleum University (PDPU)

Organized Jointly with IQAC-PDEU
Center of Excellence in Water Treatment & Management
Department of Mechanical Engineering, School of Technology

In Association with

Gujarat Council on Science & Technology (GUJCOST)
Gandhinagar, Gujarat, India

Supported by

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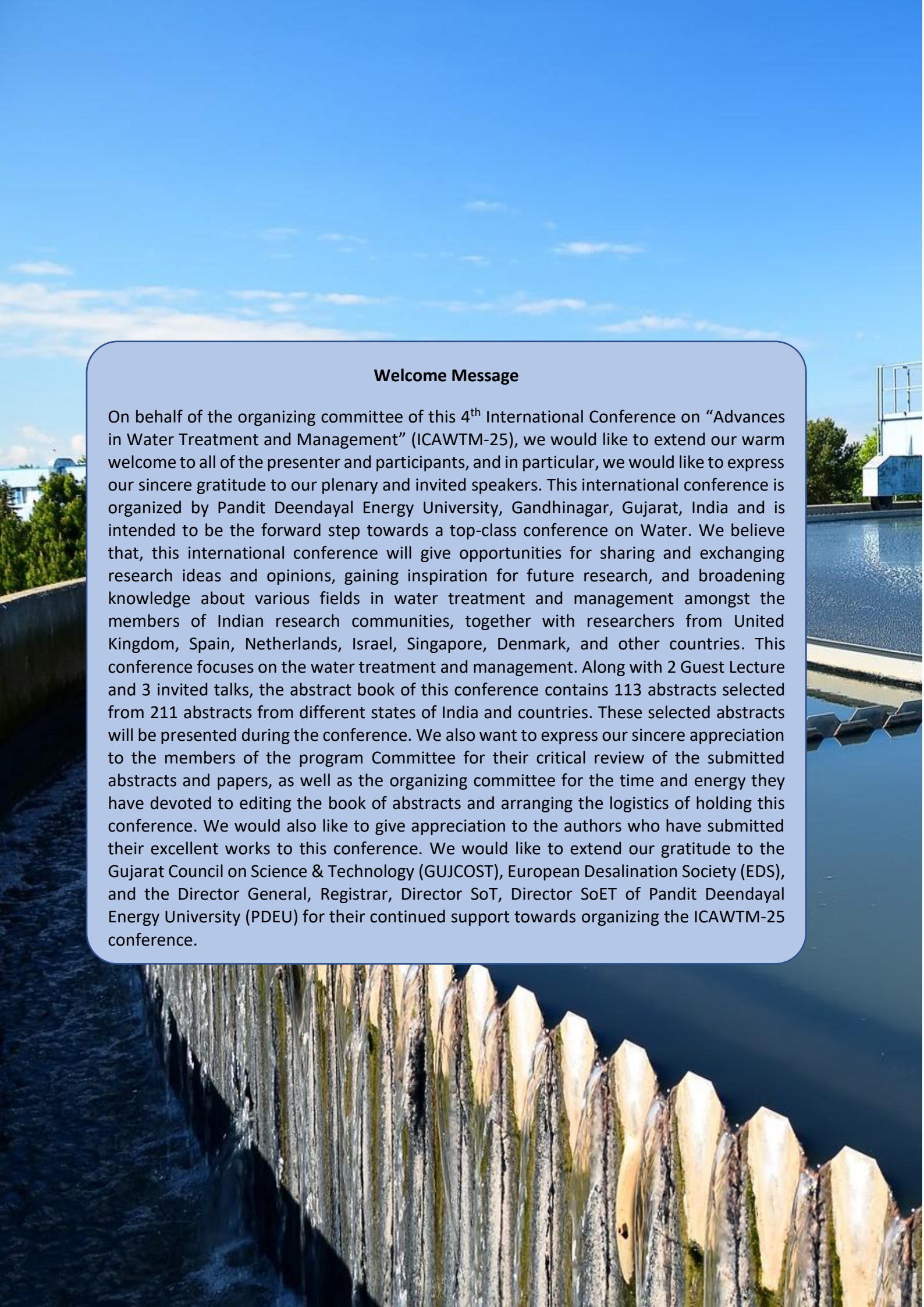
Springer Proceedings



Welcome Message

On behalf of the organizing committee of this 4th International Conference on "Advances in Water Treatment and Management" (ICAWTM-25), we would like to extend our warm welcome to all of the presenter and participants, and in particular, we would like to express our sincere gratitude to our plenary and invited speakers. This international conference is organized by Pandit Deendayal Energy University, Gandhinagar, Gujarat, India and is intended to be the forward step towards a top-class conference on Water. We believe that, this international conference will give opportunities for sharing and exchanging research ideas and opinions, gaining inspiration for future research, and broadening knowledge about various fields in water treatment and management amongst the members of Indian research communities, together with researchers from United Kingdom, Spain, Netherlands, Israel, Singapore, Denmark, and other countries. This conference focuses on the water treatment and management. Along with 2 Guest Lecture and 3 invited talks, the abstract book of this conference contains 113 abstracts selected from 211 abstracts from different states of India and countries. These selected abstracts will be presented during the conference. We also want to express our sincere appreciation to the members of the program Committee for their critical review of the submitted abstracts and papers, as well as the organizing committee for the time and energy they have devoted to editing the book of abstracts and arranging the logistics of holding this conference. We would also like to give appreciation to the authors who have submitted their excellent works to this conference. We would like to extend our gratitude to the Gujarat Council on Science & Technology (GUJCOST), European Desalination Society (EDS), and the Director General, Registrar, Director SoT, Director SoET of Pandit Deendayal Energy University (PDEU) for their continued support towards organizing the ICAWTM-25 conference.

4th International Conference

on

Advances in Water Treatment and Management (ICAWTM-25)

March 01-02, 2025

Pandit Deendayal Energy University

Knowledge Corridor, Raisan Village

Gandhinagar, Gujarat-382 426, INDIA

Book of Abstracts

About the Conference

Water is a pressing issue in current times. The increase in the urban population, limiting natural resources and improper water management has increased the need for effective & efficient water treatment strategies. This conference is specially designed to bring together an interdisciplinary team of researchers to share their expertise and research experience on recent trends in water treatment and management. The idea is to bring together like-minded agencies and stakeholders including research organizations, universities, NGOs and SMEs from India and abroad to share their expertise in low-cost water treatment, wastewater treatment, recycle and reuse. Conference includes keynote lectures and invited talks by eminent resource persons from reputed universities and organizations, poster presentations, paper presentations, and interactive sessions. The faculties from different colleges, research scholars, students and scientists will be given opportunity to demonstrate their own works and get valuable suggestions from experts. The conference aims to create an integrated learning environment and encourage academicians, researchers and students to develop various competencies and enhance their self–efficacy in different techniques for affordable and feasible water treatment and management options.

Themes

Thrust Area

- Novel water treatment options for sustainable solutions to clean water scarcity
- Water desalination
- Wastewater treatment and management

Sub Themes to be addressed in this conference include, but not limited to the following

- Membrane and thermal desalination technologies
- Electrochemical systems in water treatment
- Renewable energy-based water treatment technologies and Low-cost solutions
- Novel hybrid systems and module design
- Emerging desalination technologies
- Novel materials for water treatment
- Artificial Intelligence and Machine Learning application in water
- Pre-treatment and post-treatment processes
- Membrane fouling and control
- Brine/concentrate management
- Resources recovery from brine
- Water recycling and reuse
- Wastewater treatment using immobilized microorganism technology
- Sustainability and water management
- Cost effective methods for removal of heavy metals
- Phytoremediation technologies for contamination of organic pollutants
- Bioremediation of contaminated water or wastewater
- Renewable energy applications in groundwater treatment
- Renewable energy applications in industrial water treatment
- Advancing Sustainable Energy: Green Hydrogen Production Through Desalination and Recovery Technologies
- Constructed wetlands for dealing with emerging problem of polluted water
- Ex-situ/ In-situ phytoremediation for treatment of polluted water
- Energy and sustainability, economic evaluation, case studies
- Water policies, governance and planning
- Water, food, energy nexus towards circular economy
- Future trends in water security

- Energy needs for the water sector
- Green technologies for sustainable water resources
- Water and energy in context of industry 4.0
- Decarbonization and future energy systems
- Energy-saving technologies
- Nanotechnology applications in water
- Biomimetics/Nature-based solutions
- Sustainable development goals implementation
- Green Chemistry in Water Treatment: Reducing Environmental Footprints
- Smart Water Networks: AI-Driven Decision Making and Management
- AI for Desalination: Enhancing Efficiency and Reducing Energy Costs
- AI in Predictive Maintenance of Water Treatment Facilities
- AI in the Water-Energy Nexus: Integrating Renewable Solutions
- Green Innovation and Environmental Resilience

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Dr. Puyam Sobhindro Singh
Chief Scientist
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Invited Speakers

Dr. Hiteshkumar Zinjala
Manager - CFD Treatment, Xylem Water Solutions India Pvt. Ltd. - Global Capability Centre

Mr. Vishal Phalke
Asst. Manager, Research & Development, Aquatech Systems(Asia) Pvt. Ltd.

Program at Glance

Day-1

10:00 to 10:45	Inauguration of the Conference
10:45 to 11:30	Visit to Centre of Excellence in Water Treatment and Management
11:30 to 12:00	Keynote Lecture by Dr. Puyam Sobhindro Singh, Chief Scientist, CSIR - CSMCRI, Bhavnagar
12:00 to 12:30	Keynote Lecture by Dr. Kamalesh Prasad, Chief Scientist, CSIR - CSMCRI, Bhavnagar
12:30 to 14:00	Lunch
14:00 to 14:30	Dr. Hiteshkumar Zinjala Manager - CFD Treatment, Xylem Water Solutions India Pvt. Ltd. - Global Capability Centre Talk: CFD in water industry
14:30 to 15:00	Invited Talk: Mr. Vishal Phalke Asst. Manager, Research & Development, Aquatech Systems(Asia) Pvt. Ltd. Talk: Revolutionizing STP Treatment: Aquatech's iGBR Technology for Sustainable WastewaterManagement
15:00 to 15:30	Tea Break
15:00 to 17:30	Paper Presentation: Track 1 - Track 10
17:30 to 18:00	Paper Presentation: Track 1 - Track 10

Day-2

09:30 to 10:00	Introduction to Center of Excellence in Water Treatment and Management Prof. Anurag Mudgal Mechanical Engineering Department, Pandit Deendayal Energy University, Gandhinagar
10:00 to 10:15	Paper Presentation Track 5 - Track 8

10:15 to 12:45	Paper Presentation Track 11 - Track 14
12:45 to 14:15	Lunch
14:15 to 15:00	Valedictory Function

Paper Presentations

Track 1 Advanced Technologies for Sustainable Wastewater Treatment			
Track ID	**Author Name**	**Paper Title**	**Page No.**
Water-001	Ms.Riddhi Upasani	Electrocoagulation for Wastewater Purification: Insights, Innovations and Future Perspectives	15
Water-002	Dr. Parin H Kanaiya	Treatment of Waste Water by Advanced Oxidation Process - Hydrodynamic Cavitation	15
Water-003	Mr. Mohin Patel	Sewage Water Treatment Using Venturi Base Hydrodynamic Cavitator Reactor	15
Water-004	Mr. Vijender Singh	A Porous Media Model For The Underdrain Application	16
Water-005	Dr. Chetankumar Anghan	A Non-Newtonian Model For Simulation Of Mixing In Sludge Holding Tank	16
Water-006	Mr. Sagar Deshmukh	Advances in electrocoagulation technology for an effective treatment of this highly polluted industry effluent's wastewater	17
Water-007	Mr. Meet Chiragkumar Trivedi	Treatment of Stubborn Waste Water from Caprolactam Plant	17
Water-008	Dr. Rama Gaur and Jinal Patel	Synthesis and characterization of rGO via different chemical route for photocatalytic mineralization of noxious agrochemicals in wastewater	18
Water-009	Miss. Shruti Uphale	Sewage Treatment Using Membrane Bioreactor: A Review	18

Track – 2 Sustainable Water Management: Treatment, Quality Assessment, and Societal Impact			
Track ID	**Author Name**	**Paper Title**	**Page No.**
Water-010	MISS ASHKA ARJUNSINH CHAUHAN	STUDIES ON WASTEWATER TREATMENT BY THE INCORPORATION OF PARTICLES IN EMULSION LIQUID MEMBRANE	18
Water-011	Shambhuraj Rajesh Chavan, Sucheta Pathak	Techno-Commercial Evaluation of Continuous vs. Intermittent Water Supply for Self-Sustainability in Urban Area	19
Water-012	Mrs. Ami Dharmesh Parekh	Analysis of ground-water levels and quality parameters EC and PH and associated Trends of Pre monsoon and post monsoon over 20 years for the Nadiad branch canal command area of Mahi Right Bank Canal Project, Gujarat, India.	19
Water-013	Dr Namrata Bist	A Chronological review of geothermal water quality assessment: A case study from Unai, Gujarat, India	20
Water-014	Mr. Shreyansh Bhatiya, Kashyap Karmur	WQI and IWQI-Based Aquifer Assessment for Sustainable Irrigation: A Geospatial Evaluation of Surface and Groundwater Quality in Gujarat	20
Water-015	Dr. Megha D Bhatt	Industrial Waste Water Treatment through Sequential Aerobic & Anaerobic Digestion Cycle: A Green Approach	20
Water-016	Dr Rachna Arora	From Wells to Watersheds: Women's Strategic Role in Water Conservation and Management	21
Water-017	Dr. Milankumar Bhatt	HYDRATION: IMPACT ON ATHLETIC PERFORMANCE AND INJURY PREVENTION	21

Track – 3 Sustainable Water Resource Management and Infrastructure			
Track ID	**Author Name**	**Paper Title**	**Page No.**
Water-019	Mr. Satyam Panchal	Reservoir Optimal Release Policy By Nature Inspired Metaheuristic Algorithm	22
Water-020	Mr.Darshankumar Patel	Water Demand & Management: A Case Study of Jaipur	22
Water-021	Dr. BASWESHWAR S. JIRWANKAR	Sustainable Management of Ageing Water Storage Infrastructure in Maharashtra: The Case for Dam Neutralizing	22
Water-022	Dr. BASWESHWAR S. JIRWANKAR	Storm Water Management in Kusumba Village: A Design Framework for Climate Resilience	23
Water-023	Mr. Hemant Kumar	Assessing Shoreline Change Along Ireland's Coastline (2000-2024) Using Google Earth Engine	23
Water-024	Dr. Mukesh A. Modi	River Pollution Monitoring flowing through an Industrial Catchment using GIS and Remote Survey	24
Water-025	Amee Kiritkumar Daiya	Predictive Analytics of Wind Speeds Using Machine Learning Algorithm for Efficient use of Harnessing Water using Wind Turbine in an Agricultural Field	24
Water-026	Dr. Ankita Srivastava	Bibliometric Analysis of Water Resource Management: Trends and Evolution from 2015 to 2025	24

Electrocoagulation for Wastewater Purification: Insights, Innovations and Future Perspectives

Upasani Riddhi Kamleshkumar[a]

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Abstract: Electrocoagulation (EC) is a cutting-edge technology which is gaining recognition as a promising technology for wastewater purification due to its efficiency, eco friendliness and versatility in treating a variety of contaminants. This review explores the core principles recent advancements and future directions of EC in wastewater treatment. The paper delves into the electrochemical processes of EC focusing on the role of electrode reactions, coagulation, and flocculation in removing pollutants such as heavy metals, oils, dyes and suspended solids from wastewater. Recent innovations in EC systems including the development of advanced electrode materials, process optimization strategies and hybrid electrocoagulation systems are examined. The comparison of Electrocoagulation with other treatment methods such as membrane filtration and advanced oxidation is discussed to overcome limitations and improve treatment efficiency. The future scope of electrocoagulation is explored with an emphasis on its role in sustainable water management, wastewater reuse and decentralized treatment systems. The review concludes that electrocoagulation holds great promise as a cost-effective and environmentally sustainable solution for wastewater purification which is contributing to global water conservation efforts.

Keywords: *Electrocoagulation; Wastewater Purification; Electrochemical Processes; Coagulation; Flocculation; Heavy Metal Removal; Advanced Electrode Materials; Process Optimization; Hybrid Electrocoagulation*

Treatment of Waste Water by Advanced Oxidation Process - Hydrodynamic Cavitation

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Abstract: Water pollution is a significant environmental concern, necessitating the development of innovative and efficient treatment methods. Advanced Oxidation Processes (AOPs) have emerged as powerful tools for wastewater treatment due to their ability to degrade a wide range of organic pollutants. Hydrodynamic cavitation (HC), a specific type of AOP, has gained considerable attention because of its high efficiency, cost-effectiveness, and ability to generate reactive radicals. This paper explores the principles, mechanisms, and applications of HC in wastewater treatment. It also discusses the factors affecting cavitations' efficiency and highlights recent advances and future directions in the use of HC for the treatment of industrial and municipal wastewater. Hydrodynamic cavitation (HC+Cl 2 +lime) based processes can achieve higher degradation rates and require less energy and chemicals compared to traditional treatment methods. In this particular study, the hydrodynamic cavitation was investigated for the treatment of real industrial wastewater and effluent. The study focused on optimizing various operating parameters such as inlet pressure, temperature and chemical oxygen demand (COD). The results showed that the HC process was effective in degrading the organic matter in the wastewater and effluent and the optimal operating conditions were identified. This innovative technology based on HC has proven to be effective in treating real industrial wastewater with high levels of organic matter and contaminants, providing a promising alternative to traditional treatment methods.

Keywords: *Wastewater; Advanced oxidation processes; Hydrodynamic cavitation; Persistent contaminants*

Sewage Water Treatment Using Venturi Base Hydrodynamic Cavitator Reactor

Mehul Bambhania[a*], Meghraj Gohil[b], Mohin Patel[c], Saurabh Rajput[d]

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Abstract: The treatment of wastewater remains a significant environmental challenge due to the persistence of diverse contaminants, including organic and inorganic chemicals, as well as pathogenic bacteria such as Escherichia coli (E. coli). Hydrodynamic cavitation (HC), an energy-efficient and environmentally friendly technology, exploits the generation and collapse of cavitation bubbles to produce localized extreme conditions—high temperatures and pressures—that facilitate the degradation of contaminants and the disruption of microbial cells. This study employed a Venturi-based cavitation reactor for sewage treatment, with operational parameters optimized using computational fluid dynamics (CFD). The

optimization involved varying Venturi throat diameters (1, 2, and 3 mm) and injection pressures (2, 5, and 8 bar). Results identified a throat diameter of 2 mm and an injection pressure of 8 bar as optimal, providing maximum cavitation intensity. Further enhancement of cavitation efficiency was achieved by modifying the Venturi geometry to incorporate a converging section upstream of the throat. Under optimized conditions, the HC reactor achieved a significant reduction in E. coli populations, with an initial concentration of 86×10^3 times CFU/mL (of which E. coli accounted for 33×10^3 times CFU/mL) decreasing to 11×10^3 times CFU/mL after 30 minutes of treatment. The observed E. coli reduction rate was 81.6%. Additionally, the chemical oxygen demand (COD) and biochemical oxygen demand (BOD) were reduced by 77% and 89%, respectively. These findings underscore the potential of hydrodynamic cavitation as an effective and scalable technology for the simultaneous removal of chemical and microbial contaminants in wastewater treatment applications.

Keywords: *Hydrodynamic Cavitation (HC); Wastewater Treatment; Escherichia coli Reduction; Venturi Cavitator; Biological Oxygen Demand (BOD); Chemical Oxygen Demand (COD)*

A Porous Media Model For The Underdrain Application

Hiteshkumar Zinjala[a] and Vijender Singh*

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Abstract: A gravity-based filtration media system has underdrains to collect filtered water during the filter run and distribute air and water during the backwash cycle. During the backwash cycle, the accumulated particulate matter is removed from the surface which increases the overall efficiency of the filtration process with reduced wastage of water and energy. A typical filtration system consists of around 50 to 100 underdrain laterals attached to the opening of the flume. To ensure proper cleaning, it is essential to maintain uniform backwash flow rates throughout the filter. This flow rate distribution is quantified in terms of maldistribution which is the percentage deviation of actual mass flow rate from the ideal flow rate. The maldistribution is estimated using the deviation of lateral pressure from the expected pressure drop as measurement of pressure is a feasible and cost-effective alternative to measuring flow rate in individual laterals. However, in an actual scenario it is always difficult to achieve equal maldistribution in each underdrain lateral from simple one-dimensional calculations. Therefore, computational fluid dynamics (CFD) analysis is performed to verify the design of the filtration system. To accurately model the actual site conditions with CFD analysis, it is essential to consider the full lateral into the calculation. Meshing a full lateral is a bottleneck in CFD workflow due to small orifices on the lateral surface. In the present article, we have developed a porous media-based approach to model full laterals. In this approach, a porous media is added over the surface of the lateral where orifices are present. The pressure drop or head loss across the lateral top surface (where there are holes for water to flow through) is provided as the input to the porous media model. The head loss coefficient as a function of pressure drop and porous media permeability are incorporated into the model to replicate the physical model. This modelling approach provides computationally lean and accurate results for this application. The method is implemented in ANSYS Fluent solver which is a well-known commercial CFD tool for general fluid dynamic simulations. The pressure field data at specified locations are extracted from the simulations inside laterals and the pressure-based maldistribution is estimated. Both developed pressure and maldistribution data from the CFD analysis are validated with three different site test data. The overall error in maldistribution is within the limit of 3% which show excellent agreement between computational and experimental measurement. This approach simplifies the overall model while capturing the maldistribution across the system with accurate computation of flow field across the underdrain.

Keywords: *Computational fluid dynamics; filtration; underdrain; maldistribution; porous media*

A Non-Newtonian Model For Simulation Of Mixing In Sludge Holding Tank

Hiteshkumar Zinjala[a] and Chetankumar Anghan*

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**Lead Engineer, Research and Development, Xylem Water Solutions India Pvt. Ltd, Vadodara – 390023, Gujarat, India.*

Abstract: Computational fluid dynamics (CFD) is a rapidly emerging field in wastewater treatment (WWT). It is a tool which provide an opportunity to study the mixing phenomena inside a treatment tank through numerical investigation. The rheology of the wastewater is different compared to the clean water due to presence of solid particles. The total solid content in the wastewater such as sludge varies from 2 to 10% and hence it behaves as a non-Newtonian fluid. In the literature, the rheological characteristic of sludge is modelled by the power law model. However, when the solid content in the sludge is higher than a threshold value (2%), the sludge no longer follows the power law. In fact, the sludge remains rigid up to yield stress and behave as a fluid beyond this limit in a stress-strain curve. Regularized Herschel-Bulkley model can capture rigid limit as well fluid behavior. But it operates on a limiting viscosity value at lower strain rates less than critical strain rate. In the present article, we propose a modified Herschel-Bulkley model to accurately model sludge behavior when solid content is higher. The model is modified to account for the variation in the viscosity with the strain rate. It utilizes the ratio of strain rate and the critical strain rate along with the flow index into the calculation when the strain rate value is lower than the critical stain rate while a power law model is applied when the strain rate value is higher than the critical strain rate. The consistency index is now multiplied by a term which contains the critical strain rate and

the flow index. Therefore, the consistency index is modified in the present formulation. Thus, the proposed model considers entire range of shear stress-strain curve for varying content of solid in the wastewater. The model is implemented in a commercial solver ANSYS Fluent using user defined function (UDF) for the industrial applications. The model is tested with benchmark problem of channel flow and verification is carried out with analytical solution. A good agreement is obtained with the analytical solution for shear thinning and shear thickening test cases. Finally, the model is applied to wastewater sludge holding tank containing jet nozzle to induce mixing in the tank. Two cases are considered for the comparison purposes with lower TS (total solids) fluid and wastewater sludge with higher TS fluid. First the solver has been benchmarked against the experimental data of lower TS fluid from literature. Later, the proposed non-Newtonian model has been applied to sludge holding tank with the higher TS fluid. Significant differences are observed between the two cases due to difference in the fluid rheology. It is established that accurate prediction of the mixing behavior inside a treatment tank require a non-Newtonian model when total suspended solid is high..

***Keywords**: Computation fluid dynamics; non-Newtonian; wastewater; sludge; mixing*

Advances in electrocoagulation technology for an effective treatment of this highly polluted industry effluent's wastewater

Charudatta Thosar[a*] Dr.Shrikant Randhavane[b] Sagar Deshmukh[c] , Darshankumar Patel[d] , Dr.Basweshwar Jirwankar[e]

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Abstract: The study evaluates the use of electrocoagulation as a treatment process in electroplating wastewater, which is usually characterized by containing heavy metals like nickel, copper, and zinc. It is shown that the described process may provide efficiencies exceeding 98% for removal of these contaminants under optimized current densities and pH levels. The process uses electrodes of stainless steel and incorporates coagulants such as lime and ferric chloride to improve metal removal. Compared to conventional chemical coagulation, EC offers advantages such as reduced chemical usage, lower sludge production, and the potential for water reuse in industrial processes. Moreover, the integration of EC with membrane filtration technologies holds promise for further improving treatment efficiency. This paper showcases the effectiveness of EC in obtaining compliance with environmental regulations and underscores its role in the promotion of sustainable practices within the electroplating industry.

***Keywords:** Electrocoagulation (EC); Wastewater treatment; Electroplating effluents; Heavy metal removal; Membrane filtration*

Treatment of Stubborn Waste Water from Caprolactam Plant

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Abstract: Waste water generated during the production of Caprolactam presents a significant environmental challenge due to its elevated levels of chemical oxygen demand (COD) and toxicity. This study explores the solution for the efficient treatment of Caprolactam waste water, considering its unique characteristics that often hinder conventional treatment processes. The waste water consists of approximately 3 wt% organic waste with COD of ~48500 ppm, 2 wt% Ammonium Sulphate and 95% water. Experiments were conducted to investigate various treatment strategies, including Extraction with organic solvent, Hydrogen peroxide treatment, Hydrodynamic cavitation, and Fenton's reaction. The Organic impurities present were highly soluble in water and hence, require complete evaporation of water prior to extraction which is energy intensive. Comparative analysis revealed that Fenton's oxidation outperformed direct Hydrogen peroxide treatment combined with hydrodynamic cavitation in terms of COD reduction efficiency. This finding highlights Fenton's oxidation as a superior approach for the treatment of Caprolactam waste water, emphasizing its potential for addressing the environmental hazards associated with this industrial waste water. The study revealed that under the optimized conditions the highest percentage reduction in COD could be 45.2%..

***Keywords:** Electrocoagulation (EC); Caprolactam plant; Waste wate; Fenton's reaction; Hydrodynamic cavitation; Chemical oxygen demand*

Synthesis and characterization of rGO via different chemical route for photocatalytic mineralization of noxious agrochemicals in wastewater

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Abstract: The agricultural sector is currently facing a pressing need to utilize agrochemicals to meet the growing demand for food. In recent years, there has been a significant increase in the use of agrochemicals. Several studies have been conducted to investigate the effectiveness of graphene derivatives in efficiently removing agrochemicals. Due to its abundant availability and relatively low cost, graphite is a natural carbon source for graphene synthesis. In the present study reduced graphene oxide (rGO) was synthesized using three different routes: chemical reduction, microwave irradiation, and the hydrothermal process. The rGO synthesized using different methods was characterized using X-ray diffraction, Raman analysis, Infra-red spectroscopy and diffuse reflectance spectroscopy. The rGO samples were evaluated in terms photocatalytic efficacy towards degradation of different agrochemicals, namely, chlorpyrifos (CPY), 2,4 dichlorophenoxyacetic (2,4-D) acid and atrazine (ATZ). Among the reduction techniques, rGO synthesized through chemical reduction and microwave-assisted methods demonstrated high removal efficiency of 94 and 95 %, respectively as compared to hydrothermal (83%) for the degradation for 2,4-D. The variation in temperature during the different reduction processes led to the formation of distinct functional groups and crystal structures, which play a crucial role in determining the photocatalytic activity.

Keywords: *rGO; Photocatalytic degradation; Agrochemical; Atrazine; Chlorpyrifos; Synthesis*

Sewage Treatment Using Membrane Bioreactor: A Review

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Abstract: A proper sewage treatment is necessary to avoid the contamination in the fresh water ecosystem. The conventional treatments are widely used for treatment of sewage. Due to the population growth and the pollutant load increases creates the thread to the aquatic environment. So, advanced treatment techniques like membrane bioreactor is essential to meet the good quality of treated wastewater. A system that combines membrane filtration with biological waste product breakdown is known as a membrane bioreactor. As wastewater properties change and pollutant loads rise, traditional solutions are no longer able to fulfill the growing standards. As a result, the membrane bioreactor has emerged as a useful substitute for treating wastewater since it can both handle the wastes and be used to fulfill discharge requirements. The review study focuses MBR performance in the literature in comparison to the traditional activated sludge wastewater treatment method. It is evident from the treatability tests that were taken from the literature that the MBR performed better in terms of operating conditions and removal efficiency than the conventional activated sludge process. To meet water consumption standards, numerous researchers have undertaken second-stage studies, which have revealed that MBR removes organic matter, nutrients, and microorganisms. Additionally, MBR produces an effluent that is unaffected by membrane configuration and biological treatment.

Keywords: *Organic matter; Nutrients, microorganisms; Membrane bioreactor; Conventional activated sludge process*

Studies on Wastewater treatment by the incorporation of particles in emulsion liquid membrane

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Abstract: Rapid growth in industrialization and urbanization has led to a significant rise in the generation of effluents from different industries concerning to textiles, food and beverages, dairy, petrochemicals pharmaceuticals, dyes, mining, electroplating and many more. This has generated issues related to proper disposal and treatment of these waste streams. Different techniques like adsorption, extraction, ion exchange and precipitation are already available but suffer from demerits like sludge generation, requirement of excessive and costly chemicals, more energy and auxiliary equipment. Emulsion liquid membrane (ELM) is a suitable option to treat these waste streams as it provides high surface area, require less chemicals, combines extraction and stripping in a single operation, less expensive and also saves the energy. But ELM has the demerit of emulsion stability. This issue has been investigated by different researchers by the incorporation of particles or nanoparticles and has been a subject of research for various investigators. Nanoparticles, owing to their high surface area and unique physicochemical properties, are utilized to improve the stability, selectivity, and mass transfer efficiency of the ELM system. The present study focuses impact of several factors towards contaminant removal efficiency. This study also underscores the critical role of nanoparticles in

advancing ELM technology, offering a sustainable and an efficient solution for industrial wastewater treatment applications and provides opportunity to the researchers to explore this area.

Keywords: *Emulsion Liquid Membrane*; *Wastewater treatment*; *Nanoparticles*; *Stability*

Techno-Commercial Evaluation of Continuous vs. Intermittent Water Supply for Self- Sustainability in Urban Area

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Abstract: Water is a critical resource, and ensuring its equitable, sustainable, and efficient supply remains a challenge for urban and rural areas worldwide. This study investigates the transition from Intermittent Water Supply (IWS) to Continuous Water Supply (CWS) systems, focusing on achieving a self-sustainable, 24x7 water supply. Key parameters include the role of water tariff systems, performance comparison of IWS and CWS, water audit outcomes, and self-sustainability of these systems. By analysing technical, and economic factors, this research aims to provide actionable insights for water engineers, policymakers, and utility concerned managements. The comparative analysis highlights significant inefficiencies in IWS systems, including high leakage rates, contamination risks, and uneven distribution. In contrast, CWS systems demonstrate superior performance with lower leakage, enhanced water quality compliance and increased user satisfaction. However, the shift to CWS systems entails challenges such as high initial capital investment, increased energy demands, and the need for upgraded infrastructure. This study also explores the potential of hybrid tariff models combining volumetric and flat-rate pricing to address revenue generation and affordability issues. Hybrid models incentivize water conservation, ensure equitable access for low-income households, and achieve up to 90-100% cost recovery compared to IWS systems with flat-rate tariffs. A detailed water audit was conducted to evaluate the performance of IWS and CWS systems. The audit revealed that non-revenue water (NRW) in IWS systems is high as compared to CWS systems, primarily due to physical losses like leakage and unauthorized usage. Recommendations include regular audits, advanced metering systems, and enforcement mechanisms like DMA formation to reduce NRW and improve system efficiency. The sustainability assessment considers economic, environmental, and social dimensions. CWS systems demonstrate long-term cost-effectiveness through reduced losses and enhanced resource utilization. Environmentally, they minimize water wastage and over-extraction, contributing to ecosystem balance. Socially, continuous supply systems reduce public health risks by delivering high-quality water consistently, thus improving user satisfaction and equity. The study concludes with a roadmap for transitioning to CWS, emphasizing phased implementation, infrastructure upgrades, and community engagement. Technical recommendations include using IoT-enabled monitoring systems, predictive maintenance tools, and energy-efficient pumps to address operational challenges. Policy-level interventions include implementing robust tariff reforms, institutionalizing regular water audits, and fostering collaboration among stakeholders. Also this research contributes to the global discourse on sustainable water management by presenting a comprehensive framework for designing and operating 24x7 water supply systems. While challenges such as resource constraints and resistance to change persist, the findings demonstrate that a transition to CWS systems is not only feasible but imperative for achieving long-term water security and sustainability.

Keywords: *Self-Sustainability; Water Tariff System; Non-Revenue Water (NRW); Water Audit, DMA*

Analysis of ground-water levels and quality parameters EC and PH and associated Trends of Pre monsoon and post monsoon over 20 years for the Nadiad branch canal command area of Mahi Right Bank Canal Project, Gujarat, India

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Abstract: Almost 980 water-level measurements in 49 wells in the Nadiad branch canal command area from 2001 to 2000 were taken and analyzed. An interpretative database was developed that describes water-level conditions for each water level. The climate of the study area is semi – arid and it is located in the agro-climatic zone GJ-3 middle Gujarat zone, Length 37.8 km and design discharge m^3/sec. The data were collected for pre-monsoon (May / June) and post-monsoon (October / November) periods. Water levels in 49 wells were analyzed for variability and for statistically significant trends. An attempt was made to identify the cause of many of the water-level fluctuations or trends. Trend analysis of groundwater depth (for pre and post monsoon periods) for 49 wells located in the command area shows that 45 wells in pre-monsoon period and 48 wells in post-monsoon period have decreasing trend of groundwater depth over years indicating rise in groundwater table with time in the Nadiad branch canal command area. Ground Water Depth Decreasing with time which indicates water logging condition over years. Analysis shows that during post-monsoon period, Average minimum value of EC of groundwater was found as 769 micromhos/cm to average maximum value was found as 1820.56 micromhos/cm. In the study area Average PH value post and pre monsoon is 8.7, slightly higher than recommendation, need to be treated. The study will be useful for the optimum allocation of crop area and water resources for maximize

revenue in a canal command area of Mahi Right Bank Canal. It is in direct relationship with the optimization of cropping pattern to get maximum crop revenue.

***Keywords**: water resource; canal command area; agricultural sustainability; Mahi Right Bank Canal; water quality parameters*

A Chronological review of geothermal water quality assessment: A case study from Unai, Gujarat, India

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Abstract: Unai is a prominent geothermal location in India. The water quality in the area has changed significantly due to a combination of geological, geochemical, and environmental factors. The quality of the water has been significantly affected by a combination of natural geological processes and human activities. The intricate interplay between geothermal fluids and the surrounding basaltic rocks, facilitated by the complex tectonic structures such as the Narmada-Son Lineament in the region, has caused substantial alterations in the composition of the water. These geological interactions have led to the dissolution of minerals, resulting in heightened levels of silica, sodium, potassium, and other ions in the water. The environmental conditions, such as the interaction of geothermal fluids with surface water, have significantly modified the water's pH, temperature, and overall chemical composition. This study has tried to assess the parametric changes in the quality of water in the study area over the past five years. Alongside natural factors, human activities like agriculture and industrialization have introduced additional pollutants, including nitrates, chlorides, and heavy metals, leading to further degradation of water quality. The interplay of natural geochemical processes and human activities has significantly altered the water quality in Unai Village. The study tries to find out the reason for the change in the water quality index. These changes have implications for the sustainable management and responsible use of geothermal resources in the region. Understanding these complex interactions is essential for effectively safeguarding the environmental and societal aspects of geothermal development in the area.

***Keywords**: Unai; Water Assessment Studies; Chronological; analysis; water*

WQI and IWQI Based Aquifer Assessment for Sustainable Irrigation: A Geospatial Evaluation of Surface and Groundwater Quality in Gujarat

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Abstract: Irrigation water quality is a crucial factor influencing agricultural sustainability and economic stability, especially in regions heavily reliant on groundwater. In Gujarat, rapid urbanization and intensified farming have led to increased dependence on surface and groundwater, making water quality assessment essential for effective irrigation management. This study applies the Water Quality Index (WQI) and IWQI to evaluate the viability of water sources for agricultural irrigation of available water resources. essential factors, including pH (7.4–8.2), Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Chloride (Cl^-), Sodium Percentage (Na%), and Bicarbonate (HCO_3^-), were analyzed across multiple locations. The IWQI values range from 22.34 (high restriction) to 93.96 (low restriction), indicating regional variability in water usability. Geospatial mapping techniques reveal zones with excessive salinity and sodium levels, which may lead to soil degradation and reduced crop productivity. Poor irrigation water quality can escalate agricultural costs, lower crop yields, and negatively impact rural livelihoods. Addressing these challenges aligns with the Sustainable Development Goal (SDG 6: Clean Water and Sanitation) by promoting effective water resource management. Implementing precision irrigation techniques, soil conservation measures, and strategic water policies can significantly improve water use efficiency. Strengthening monitoring systems and promoting sustainable aquifer management will be key to ensuring long-term agricultural viability and water security in Gujarat..

***Keywords:** Water Quality Index; Irrigation Water Quality Index; Water Quality Index; Sustainable Development Goal*

Industrial Waste Water Treatment through Sequential Aerobic & Anaerobic Digestion Cycle: A Green Approach

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Abstract: The treatment of effluent streams with high chemical oxygen demand (COD) remains a critical challenge in industrial wastewater management as they require high operational costs. Such streams often contain recalcitrant organic compounds that can create toxic environments for microbial communities, necessitating innovative and adaptive treatment approaches to mitigate environmental risks while ensuring compliance with discharge regulations. This study addresses the treatment of an exceptionally COD-loaded effluent stream generated from a caprolactam production plant using a novel green sequential approach. In order to promote microbial metabolism and facilitate the easy digestion of the toxic effluent, this method involves first acclimatizing cowdung slurry with Effluent Treatment Plant (ETP) sludge, followed by a periodic lower dose of caprolactam-based effluent in an anaerobic environment. And then, anaerobic digestion was performed using same acclimatized sludge as an inoculum. Finally, an aerobic treatment with ETP

sludge was applied to further polish the effluent and maximize COD removal efficiency. This integrated treatment strategy achieved an impressive 90% of overall reduction in COD of the caprolactam stream, as against single anaerobic treatment that gave only 44% reduction in COD in the lab scale studies. The same stream that underwent ammonia stripping provided 41 % of COD reduction using sequential treatment against 21% of COD reduction using only anaerobic treatment. This demonstrates the synergistic potential of combining anaerobic and aerobic processes. The findings contribute to advancing sustainable wastewater management practices and underscore the role of integrated green approach as a viable solution for challenging effluents.

Keywords: *Industrial Effluent; Anaerobic Digestion; Caprolactam; Chemical Oxygen Demand; Cowdung; Sequential Approach*

From Wells to Watersheds: Women's Strategic Role in Water Conservation and Management

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Abstract: Water conservation and management are crucial in addressing the escalating global water crisis. In India, women, as primary users and caretakers of water resources, play a vital role in ensuring sustainable water practices at both local and regional levels. This research resonates with Vandana Shiva's eco-feminist perspective, which underscores the deep ecological knowledge women possess and their pivotal role in water conservation. Shiva highlights how women's struggles for water security are intrinsically linked to broader ecological movements, emphasizing traditional practices such as rainwater harvesting and community-led watershed management as vital components of sustainable resource use.

Employing a case study approach, this study draws on document analysis of reports from NGOs and government agencies to examine five key instances of women-led water conservation efforts in rural India:

- Johad Revival in Rajasthan (Alwar District) – Women's role in restoring traditional johads to recharge groundwater.
- Amla Ruia's Check Dams in Rajasthan – Community-driven check dam initiatives improving irrigation and water security.
- Chauka System in Laporiya (Rajasthan) – Women-led implementation of structured rainwater harvesting techniques.
- Rameshwari Devi's Reservoir Initiative – Small reservoir construction enhancing year-round water availability.
- Women's Role in Hiware Bazar's Watershed Development (Maharashtra) – Self-help groups (SHGs) managing water resources for sustainable farming.

Through an analysis of these initiatives, the study explores women's contributions to water budgeting, community mobilization, and ecosystem restoration, while also identifying systemic challenges such as gender inequality, resource constraints, and limited representation in governance structures. By highlighting these case studies, the research underscores the transformative role of women in water conservation, from wells to watersheds. It advocates for gender-responsive policies, capacity-building initiatives, and the integration of women-led strategies into broader water management frameworks. In line with Shiva's ecofeminist perspective, this study reaffirms that empowering women in water governance is essential for achieving long-term water sustainability, environmental resilience, and social equity.

Keywords: *Water conservation; Water budgeting; Women's Strategic Role; Ecosystem Restoration*

HYDRATION: IMPACT ON ATHLETIC PERFORMANCE AND INJURY PREVENTION

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Abstract: Athletes often push their bodies to the limit, yet many overlook a simple but critical factor that could make or break their performance: hydration. Dehydration can creep up quickly during intense workouts, leading to fatigue, muscle cramps, and a loss of focus. As dehydration sets in, blood flow to working muscles diminishes, slowing recovery and impairing physical output. This can lead to prolonged soreness, reduced endurance, and an even higher likelihood of injuries such as strains and sprains. Understanding athlete hydration's role in recovery and injury prevention empowers athletes to train smarter and reach their potential safely. While drinking enough water may seem like a simple action, it impacts virtually every aspect of sports performance. Staying hydrated increases energy, improves movement, recovery and agility, thermoregulation, and aids in mental clarity and activity – all of which can improve physical performance and reduce the risk of injuries.

Keywords*: Hydration; Athletic Performance; Injury Prevention*

Reservoir Optimal Release Policy By Nature Inspired Metaheuristic Algorithm

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Abstract: Many places of the world are facing very serious problems of water scarcity. To tackle this issue, it should be essentially required to manage our present resources of water by adopting an optimistic usage strategy. Nowadays, different soft computing optimization techniques are motivating researchers to investigate complex real-life water resources issues to achieve promising and adoptable results. Metaheuristic algorithms (MHAs) are found to be better alternative optimization tools for identifying the optimal reservoir operation policies compared to traditional optimization methods due to their global approach to solving problems. During this study, a nature-inspired metaheuristic algorithm, namely the Cuckoo Search Algorithm (CSA), is adopted in the optimal operation of the Kadana Dam, located in the eastern part of the state of Gujarat in India. The developed CSA model shows high performance of optimal operating policies from the Kadana, which were considered over a period of 72 months, with a target of minimizing the gap between the supply of water for domestic, industrial, and irrigation purposes against demands by comparing historical releases with those of CSA model releases. Finally, observed to save 29.82% of the water of an amount of 6723 Mm^3 in total, spanning 72 months without compromising demands.

Keywords: *Metaheuristic Algorithm; Cuckoo Search Algorithm; Reservoir Optimization Operation*

Water Demand and Management: A Case Study of Jaipur

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Abstract: Jaipur, the capital of Rajasthan, is experiencing significant challenges in managing its water resources. The city, covering 413 sq.km and home to 3.01 million people, relies heavily on water supplied by the Public Health Engineering Department from the Bisalpur dam and tube wells. However, the current water supply of 509 Million Liters per Day falls short by 90, and a high Non-Revenue Water of 45% exacerbates the situation. This inefficiency points to critical issues in both water supply management and distribution. Given the finite water resources and growing demand, sustainable management and conservation are imperative for ensuring adequate water availability for future generations. This research paper aims to develop strategies for urban water management in Jaipur by assessing current water resources, evaluating supply and distribution systems, and exploring innovative management approaches. The scope of the research is confined to water resources within the Jaipur Municipal Corporation area, with an emphasis on understanding the connection between water supply sources and population distribution. By identifying key challenges and proposing effective strategies, the research seeks to lay the foundation for a more efficient and sustainable urban water management plan for Jaipur.

Keywords: *Water resource; Urban water management; Water conservation; Urban water infrastructure*

Sustainable Management of Ageing Water Storage Infrastructure in Maharashtra: The Case for Dam Neutralizing

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Abstract: Maharashtra, a state in India with significant water demands, depends on an extensive network of dams for irrigation, water supply, and hydropower generation. Many of these dams, constructed several decades ago, are now showing signs of ageing, leading to safety concerns, reduced efficiency, sedimentation, and escalating maintenance costs. These ageing structures also pose challenges to environmental sustainability and the long-term availability of water resources. This study investigates the feasibility of dam decommissioning as a sustainable strategy to address these pressing issues. The research assesses the condition of existing water storage infrastructures in Maharashtra, with a focus on identifying dams that are structurally unsound, environmentally detrimental, or economically unsustainable. Drawing insights from international case studies, the study evaluates the ecological, economic, and social benefits of decommissioning, such as river ecosystem restoration, improved sediment management, and enhanced community safety. Additionally, a framework for assessing and prioritizing dams for decommissioning in the context of Maharashtra is proposed, incorporating criteria such as environmental impact, structural integrity, and alternative water management solutions. The study also emphasizes the importance of stakeholder involvement and policy development to ensure equitable and sustainable outcomes. This paper concludes by advocating for the inclusion of dam decommissioning as a

strategic component of sustainable water resource management in Maharashtra, emphasizing its potential to restore ecological balance, enhance water security, and reduce long-term risks.

Keywords: *Ageing dams; Dam Neutralizing; Water infrastructure; Sustainable water management; Maharashtra; Ecosystem Restoration*

Storm Water Management in Kusumba Village: A Design Framework for Climate Resilience

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Abstract: The number and size of towns and cities in India have increased significantly due to rapid urbanization; between 2001 and 2011, urban agglomerations expanded at a rate of knots. This growth has made stormwater management more difficult, especially in unplanned areas where there is often inadequate drainage infrastructure. Additionally, the encroachment of natural drainage systems, like rivers and streams, complicates water management by reducing its ability to regulate runoff and filter pollutants. Surface runoff increases due to the dominance of impermeable surfaces like roads and buildings in urban landscapes, raising the risk of flooding, especially during periods of heavy rainfall. Urban planning now heavily relies on sustainable stormwater management techniques to overcome these problems. In order to anticipate peak runoff and direct the design of drainage systems, advanced hydraulic models like Manning's equation and the Rational Method are used. The use of climate models to evaluate infrastructure resilience in response to climate change is highlighted by case studies, such as those conducted in Malaysia. Reducing urban floods, enhancing water quality, and safeguarding ecosystems may all be achieved through sustainable stormwater management. Cities may become more resilient to present and future environmental concerns by combining contemporary technology with natural remedies.

Keywords: *Storm water; Management; Urban Planning; Rainfall; Drainage Systems; Runoff*

Assessing Shoreline Change Along Ireland's Coastline (2000-2024) Using Google Earth Engine

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Abstract: Coastal environments are constantly changing due to both natural forces and human activities, creating challenges as well as opportunities for sustainable growth. As shorelines undergo rapid transformation, it's crucial to understand the factors driving these changes in order to protect our coasts and local communities. This study focuses on the changes to Ireland's coastline between 2000 and 2024, using MODIS satellite imagery processed through Google Earth Engine (GEE). To detect the shoreline, techniques such as the Canny Edge Detector were applied, along with the Normalized Difference Water Index (NDWI) to identify change in water bodies. In 2000, Ireland's shoreline measured about 2376.637 km, but by 2005, it had shrunk to 2270.572 km. By 2020, the length was further reduced to 2084.948 km, showing a steady decline over the two decades. While erosion was a significant factor, some regions also experienced land deposition. Between 2015 and 2020, approximately 98 square kilometers of land were deposited, while 107.402 square kilometers were eroded. By 2024, the shoreline length had dropped to about 2070 km. Analyzing these changes is crucial for addressing the risks linked to shoreline shifts. By promoting sustainable management of coastal resources, this research aligns with the United Nations Sustainable Development Goal 11. Understanding and managing the dynamics of shorelines is key to fostering resilient communities, protecting biodiversity, and ensuring a sustainable future for coastal areas around the world.

Keywords: *Google Earth Engine (GEE); MODIS; Canny Edge Detector; NDWI; Sustainable Development Goals (SDG)*

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River Pollution Monitoring flowing through an Industrial Catchment using GIS and Remote Survey

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Abstract: The Sabarmati River, a major west-flowing river in India, traverses industrialized regions in Rajasthan and Gujarat, where it faces severe pollution challenges due to untreated sewage and industrial discharge. This study assesses the water quality in parts of Sabarmati river, which is crucial for potential projects like the Kalpasar reservoir. Ahmedabad, a major city along the river, generates 1,693 million litters of sewage daily, yet 613 million litters bypass treatment facilities and flow directly into the river, leading to significant environmental degradation. A GIS-based elevation and slope model was developed to identify optimal locations for decentralized sewage treatment plants (STPs), reducing the need for energy-intensive pumping. The results suggest that decentralized sewage treatment systems are more cost-effective than centralized ones, leveraging existing infrastructure and proposing the installation of additional STPs. This approach also presents an opportunity for sustainable power generation through biogas produced at the STPs, which can be used to operate the facilities. The study underscores the need for near real-time water quality monitoring in industrial urban catchments to prevent illegal wastewater dumping and improve river health.

Keywords: *River water Contamination; Untreated sewage; Sewage treatment plants; Remote survey; GIS*

Predictive Analytics of Wind Speeds Using Machine Learning Algorithm for Efficient use of Harnessing Water using Wind Turbine in an Agricultural Field

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Abstract: Earth's distinction among the many planets lies in its abundant water resources, fundamental to sustaining life. Beyond quenching thirst, water is a pivotal economic resource that fuels both economic and social development. Integrating wind turbines with water pumping systems, enhanced by artificial intelligence (AI) and machine learning (ML), offers a sustainable solution for water management, particularly in remote or off-grid areas. This approach combines renewable energy with an advanced prediction algorithm to predict wind speed. The idea of the work suggests the prediction outcome of the wind speed. The amount of water coming out for the pumping application depends on the speed of wind. The simulation model has been established by taking a wind speed for various locations. The wind turbine used for this work is applicable for water-pumping applications. The data set is generated with the help of system advisor model (SAM) software for different locations. To predict the wind speed the prediction algorithms are used to obtain the values of root means square error (RMSE) and mean square error (MSE). The comparative analysis is done by considering various locations of the Gujarat, India where there might be a possibility to install such wind turbines for water-harnessing applications in agriculture fields.

Keywords: *Artificial Intelligence; Agricultural Application; Machine Learning; Means Square Error; Root Mean Square Error; Wind Turbine; Water harnessing application*

Bibliometric Analysis of Water Resource Management: Trends and Evolution from 2015 to 2025

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Abstract: Purpose: Water resource management has emerged as a critical research domain due to increasing global water scarcity, climate change, and growing population demands. This study aims to conduct a comprehensive bibliometric analysis of research trends, thematic evolution, and impact in water resource management from year 2015 to 2025. This study identifies key areas of focus, influential authors, and emerging research themes in the field by analyzing research outputs, citation patterns, and collaborative networks.
Methodology: A bibliometric approach was employed using the Scopus database to retrieve relevant research articles published between year 2015 and 2025. The search strategy included article title, abstract, and keywords related to "water resource management". Data preprocessing involved removing duplicate and irrelevant records. Three leading bibliometric software tools VOSviewer, R-based Biblioshiny, and CiteSpace were utilized for analysis. VOSviewer was used for network visualization of co-authorship, keyword co-occurrence, and citation relationships. Biblioshiny, an R-based tool, provided statistical insights into publication trends, collaboration networks, and thematic clusters. CiteSpace facilitated the detection of emerging research fronts, burst keywords, and knowledge domain evolution.

Findings: The analysis reveals an increasing trend in research publications on water resource management. Especially with a significant rise in contributions from countries with high water stress and climate vulnerability. Keyword co-occurrence analysis highlights dominant themes such as integrated water management, sustainable development, and climate change adaptation. Citation network analysis identifies the most influential papers and authors shaping the field. Collaboration networks indicate a strong international research presence, with key partnerships among institutions in the United States, China, and Europe. Thematic evolution analysis suggests a transition from traditional water governance frameworks to more technology driven solutions such as artificial intelligence, machine learning, and blockchain applications in water resource management. Emerging trends indicate a growing focus on resilience strategies, nature-based solutions, and transboundary water cooperation.
Implications: This study provides valuable insights for researchers, policymakers, and practitioners in water resource management by mapping research trajectories and highlighting emerging areas of interest. The findings can guide future research by identifying gaps in knowledge, promoting interdisciplinary collaboration, and emphasizing the need for innovative solutions in sustainable water management. Policymakers can leverage these insights to develop evidence-based strategies for addressing global water challenges. The study underscores the importance of open access research dissemination to enhance knowledge sharing and international cooperation.
The bibliometric analysis of water resource management research from 2015 to 2025 underscores the dynamic evolution of this field. The integration of advanced bibliometric tools provides a structured approach to understanding research impact and emerging trends. Future studies should focus on further refining bibliometric methodologies and incorporating real time data analytics to enhance predictive capabilities in water resource research.

Keywords: *Bibliometric analysis; Water resource management; VOSviewer; Biblioshiny; CiteSpace; Sustainability*

Predictive Analysis of Multi-Effect Distillation Systems Using Artificial Neural Networks

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Abstract: Multi-Effect Distillation (MED) systems play a vital role in water desalination, yet accurately predicting their performance under varying operating conditions remains a significant challenge. While optimization methods have advanced, current studies often emphasize simpler thermal desalination processes, neglecting the intricate dynamics of MED systems. To address this gap, an Artificial Neural Network (ANN) model is developed to predict the distillate production rate (D/hr) using key input parameters, including steam flow rate, feed-to-steam ratio, system pressure, steam temperature, and feedwater temperature. Experimental data for training and validation were obtained from a 9-effect MED system with one condenser and preheated feedwater, capturing distillate production for a consistent steam flow rate of 29.9 kg/hr ± 0.8 kg/hr across 30 datasets. To enhance model performance, dropout layers were employed to mitigate overfitting, and data scaling techniques were implemented for optimal accuracy. The ANN models were tested across various train-test splits, ranging from 95-5 to 50-50, revealing a clear relationship between training data proportion and prediction accuracy. The analysis identified the 85-15 train-test split as the most effective configuration, achieving an average error of ±0.04% with maximum positive and negative deviations of +7.7% and -5.49%, respectively. Additionally, sensitivity analysis revealed that steam temperature and system pressure were the most significant predictors of system performance. This study demonstrates the capability of ANNs to address the complexities of MED system performance prediction while emphasizing the importance of methodological choices, such as train-test splits, in achieving accurate results. By refining predictive frameworks, this research provides a foundation for advancing ANN-based modelling in water desalination processes, ultimately supporting the development of more efficient and adaptive desalination systems.

Keywords: *Artificial Neural Networks; Multi-Effect Distillation; predictive analysis*

Design and Performance Analysis of 3D-Printed Free Piston for Household-Scaled Batch Reverse Osmosis (BRO) Systems

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Abstract: This research investigates the design, development, and performance evaluation of 3D-printed free piston mechanisms for a household-scaled Batch Reverse Osmosis (BRO) system. As freshwater scarcity becomes an increasingly critical global challenge, compact and energy-efficient desalination solutions are essential for domestic applications. The study explores a variety of piston geometries and materials, leveraging additive manufacturing techniques to achieve high precision and innovative design features. These pistons are optimized for key performance parameters, including work transfer, forward-backward pressure, fluid dynamics, and structural integrity, while minimizing material usage and manufacturing costs. Comprehensive testing is conducted under controlled conditions to measure the piston's influence on critical metrics such as water recovery rates, energy efficiency, and operational durability. The findings aim to identify the optimal piston configurations for achieving maximum efficiency in small-scale BRO systems. This research contributes to

the advancement of desalination technology by demonstrating the potential of 3D printing to enable cost-effective and sustainable water treatment solutions tailored to household needs.

Keywords: *Free Piston; Batch Reverse Osmosis (BRO); Additive Manufacturing; 3D Printing; Household Water Treatment; Sustainability*

Comparison of Paraffin Wax and Beeswax as Phase Change Materials for Energy Storage to Enhance Solar Still Output

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Abstract: The solar still Clean and potable water is one of the most important challenges in modern world. Clean water is a key goal mentioned in sustainable development goals for the globe. Solar stills proved a very cost effective and highly sustainable method to generate clean water using solar energy. The only limitation of a solar still in producing clean distilled water is its low output. Variety of methods have been tried to increase the distillate output of the solar still. Use of Phase Change Materials (PCMs) is one of the popular methods for increasing the output of the solar still by storing the heat energy in the PCM when the solar insolation is abundant during the daytime. Once the solar insolation starts to reduce in the evening, the heat stored in the PCM helps in keeping the temperature of the solar still high and increases the yield of the solar still. The passive solar still does not require any external power for sustaining its operations and augmentation of such solar still with PCM provides an excellent way to increase the utilization of solar energy for higher yield from the passive solar still. Different phase change materials have been used for this purpose. This paper compares the results of using paraffing wax and beeswax as PCM with single slope single basin type of solar still. Two solar stills of exactly same design and dimensions are used. One of the solar stills is augmented with paraffin wax containers as for energy storage and other is augmented with beeswax container for the same purpose. The results in terms of enhancement of output and efficiency of solar stills are compared for the two PCM materials.

Keywords: *Solar Still; Phase Change Material; Paraffin wax; beeswax*

Development and Validation of a Household-Scale Free-Piston Batch Reverse Osmosis (BRO) System for Brackish and Groundwater Desalination

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Abstract: As freshwater scarcity becomes an increasingly critical global challenge, compact and energy-efficient desalination solutions are essential for domestic applications. Batch reverse osmosis (BRO) systems are designed to maximize energy efficiency and water recovery in desalination processes. However, experimental investigations of batch RO systems, particularly at the household scale, remain limited. This study presents a comprehensive experimental analysis of a single-acting, free-piston BRO system developed as a pilot model for household-scale desalination of brackish and groundwater. The system utilizes a 3-inch spiral-wound membrane and was evaluated under environmental conditions with feedwater containing up to 5 g/L NaCl. Key performance metrics, including specific energy consumption (SEC), water recovery, salt rejection, and permeate output, were quantified. The influence of operational parameters, such as permeate flux and recirculation flow rate, on system performance was also examined. For the first time, osmotic back-flow was directly measured and integrated into the performance model. Experimental data were compared with a theoretical model of large-scale BRO systems, which accounts for salt retention, concentration polarization, and longitudinal concentration gradients within the RO module. The results confirm the performance of the pilot system, demonstrating its feasibility and energy efficiency. Furthermore, the system shows significant potential for future commercialization as a compact, sustainable solution for household scale desalination, offering a promising avenue for addressing water scarcity in domestic settings.

Keywords: *Batch Reverse Osmosis (BRO); Desalination; Brackish water; Specific Energy Consumption (SEC); Recovery; Household RO*

Sustainable Brine Management: Brine Valorization and Salt Mining in Desalination Processes with RecovOAR™ Technology

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Abstract: The environmental challenges posed by brine discharge from seawater desalination processes necessitate innovative solutions to mitigate ecological harm and promote resource recovery. This case study explores the implementation and performance of the RecovOAR™ pilot plant, a cutting-edge brine valorization and salt mining technology. The pilot plant leverages advanced membrane technologies, including nanofiltration (NF) and the RecovOAR™ process, to recover high-purity sodium chloride (NaCl) from desalination reject streams. Operating at a recovery rate of 75–78%, the system produces concentrated brine with salinity levels up to 255 g/L, addressing industrial demands for high-quality feedstocks while significantly reducing brine discharge volumes. The findings highlight the dual benefits of environmental sustainability and economic feasibility. By recovering valuable salts and minerals, the technology demonstrates the potential to transform brine from a waste product into a resource, supporting a circular economy. Conducted at the Al-Jubail facility in Saudi Arabia, one of the world's largest membrane desalination plants, the study validates the system's ability to process high-salinity reject water with minimal energy consumption and reduced concentration polarization, achieving a 5.7-fold reduction in waste volume at an energy demand of 4.5 kWh/m³. This study underscores the importance of integrating advanced desalination technologies to address the global challenges of freshwater scarcity and sustainable resource management. The RecovOAR™ process offers a promising pathway for industries reliant on NaCl imports and highlights the potential for scalable applications in environmentally sensitive and resource-scarce regions worldwide.

Keywords: *High recovery Seawater Desalination; Brine Valorization; Seawater Mineral Mining*

Hybrid Desalination Technologies: A Path towards Sustainable and Efficient Water Production

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Abstract: In this era of modernisation we are on the verge of freshwater scarcity and some parts of world is already facing the issue. Traditional techniques such as reverse osmosis (RO) and multistage flash distillation (MFD) are great to some extent, but they use high energy, have environmental cons and have saturated efficiency. Hybrid method of desalination is essential in that case to achieve highest potential to energy efficiency, flexibility and cost effectiveness, this can be achieved by combining two or more desalination processes. We will talk on different hybrid models such as Reverse Osmosis with Multi-Feed Desalination (RO-MFD), Reverse Osmosis with Electrodialysis (RO-ED) and Forward Osmosis with Membrane Distillation (FO-MD), referring that how these methods can improve water recovery and bring efficiency in energy consumption. It also talks about the integration of renewable energy in the hybrid model thus making it more sustainable. Moreover, emerging tech like microbial desalination cells shows possibility of small-scale water treatment plant. To make the hybrid model further better latest development is aiming for integration of optimised control system and better resource utilization techniques. One of it is nanofiltration (NF) membrane, majorly used for seawater treatment in order to make the desalination process work at high temperatures for thermal desalination and thereby increasing the water output. Innovation in technologies like desalination batteries and salinity gradient power (SGP) are ways to decrease energy usage by making electricity from natural salinity differences and there by making it more self-sustaining. Artificial Intelligence (AI) and machine learning (ML) helps in cost cutting by optimizing the process and also predicting the maintenance requirement. Although these techniques are existing but still there are some major problems which need to be addressed like brine disposal, membrane fouling, and high capital investment. Currently, research is going on for sustainable brine management techniques like zero liquid discharge (ZLD) and thereby reducing the environmental impact. This paper reviews present hybrid desalination techniques and its benefits, challenges and its potential, to add a step towards sustainable and efficient desalination.

Keywords: *Desalination; Reverse Osmosis; Batch Reverse Osmosis; Water Treatment; Multi-Effect Distillation*

Hydrogen Production by Electrolysis: A Review on Current Developments and Challenges

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Abstract: Growing concerns of climate change has made it imperative to look for alternative and clean energy sources for green future. Further, energy security is also a prime concern for any rising economy. One such source of energy that has

gained the spotlight in the recent times is green hydrogen (H_2) energy and economy. Although there are various techniques through which green hydrogen can be produced, one way to produce green H_2 is by water electrolysis using renewable energy. Recent studies have revealed the possibility of hydrogen production by different water electrolysis methods namely alkaline water electrolysis, anion exchange membrane (AEM) electrolysis, proton exchange membrane (PEM) electrolysis, and solid oxide electrolysis (SOE). Green hydrogen generation through water electrolysis accounts of only 4% of the total hydrogen production throughout the world. Further, this process requires ultrapure water to be used in elecrolyzer. Any salt present in the feed water corrodes the electrodes of electrolyzer and shortens its useful life. However, producing green H_2 at a global scale could strain freshwater sources for drinking and use in numerous industrial processes. The availability of vast seawater may help solve this problem if seawater desalination can be achieved at lower cost water. Therefore, desalination technologies will play a pivotal role in future H_2 production. This study aims at investigating the effects of water purity on green hydrogen generation. The research also focuses on providing the insights on the effect of feed water salinity on energy consumption, overall efficiency of the elecrolyzer, life of process components, and hydrogen production. Also the electrolyzer arrangement like zero gap electrolyzer cell is discussed based on its performance on different water salinity. The findings contribute to development of strategies for optimizing electrolysis process, considering the diverse water sources available, thereby advancing and maximizing the production rates from the available water sources.

Keywords: *Desalination; Reverse Osmosis; Batch Reverse Osmosis; Water Treatment; Multi-Effect Distillation*

Groundwater quality assessment for drinking purposes: A comparative study of Bharuch and Dang districts in Gujarat, India

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Abstract: The assessment of drinking water quality in the Bharuch (17 locations) and Dang (13 locations) districts of the South Gujarat Region is crucial for ensuring public health and sustainable water resource management. This study evaluates various water quality parameters, including pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Nitrate, Sulfate, Chloride, Fluoride, Hardness, Alkalinity, Sodium, etc. Principal Component Analysis (PCA) and a correlation matrix are applied to identify key contributors to water quality variations for drinking water quality. PC1 indicates hard water, PC2 indicates hazardous chemical contamination for health, and PC3 shows high minerals. The results indicate that drinking water in Bharuch is not suitable for consumption, primarily while half of the location of Dang's water is suitable for drinking.

Keywords: *Groundwater; Drinking; Principal Component Analysis; water quality*

Legal Frameworks for Ensuring Water Security in the Era of Climate Change: Challenges and Future Trends

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Abstract: Water security has become one of the most critical challenges in the face of climate change, which has amplified water scarcity, pollution, and uneven distribution. This paper explores the evolving legal frameworks designed to address these pressing issues and safeguard water resources for future generations. It examines the role of international, national, and local legal instruments in ensuring water security, focusing on their adaptability and effectiveness in responding to the dynamic challenges posed by climate change. The paper highlights existing legal challenges, such as transboundary water disputes, the recognition of water as a fundamental human right, and the integration of climate change considerations into water governance. Additionally, it looks at emerging trends in legal frameworks, such as the incorporation of sustainable water management practices, the promotion of water conservation through legal incentives, and the role of public-private partnerships in advancing water security initiatives. The paper also considers future trends in water law, including the potential for new international treaties, regional cooperation, and innovative legal solutions to address water scarcity, equity, and access. In conclusion, the paper emphasizes the need for stronger, more adaptive legal systems that can respond proactively to the challenges of climate change, ensuring long-term water security for all.

Keywords: *Water security; Climate change; Legal frameworks; Sustainability; Transboundary water disputes*

Design And Analysis of Urban Sewerage System Using Sewer GEMS

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Abstract: With the rapid pace of urbanization in the contemporary world, the intricate interplay between urban development and environmental equilibrium has become a critical concern. While urbanization contributes to overall national progress, it concurrently disrupts the delicate balance between human society and nature. The escalating complexities in combined storm and sewer water management, exacerbated by increased urbanization, pose significant challenges. Inadequate management of storm and sewer water elevates the risks of floods and waterborne diseases, with detergents in wastewater potentially causing kidney and liver damage. Sewer water carries hazardous syndromes such as giardiasis, amoebic dysentery, and cholera, leading to a decline in water quality and disturbing the broader hydrological cycle. The objective is to assess the existing network, identify deficiencies, and propose an optimized system that ensures effective wastewater management and environmental sustainability. This study employs SewerGEMS software as a comprehensive tool for evaluating existing and newly proposed drainage systems. By identifying deficiencies in the current drainage infrastructure, the research offers insights into potential remedies. Utilizing SewerGEMS software, the study meticulously details various input data and presents the obtained output results. Through the interpretation of these results, the shortcomings of the drainage system are highlighted. The research concludes by proposing viable solutions to address these issues, providing a pathway towards the development of an enhanced drainage system for a specific region. The findings of this study contribute to the broader discourse on sustainable urban development and water management strategies in the face of rapid urbanization.

Keywords: *Urbanization, SewerGEMS; Drainage Infrastructure; Sustainable Urban Development; Sewer System Optimization; Urban Water Management*

Innovative Strategies for Utilizing Treated Sewage in Power Plants: A Review

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Abstract: A major problem facing the world is water, or more specifically, freshwater shortage; about 380 billion cubic meters of wastewater are produced yearly, and over 72 billion cubic meters are produced in India. To address this issue, the Indian Power Tariff Policy 2016 mandates that thermal power plants (TPPs) utilize treated sewage water from nearby sewage treatment facilities (STPs) for non-potable uses. The Korba Municipal Corporation (KMC) provides 51 MLD of water, with 80% released as untreated effluent into the Hasdeo River. NTPC Korba, a major thermal power producer, has committed to recycling 20 MLD of treated effluent for industrial purposes as part of an agreement with KMC. This study evaluates the quality of municipal wastewater in Korba by examining parameters such as pH, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), and Total Suspended Solids (TSS). The effectiveness of advanced tertiary treatment methods, including reverse osmosis (RO), activated carbon filtration, ultraviolet (UV) disinfection, and ultrafiltration (UF), is assessed to ensure compliance with stringent industrial water quality standards. The overall results revealed that the BOD of the treated sewage was 10 mg/L, and TSS was 20 mg/L, which was in-stack with the reuse standards at NTPC Korba. By deploying tertiary treatment procedures, freshwater use was as much as 40% lower, allowing more sustainable water management practices, particularly in power plants. If treated, the sewage can eat up a lot of fresh water, and in turn, lessen the environmental impact of power plants.

Keywords: *pH; Chemical Oxygen Demand; Biological Oxygen Demand; Total Suspended Solid; Sewage Treatment*

The Role of AI and Robotics Material Handling in Enhancing Efficiency and Safety in Water Treatment: A Review

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Abstract: Water treatment plays critical role in availability of clean and safe water for various purposes, including drinking, industrial use, and irrigation. The rapid growth of need of water treatment plants has necessitated advancements in AI and material handling processes to meet increasing customer demands and enhance operational efficiency. Artificial Intelligence & Robotics are transforming the landscape of water treatment by addressing the challenges of efficiency, precision, and safety in water treatment facilities. Robotics Material Handling enables the execution of repetitive tasks like Chemical Dosing, Sludge Management, Filtration and Sedimentation Processes and Inspection in water treatment with safety and precision. This review explores the role of robotics in streamlining material handling processes during water

treatment processes, emphasizing its role in automating repetitive tasks, improving safety, enhancing precision, reducing costs, and contributing to sustainable practices.

Keywords: *Water treatment; Artificial Intelligence; Robotics*

Reuse of Produced Water for Drilling and Completion Fluids Through Resin Treatment

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Abstract: Produced water (formation water), the water received from oil and gas wells, represents one of the largest waste streams by volume and presents significant challenges in the oil and gas industry due to its complex composition. Effective treatment and recycling of produced water for reuse in drilling/completion/workover operations can significantly reduce the industry's environmental impact. In traditional operations either physical methods such as reduction in pressure drawdown and water shut-off jobs or permeability modification in the near wellbore region are conducted to control the water production. But these methods do not restrict and stop the associated water along with oil or gas stream from reaching to the surface production facilities and it is essential to handle and treat all such produced water from self-flowing wells or water coming after the enhanced oil recovery processes. The cost of separation, effluent treatment operations is significantly high. Most of the E&P companies are making an attempt to use the produced water by the re-injection of it into the reservoir order to maintain the pressure of oil wells and their by going for secondary recovery processes such as waterflooding. Therefore, efficient treatment of produced water should meet the objectives of cleaning the polluted water besides making it compatible for the useful use in various oilfield operations This research focuses on effective utilization of produced water, minimizing the carbon footprint, and proper handling of the contaminants present in the produced oilfield water through advanced treatment processes to promote the principles of reuse, reduction, recycling, and environmental sustainability. The contaminants in produced water typically include dispersed oil droplets, suspended and dissolved solids, heavy metals, and chemicals/additives. This paper highlights the use of ion exchange technology, specifically utilizing the "DOWEX OPTICORE" resin, for treating produced water by removing unwanted ions such as calcium, magnesium, and iron, making the water more suitable and compatible with the reservoir for use in drilling/well completion fluids for various wellbore operations. Ion exchange resins like DOWEX OPTICORE are highly effective in purifying water for drilling operations and reducing waste generation. The conventional preparation of ion exchange resins involves forming a cross-linked polystyrene matrix using styrene and a cross-linking agent like divinylbenzene (DVB). Functional groups are then incorporated to give the resin its ion exchange properties. Sulfonation, achieved by reacting phenol with concentrated sulfuric acid, imparts ion exchange capabilities to the resin beads. The treatment process for produced water involves several key steps: filtration and sedimentation to remove large suspended particles, oil and grease separation through gravity separators or skimmers, and ion exchange to remove dissolved ions. Following resin treatment, the water undergoes quality testing to analyze its composition, ensuring its suitability for use as drilling and completion/workover fluids. The newly prepared solution will be further processed to give drilling/completion / workover fluids. This research demonstrates a novel and efficient method for utilizing produced water in drilling applications, minimizing waste, reducing the environmental impact, and cutting down the cost of sourcing highly consumable materials. The use of ion exchange resins provides a sustainable solution for produced water management in the oil and gas sector.

Keywords: *Produced water; reuse, sulfuric acid; phenol, ion exchange; resin, adsorb; reuse, drilling fluid*

Leveraging Green Technologies for Climate Change Adaptation in Water Resource Management

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Abstract: Climate change poses significant challenges to water resources, necessitating innovative adaptation strategies that enhance resilience and sustainability. This paper explores the development of strategies that leverage green technologies to address the vulnerabilities associated with changing climate conditions affecting water management systems. As climate change leads to altered precipitation patterns, increased water scarcity, and the degradation of existing water infrastructure, it is imperative to implement adaptive measures that not only mitigate risks but also promote sustainable practices. We assess the current vulnerabilities in water resource management, emphasizing the importance of integrating green technologies such as rainwater harvesting, advanced irrigation systems, and eco-friendly wastewater treatment processes. These technologies can significantly improve the efficiency of water use and enhance the adaptive capacity of communities facing climate-related challenges. Furthermore, we discuss the role of policy frameworks and collaborative partnerships among governments, industries, and local communities in fostering an environment conducive to innovation and investment in sustainable water management practices. This paper presents case studies highlighting successful implementation of green technologies in various regions, showcasing their effectiveness in reducing vulnerability and improving water resource resilience. By adopting a multi-faceted approach that combines technological

innovation with community engagement and regulatory support, we aim to provide a comprehensive framework for developing effective climate change adaptation strategies in water management.

Keywords: *Climate Change; Water Resources; Adaptation Strategies; Green Technologies; Sustainable Water Management; Vulnerability Assessment*

Drilling Optimization for Geothermal Energy

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Abstract: The growing emphasis on sustainable energy has driven the development of advanced and cost-effective geothermal drilling technologies. This study evaluates the performance, energy requirements, and lithological applicability of three innovative methods: plasma torch drilling, percussive drilling, and thermal spallation drilling, based on a detailed analysis of available data. Plasma torch drilling uses high-temperature plasma to melt and vaporize rock, enabling a non- contact drilling process with minimal mechanical wear. While highly effective for ultra-hard formations and precise operations, its significant energy consumption presents economic challenges. Percussive drilling, which combines mechanical hammering with rotary motion, is particularly effective in hard rock environments. Its durability and compatibility with conventional drilling equipment make it a reliable choice, though it operates at a slower rate compared to newer thermal techniques. Thermal Spallation Drilling relies on high-temperature jets to create thermal stress that breaks down rock particles. This method strikes a balance between operational speed and cost-effectiveness. It is particularly advantageous for producing smooth wellbores and minimizing equipment wear, making it ideal for large-scale geothermal projects. The analysis reveals that spallation drilling outperforms the other methods in energy efficiency, operational speed, and adaptability to various geological conditions. Its low mechanical wear and rapid penetration reduce downtime and overall costs, making it the preferred technique for modern geothermal energy extraction. This research highlights the importance of selecting drilling methods tailored to specific reservoir conditions and emphasizes the potential of spallation drilling to advance geothermal energy production effectively and sustainably.

Keywords: *Geothermal energy; Plasma Torch Drilling Thermal Spallation Drilling; Percussive Drilling, Hard Rock and ROP*

Methodologies for hydrogen generation from oil and gas effluents: a case study from Cambay basin, India

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Abstract: Given India's commitment to becoming net zero and the growing energy demand as well as the detrimental environmental effects of the oil and gas industries, it's inevitable to use the effluents from these sources to generate carbon-free, accessible, safe, and reasonably priced fuel, like hydrogen gas. Heavy metals, hydrocarbons, and other pollutants present in oil and gas such as produced water and gas effluents are harmful to the public health and the environment. The most employed method to produce hydrogen gas is the Steam Methane Reforming method which uses the produced natural gas. The present study investigates various techniques used presently to produce hydrogen gas. The present study suggests that the Bioelectric Hydrogen Production method, which employs the use of electrolysis technology enhanced by renewable energy sources like biomass, is the most environmentally friendly way to produce hydrogen gas from oil and gas effluents in India. Utilizing its abundant biomass resources helps India achieve its goals for decarbonization and renewable energy while lowering its dependency on fossil fuels and purifying water. Based on the anticipated mission outcomes by the National Green Hydrogen Mission, utilizing the methodologies reviewed in this study will guarantee the reduction of nearly 50 MMT of annual greenhouse gas emissions with the development of a minimum 5MMT of green hydrogen production capacity per year at the same time treating oil and gas effluents and abating the dependency of fossil fuel.

Keywords: *Bioelectric hydrogen production; Steam methane reforming; Carbon capture and storage; Hydrogen gas, oil and gas effluents; Cambay basin*

Removal of Cationic dyes from river water at neutral pH through TEOS Cryogel

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Abstract: Organic dyes are widely used in various industries, but their unchecked discharge into water bodies poses serious environmental threats to ecosystems and human health. To address this challenge, it is essential to develop advanced materials capable of efficiently removing these pollutants. In this study, we synthesized a novel Tetraethylorthosilicate (TEOS) based aerogel using freeze drying, followed by a comprehensive structural and specific surface area analysis. The efficacy of the aerogel to adsorb Methylene Blue (MB) and Crystal Violet (CV) dyes from water. Parameters such as initial dye concentration, contact duration, and initial adsorbent dosage, were optimized for effective dye removal. The adsorption process adheres to a pseudo second-order kinetics model and conforms to the Langmuir isotherm. Remarkably, even after freeze drying, the aerogels demonstrated an ability to maintain their structural integrity, a feature of considerable significance. The specific surface area of the aerogel was measured to be 351.02 m^2/g with pore volumes 0.996 cc/g.

Notably, the synthesized aerogels exhibited an exceptionally high adsorption capacity for MB dyes, reaching a remarkable 29185 mg/g, marking a new high-water mark in comparison to previously reported results. The equilibrium adsorption capacity, which stands at 248 mg/g, emerged as the highest among all other documented outcomes. Furthermore, the synthesized aerogel exhibited a remarkable adsorption capacity for Crystal Violet Dye, reaching a maximum of 93.37 mg/g at pH 7. The equilibrium adsorption was determined to be 15.36 mg/g. This study establishes the aerogel as a groundbreaking material for addressing dye effluent pollution, paving the way for sustainable and efficient water purification technologies.

***Keywords**: PS; Mixed matrix membranes; Humic Acid; ZIF-7; Box Behnken method*

Hydrate-Based Desalination: Advancements, Challenges, and Future Prospects for Sustainable Water Purification

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Abstract: Water scarcity is a critical global challenge, necessitating the advancement of efficient and sustainable desalination technologies. Among emerging solutions, hydrate-based desalination (HBD) has gained increasing attention due to its energy efficiency and environmentally friendly nature. Originally proposed in the 1940s and extensively studied since the 1960s, HBD exploits the selective formation of gas hydrates to separate pure water from saline solutions. Gas hydrates are ice-like crystalline structures formed at specific temperature and pressure conditions when water molecules encapsulate guest gas molecules. Depending on the guest type, hydrates form in three distinct structures - structure I (sI), structure II (sII), and structure H (sH) - with varying water-to-guest molecular ratios. The desalination process involves three key steps: hydrate formation in saltwater, separation of hydrate crystals from the brine, and controlled dissociation to release pure water. While HBD requires significantly less energy compared to conventional desalination methods, the presence of salts increases the pressure and lowers the hydrate formation temperature, posing operational challenges. Additionally, slow hydrate formation kinetics hinder large-scale application, prompting research into kinetic promoters such as CO 2 nanobubbles, which enhance nucleation and growth rates. This review provides a comprehensive overview of the principles, advantages, and challenges of HBD, critically evaluating strategies to improve hydrate formation while maintaining sustainability. Furthermore, it highlights recent advancements in kinetic promotion techniques and discusses future prospects for scaling up HBD to complement existing desalination technologies and address global water security challenges.

***Keywords:** Gas Hydrates; Desalination; Hydrate-Based Desalination (HBD); Water Purification; Kinetic Promotion; Sustainable Technology*

Molecular Insights of Directional Solvent Extraction for the Desalination and Heavy Metal Ion Separation

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Abstract: Energy-efficient technologies for desalination and wastewater separation are essential for human health and water sustainability. It is well known that the traditional solvent extraction technique is simpler, energy efficient, and requires minimal operation compared to the other thermal separation methods. The advantage of directional solvent extraction (DSE) over traditional solvent extraction is the DSE can operate at low temperatures (~ 40 to 60 oC). However, DSE processes are mainly driven by solvent design. Interestingly, very few literature reports exist on the fundamental molecular-level understanding of solvent properties in the DSE processes. In this work, we perform all-atom molecular dynamics simulations to understand the role of amine-based solvents and fatty acids in high-salinity brine solutions. We also examine these solvents for extracting heavy metal ions from the aqueous wastewater. We investigate various interatomic and intermolecular structures, thermodynamics, and transport properties. Intra and inter-molecular structure properties between solvent-water, solvent-brine, and solvent-solvent reveal that the salt or heavy metal ions are separated from the vicinity of the solvent, and they form aggregates themselves with a small temperature change. The thermodynamic behavior of solvent and salt molecules shows favorable for observed structural transitions. The solvation free energy of Na+ and Metal ions in water and solvent becomes unfavorable with an increase in temperature. The diffusion of the ions and metal ions also decreases with a temperature rise. Overall, ion-ion interactions show dominant behavior compared to the ion-water and ion-solvent interactions.

***Keywords:** Molecular Dynamics Simulations; Directional Solvent Extraction; thermodynamics*

Advancement in Membrane Technology for Water Treatment and Desalination – An Overview

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Abstract: Membrane technology has emerged as a leading solution for water treatment and desalination due to its efficiency, sustainability, and cost-effectiveness. This review explores recent advancements in membrane materials, fabrication techniques, and process optimization to improve water purification performance. Innovations in polymeric, ceramic, and hybrid membranes have enhanced selectivity, permeability, and fouling resistance. Advanced nanomaterials, including graphene oxide, carbon nanotubes, and metal-organic frameworks, have been incorporated into membranes to improve their mechanical strength and filtration efficiency. In desalination, reverse osmosis (RO) remains the dominant technology, but forward osmosis (FO), membrane distillation (MD), and electrodialysis (ED) are gaining attention for their lower energy consumption and higher water recovery. Research efforts are focused on reducing biofouling and scaling, which hinder membrane performance. Antifouling coatings, surface modifications, and novel cleaning strategies have shown promise in extending membrane lifespan. Additionally, the integration of membrane processes with renewable energy sources, such as solar and wind power, is being explored to reduce operational costs and environmental impact. Recent developments in smart membranes with stimuli-responsive properties and artificial intelligence-driven membrane monitoring systems have further optimized performance and predictive maintenance. Sustainable membrane production using biodegradable and recyclable materials is also gaining traction to address environmental concerns. Despite these advancements, challenges remain in terms of cost, scalability, and long-term durability. Future research should focus on developing low-cost, high-performance membranes and optimizing hybrid membrane processes to improve efficiency. This review highlights key breakthroughs and identifies research gaps in membrane technology for water treatment and desalination, emphasizing the need for interdisciplinary approaches to address global water scarcity challenges.

Keywords: *Wastewater; Membrane; Bio-fouling; Desalination; Sustainability*

Microbial-Nanoconjugate Systems for Enhanced Treatment of Textile Wastewater

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Abstract: The combination of microorganisms and nanomaterials presents a promising approach for enhancing textile wastewater treatment. Microbial communities play a critical role in breaking down pollutants such as organic matter, nitrogen, and phosphorus through metabolic processes, effectively reducing biological and chemical oxygen demand (BOD and COD). Specific microbial species like Candidatus accumulibacter phosphatis and Aspergillus luchuensis are particularly effective in this process. However, challenges arise with microbial-only systems, including slower response times, biofouling, and sensitivity to environmental changes, making upscaling difficult. Nanomaterials, especially nano-conjugates, offer significant advantages in water purification by improving membrane performance and pollutant removal efficiency. Materials such as carbon nanotubes and nano-composites have shown promise in simplifying large-scale purification. Bacterial cellulose nanopaper, a novel material produced by bacterial fermentation, exhibits desirable properties like strength, flexibility, and biodegradability, making it suitable for various applications in nanotechnology and water treatment. Despite the potential of nanoparticles and microbes in wastewater remediation, limitations such as nanoparticle aggregation, biofouling, and environmental concerns hinder their exclusive use at larger scales. This study proposes a solution by integrating microbe-nanoparticle conjugates into porous media balls to enhance textile wastewater treatment at an industrial level. This approach aims to overcome current challenges, offering a scalable and efficient technique for wastewater remediation.

Keywords: *Textile wastewater treatment; Microbial biotechnology; Nanoparticle conjugates; Bio-nanoconjugates; Bacterial cellulose nanopaper.*

Simultaneous removal of Methylene Blue and Tetracycline from Realtime water sample using Curcumin, Zinc-oxide and Graphene oxide decorated nanocomposite

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Abstract: Industrialization has increased the prevalence of water contaminants, including dyes and antibiotics. Toxic and carcinogenic contaminants necessitate water remediation approaches. Adsorption is recognized as an economical and environmentally favourable route of remediation. The graphene oxide (GO), ZnO and curcumin were modified at varied ratios to

synthesize the desired composite (ZnO-cur-GO). Methylene blue (MB) and tetracycline (TC) were used as model contaminants to conduct water purification testing. The composite followed a pseudo-second-order model with Freundlich and Langmuir adsorption isotherms for MB and TC respectively. The composite showed much higher adsorption capability for MB (1420 ± 20 mg/g) and TC (2000 ± 20 mg/g) compared to previous studies. Meanwhile, the nanocomposite is easily recycled and regenerated. After three cycles, the composite had a high removal efficiency for MB (98.7%) and TC (97.5%). Electrostatic attraction and π-π interactions were identified as the key adsorption mechanisms. ZnO-cur-GO composite was tested for its ability to remove Tetracycline (TC) and methylene blue (MB) pollutants in real-time using a fixed bed column and continuous-flow adsorption. Furthermore, experiments on Ganga water and tap water validated the simultaneous removal of contaminants by more than 95%.

Keywords: *Methylene Blue; Tetracycline; Graphene oxide; curcumin; adsorption capacity; regeneration*

Preparation of oxidative membranes for the treatment of textile industry effluent

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Abstract: In this study, mixed matrix polymeric membrane were prepared to oxidize the organic pollutant present in dye bearing wastewater. The polymer, polyethylenimine (PEI) dissolved in GBL solvent was used as support and eucalyptus biochar was added to provide porous surface for the oxidative reactions to take place. Eucalyptus wood collected as forest residue was carbonized in a thermochemical reactor at 500 °C. Further various membranes were prepared by using spin coater technique. Biochar and membranes were characterized using FE-SEM and BET analysis to study their porous nature. Prepared membranes were tested in a stirred cell reactor to oxidize organic impurities present in 100 ppm of methylene blue (MB) solution using hydrogen peroxide as oxidant. The amount of hydrogen peroxide in the solution is directly related to the number of hydroxyl radicals generated in catalytic oxidation process, which ultimately affects the degradation of organic pollutants. H2O2 gets broken into hydroxyl radical due to its reaction with metal sites present on the surface of biochar. These hydroxyl radicals react with organic pollutants and oxidizes them in CO2 and H2O, thus treating the wastewater. The effect of oxidant dose was investigated by varying the H2O2/MB molar ratio and maximum 95% of MB removal efficiency was achieved for 1:1 H2O2/MB molar ratio.

Keywords: *Oxidative membrane; Methylene blue; Oxidation, Biochar; Hydrogen peroxide*

Various methods for Recycling and Reuse of Industrial Wastewater - An overview

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Abstract: Industrial wastewater treatment, recycling, and reuse have become essential strategies for sustainable water management in various industries. As global water scarcity intensifies and environmental regulations become stricter, industries are increasingly adopting advanced wastewater treatment technologies to minimize their water footprint and reduce pollution. This paper provides an overview of different methods employed for recycling and reusing industrial wastewater, highlighting their effectiveness, benefits, and challenges. Traditional treatment methods such as sedimentation, filtration, and chemical coagulation play a crucial role in primary and secondary treatment processes. However, advanced technologies such as membrane filtration, reverse osmosis, electrocoagulation, and biological treatments have significantly improved the efficiency of industrial wastewater recycling. These methods help remove contaminants, heavy metals, and organic pollutants, making the treated water suitable for reuse in industrial processes such as cooling, boiler feed, and irrigation. Industries are also exploring zero liquid discharge (ZLD) systems, which maximize water recovery and eliminate wastewater discharge, thereby ensuring compliance with stringent environmental regulations. The reuse of treated industrial wastewater offers multiple advantages, including reduced dependency on freshwater sources, cost savings, and lower environmental impact. However, challenges such as high operational costs, energy consumption, and the need for continuous monitoring and maintenance must be addressed to ensure the sustainability of these methods. This paper aims to provide insights into the latest developments in industrial wastewater recycling and reuse, offering a comparative analysis of different treatment techniques. By adopting efficient and sustainable wastewater management practices, industries can contribute to water conservation and environmental protection while enhancing their operational efficiency.

Keywords: *Effluents; treatment methods; pollution; zero liquid discharge; membrane filtration*

A Review on Corrosion and its Detection Techniques

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Abstract: Corrosion is a critical challenge in the oil and gas industry, threatening the integrity of infrastructure and safety of operations. Effective corrosion detection is essential for ensuring long-term asset performance, minimizing downtime,

and preventing catastrophic failures. This review provides an overview of the various corrosion detection techniques employed in the oil and gas sector, focusing on methods that support infrastructure integrity, and maintenance efforts. The advanced technologies, their strengths, limitations, and practical applications of each method are discussed, along with the role they play in routine maintenance and safety monitoring. This review highlights the importance of early detection in minimizing operational disruptions and maximizing asset life. Additionally, it explores the integration of these detection methods within preventive maintenance programs, with an emphasis on cost-effectiveness and reliability. By summarizing current practices, this paper aims to provide a comprehensive understanding of corrosion detection techniques and their impact on safety and maintenance in the oil and gas industry.

Keywords: Corrosion*; Press Mud; D*etection Techniques*;*

Process Optimization of Electrocoagulation Treated Recycled Paper & Pulp Process Wastewater

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Abstract: The electrochemical degradation of paper & pulp (P&P) process effluent based on recovered fibre (RCF) was explored using both a batch and a continuous reactor electrocoagulation (EC) method. Eight electrode plates of aluminium with a uniform space of 0.5 cm between each were used in a reactor. Response Surface Methodology (RSM) was employed to design the experiments using Central Composite Design (CCD). Total 20 experiments were performed to monitor the impact of original effluent pH (pH0), current density (Jc) and electrolysis time (Te) on retrieval efficiencies of Suspended Solids (SS), Chemical Oxygen Demand (COD) and Colour. The significance of the generated regression models was assessed using Analysis of Variance (ANOVA) and Coefficient of Variance (CV). High R2 values (R2 = 97.66%, 96.81% and 99.05% respectively for SS, COD and colour removal) suggest a reasonable representation of expected and experimental data. Lower CV and Standard Deviation (SD) value indicates reasonable reproducibility of experimental data and low absolute permissible error rate. Optimum retrieval efficiencies of SS, COD and colour were discovered to be 95.20%, 63.30% and 94.40% respectively for Single Response at a time Optimization (SRO). Optimum state was found for Multi Response Optimization (MRO) at 6.99 pH0, 37.32 mA/cm2 of Jc and 32.88 minutes of Te with 96.76%, 64.74% and 90.05% respectively, SS, COD and colour retrieval efficiencies. The process reached the balanced condition within 60 minutes for the continuous mode of operation and the retrieval efficiencies for SS, COD and colour were higher than 91%, 60% and 88% respectively. At the optimal condition, the operating cost for the present work is obtained approximately $1.0018/m3. Experimental findings show that treated water parameters are appropriate to the discharge norms of the Ministry of Environment and Forest, Government of India.

Keywords: *Electrocoagulation; Recycled Paper & Pulp Wastewater; Chemical Oxygen Demand; Total Suspended Solids; Central composite design*

Electrocoagulation Treatment for Removal of Reactive Dyes from Textile Wastewater

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Abstract: The textile production industry is considered one of the largest industry producing a complex wastewater which is challenging to environment it is remain untreated, emitting 15% of colours produced by finishing and dyeing operations that are harmful to the world's environment. So, it is critical to manage textile dyeing waste water prior to it is released into the ecosystem. Because of its ease of use and low sludge creation, the electrocoagulation (EC) technique was proposed and explored as a feasible environmental friendly waste water treatment method. This experimental study two reactive dyes are selected for the electrochemical treatment: a blue reactive dye (Reactive Blue 21) and a black reactive dye (Reactive Black 5) which is majorly used. This research work also evaluate the effectiveness of electrocoagulation in eliminating colour and chemical oxygen demand from dye effluent. The study investigate the several factors such as pH, Initial concentration of synthetic dye wastewater, applied currents, distance between electrodes, and treatment time. This study's findings highlight the importance of the Electrocoagulation process and the potential for its implementation on a commercial level.

Keywords: *Electrocoagulation; Textile dyes; Synthetic dye wastewater; Decolorization*

Comparative study on the removal of methylene blue using bio char synthesized using different pyrolysis methods

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Abstract: The rise in contamination of water sources with synthetic colors needs enhanced environmentally friendly methods of treatment. This study looks at the extent to which biochar made from rice husk may eliminate Methylene Blue (MB) dye from wastewater using two thermal processes: microwave pyrolysis (MP) and muffle furnace (MF) heating. Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), and UV-Vis Spectroscopy are utilized to thoroughly analyze the synthesized biochar's structural, thermal, and adsorption properties. Adsorption performance is assessed in a batch reactor system using crucial parameters such as pH, temperature, biochar addition, and initial dye concentration. This study reveals the most effective biochar synthesis process and best circumstances for maximum dye adsorption, resulting in a sustainable and scalable wastewater treatment approach. These discoveries promote biochar-based adsorption technology, supporting resource-efficient water-cleaning alternatives. This research explored how pyrolysis methods shape biochar's framework, capabilities, and stability, thus determining its dye removal efficiency. It identifies the best approach for optimizing adsorption by linking synthesis conditions to performance. These research results accelerate the development of high-efficiency, long-term biochar solutions for wastewater treatment and environmental sustainability.

Keywords: *Biochar; Methylene blue; Pyrolysis; Microwave*

Harnessing Machine Learning for Water Quality Management: A Random Forest Approach

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Abstract: Ensuring access to safe drinking water is a critical aspect of public health and aligns with Sustainable Development Goal 6, particularly target 6.3.2, which focuses on improving water quality. This research explores the application of machine learning models—Decision Trees and Random Forests—to predict water potability based on various quality indicators. Utilizing a comprehensive dataset, each model was trained and evaluated for accuracy in classifying water samples as potable or non-potable. Decision Trees offer interpretability by modelling decision paths based on water quality parameters, but may struggle with complex, non-linear relationships The Random Forest demonstrated superior performance, achieving an accuracy of 94.44% an F1-Score of 96.55%, a Precision of 93.33%, and a Recall of 100%. The enhanced performance of the Random Forest model can be attributed to its ensemble approach, which mitigates overfitting and captures complex patterns within the data. Implementing such robust predictive models facilitates proactive water quality management, thereby contributing to the achievement of cleaner and safer water resources.

Keywords: *Decision Trees; Machine Learning, Random Forest; Sustainable Development Goal; Water Potability; Water Quality Prediction*

Wastewater Management System Using Smart Deep Learning Approach

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Abstract: Wastewater treatment plays a vital role in urban and industrial areas, aiming to purify water and safeguard the environment. Wastewater management systems are specifically designed to efficiently clean wastewater, but they face significant challenges due to frequent and unpredictable variations in inlet flows. These fluctuations, caused by factors such as random rainwater or periodic sewage inflows (e.g., day-night cycles), can sometimes lead to system failures and outages. To address these challenges and ensure clean water quality above a set threshold while maintaining system operation, this paper proposes an advanced wastewater management system. The system functions as a cyber-physical system, monitoring and controlling inlet and outlet flows, water quality, and plant components. Built on an Environmental Internet of Things platform, it collects data from the treatment plant and processes it in real time using an intelligent information system hosted on a server. This intelligent system leverages deep learning techniques to optimize plant operations through real-time anomaly detection and decision-making support. By continuously adapting to varying

conditions, it helps maintain consistent water quality. The paper presents, analyzes, and discusses the data and results from a case study, highlighting the feasibility and effectiveness of this intelligent wastewater management solution.

Keywords: *Smart cyber-physical system; deep learning; anomaly detection; decision making*

AI Facilitated Water Credit Scheme for Sustainable Wastewater Management: A Hypothesis on Surat's Textile Industrial Ecosystem

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Abstract: Surat, a major textile manufacturing hub in Gujarat, faces significant challenges in managing industrial wastewater pollution due to rapid industrial expansion and complex discharge profiles. To address these challenges, we propose an innovative, AI-integrated water credit scheme coupled with a centralized wastewater treatment facility specifically designed for Surat's textile industrial ecosystem. This strategy aims to reduce pollutant loads by economically incentivizing industries to adopt cleaner production practices and invest in advanced treatment technologies. Under the proposed scheme, each industry receives a baseline allocation of water credits that corresponds to its permissible pollutant discharge levels. Industries discharging below their limits earn surplus credits, while those exceeding allocations are required to purchase additional credits. This dynamic trading mechanism creates a market-driven incentive to reduce pollution and fosters cooperative investment in a shared treatment plant. In here, Artificial Intelligence plays a critical role by integrating data from IoT-enabled water quality sensors, historical discharge records, and real-time monitoring systems. AI-driven analytics enable predictive modeling of pollutant loads, optimization of treatment plant operations, and simulation of various credit allocation scenarios. A centralized decision support dashboard provides transparent, real-time reporting on water quality parameters, credit balances, and compliance status, thereby empowering regulators and stakeholders with actionable insights. The integrated approach not only ensures efficient, adaptive management of the treatment process but also promotes equitable cost-sharing among industries. Financial incentives, rigorous monitoring, and a robust regulatory framework work in tandem to achieve sustainable water quality improvements. The proposed model offers a replicable blueprint for leveraging AI in industrial water management, ensuring that Surat's textile sector can thrive economically while maintaining environmental stewardship and regulatory compliance.

Keywords: *Water credit scheme; AI-driven monitoring; Wastewater treatment incentivization; Textile industry; Sustainable water management;*

Machine Learning for Water Quality Prediction: A Survey of Techniques, Challenges, and Future Directions

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Abstract: Predictions of water quality serve as a critical task, which protects both environmental sustainability and human health while supporting agricultural practice and aquatic ecosystems. Rising pollution in water sources drives an escalating need for precise predictive models that operate efficiently. Machine learning (ML) stands as an advanced tool which processes complex water quality information to execute real-time evaluations alongside predictions throughout multiple environmental settings. The survey tracks how ML techniques have progressed for water quality prediction through examinations of commonly used regression models as well as classification systems and hybrid approaches. This work analyzes datasets with traditional evaluation metrics. The technology displays new capabilities yet ongoing difficulties stem from data fidelity problems and performance limitations across model variations. Inputting IoT-based data sources alongside explainable AI constitutes an emerging approach to improve model interpretability and system robustness. The survey presents critical findings to guide ML specialists working on developing water quality control approaches.

Key words: *Water; Quality Assessment; Survey; Machine Learning; Public Health*

Machine Learning based Structural Health Assessment using RST invariant Features for SDNET18 dataset

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Abstract: Ensuring the safety and durability of concrete structures exposed to water is crucial, as cracks in these structures can lead to significant degradation and potential failures. This study focuses on the automated detection of cracks in concrete surfaces

utilizing the SDNET18 dataset, which includes cracks ranging from as narrow as 0.06 mm to as wide as 25 mm. The dataset features images with various obstructions such as shadows, surface roughness, scaling, edges, holes, and background debris. The proposed method employs Rotation-Scale-Translation (RST) invariant features alongside advanced image processing techniques, including High Boost Spatial Filtering, Histogram Equalization, Edge Detection, and Morphological Operations, to enhance the accuracy of crack classification. A Support Vector Machine (SVM) is utilized as the classifier, effectively distinguishing between crack and non-crack images. The effectiveness of the system is evaluated using metrics such as F1-score, precision, and recall, demonstrating its reliability in identifying cracks in concrete structures. This study investigates the potential of various image processing techniques for the automated detection of cracks.

Machine learning-based Physical and Chemical parameter Estimation for Fishpond Visual Condition Dataset

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Abstract: In aquaculture, monitoring water quality is of utmost importance, as the fish health and reproduction can be substantially impacted due to some physical and chemical parameters such as total dissolved "Aids (TDS), oxygen, temperature and PH. Conventional methods, they can be very time consuming and labor-intensive in nature they may not be able to provide real-time insights. On the other hand, the modem methods have explored machine-learning techniques for predicting water quality parameters in aid decision-making in fish farming. In this study, we exploit the Fishpond Visual Condition Dataset which contains 975 entries comprising images 100 x 100 pixels of a fish pond which is taken at different but specific times and locations. This dataset enables predictive modelling on the basis of visual information. Key physical and chemical parameters can be estimated from visual inputs in machine learning-based algorithms applied to this dataset. This would then give a non-intrusive, fast, and scalable option for aquaculture water quality monitoring in real-time.

Keywords: *Aquaculture; TDS; Machine Learning; Visual Data; Water Quality Analysis*

Mitigating Air Pollution in Wastewater Treatment Processes: Challenges, Strategies, and the Role of Carbon Nanomaterial Filters

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Abstract: Air pollution from wastewater treatment plants (WWTPs) arises from emissions of gases, volatile organic compounds (VOCs), particulates, and greenhouse gases (GHGs) during biological treatment, sludge management, chemical processes, and combustion. Key pollutants include ammonia (NH_3), hydrogen sulfide (H_2S), methane (CH_4), nitrous oxide (N_2O), and fine particulate matter, which contribute to odors, health risks, and environmental degradation. Mitigation strategies encompass odor control systems, gas capture, energy recovery, and process optimization to reduce emissions. Emerging technologies, such as carbon nanomaterial-based air filters, offer transformative potential. These filters leverage high surface area, catalytic activity, and electrostatic properties to effectively capture and neutralize pollutants, including NH_3, H_2S, VOCs, and aerosols. Their durability, customizability, and potential for regeneration highlight their advantages, though challenges in cost, scalability, and environmental impact remain. This review article endeavors to provide a comprehensive summary of the extensive work conducted to date on advancements in classical practices. It also highlights the latest research trends involving the use of carbon nanoparticles, showcasing their potential to achieve enhanced performance while significantly reducing costs.

Keywords: *Air pollution; Air-filter; Carbon nanomaterial; Air quality; textile material*

Microalgae biomass-mediated wastewater treatment using reverse osmosis reject water and their risk assessment

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Abstract: The production of microalgae in wastewater is gaining popularity as an effective way to remove excess nitrate and phosphate, reducing risk of eutrophication and its environmental harm. In the present study, the potential use of reverse osmosis reject (ROR) water with wastewater was investigated for the production of microalgal biomass as well as for the removal of nitrate and phosphate. The wastewater was supplemented with different percentages (25%, 50%, and 75%) of ROR water to increase nutrient availability and promote biomass growth. The experiment was carried out in a batch reactor using a jar testing apparatus, which was operated under controlled conditions: 150 rpm agitation, room temperature (27oC) and continuous white light illumination. The highest biomass yield of 1.31 g/L was achieved when 50% of ROR water was supplemented to the

wastewater. Moreover, during the biomass cultivation period, the highest removal rates of nitrate (89%) and phosphate (82%) were obtained under 50% ROR condition due to the high growth of biomass. The water bodies are at high ecological risk due to eutrophication as the risk quotient (RQ) was found to be greater than one. However, microalgae biomass production reduced this risk (RQ<1) by reducing nitrate and phosphate content below the permissible limits. Therefore, recycling of ROR water for biomass-mediated wastewater treatment, and risk mitigation can effectively manage fresh water resources.

Keywords: *Reverse Osmosis Reject Water; Biomass Production; Wastewater Treatment; Risk Assessment*

Synthesis and Characterization of g-C_3N_4 Photocatalyst for Efficient Degradation of Various Industrial Dyes

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Abstract: Water pollution is one of the major global environmental challenges of the 21st century. Various pollutants responsible for wastewater contamination, including industrial dyes, heavy metals, organic waste, and agricultural runoff. Among these industrial dyes are particularly concerning due to their toxic nature, stability, high water solubility, carcinogenic properties, and non-biodegradability. These dyes pose significant risks to human health, aquatic life, and ecosystems through their accumulation and transfer within the food chain. The removal of hazardous dyes from wastewater can be achieved through photocatalysis approach. g-C_3N_4 has emerged as a promising photocatalyst owing to its advantages, including ease of preparation, cost-effectiveness, high efficiency, and stability. In this study, g-C_3N_4 was synthesized via the thermal polymerization of thiourea at 550 °C. The synthesized catalyst was characterized using various techniques such as X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FT-IR), field-emission scanning electron microscopy (FE-SEM), UV-Vis diffuse reflectance spectroscopy (UV-DRS), and photoluminescence spectroscopy. The photocatalytic activity of the prepared g-C3N4 catalyst was evaluated for the degradation of seven toxic industrial dyes, including crystal violet (CV), indigo carmine (IC), methylene blue (MB), malachite green (MG), methyl orange (MO), congo red (CR), and rhodamine B (RhB), under natural sunlight for 60 minutes. The results showed that the catalyst achieved maximum removal efficiency for IC (100%), followed by 98.63% for CV, 96.84% for MB, 99.28% for MG, 16.66% for MO, 81.66% for CR, and 76.54% for RhB. The results highlight the potential of g-C_3N_4 as an efficient, sustainable, and cost-effective photocatalyst for wastewater treatment, contributing to environmental preservation and public health protection.

Keywords: *Wastewater; Dye removal; g-C_3N_4; Photocatalysis; Thermal polymerization approach*

Eco-Friendly Conversion of Packaging Waste into Low Cost Adsorbents for Effective Removal of Noxious Industrial Dyes from Wastewater

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Abstract: Water pollution is a major concern in the context of environmental stability, with dye pollution playing a significant role in the degradation of water quality. As the dye industry has expanded in recent decades, dye pollution has also increased. Dyes are hazardous and can pose serious risks to both human health and aquatic life. Various methods have been explored to remove toxic dyes, one of which is the adsorption method. This study investigates the use of biochar, derived from cardboard waste, as a low- cost and effective adsorbent. Biochar was prepared through the pyrolysis process at different temperatures 300°C, 450°C, and 600°C. The prepared biochar was characterized using FT-IR (Fourier Transform Infrared Spectroscopy), XRD (X-ray Diffraction), Raman spectroscopy, FE-SEM (Field Emission Scanning Electron Microscopy) and point of zero charge (PZC) analysis. Adsorption experiments demonstrated that the biochar exhibited effective removal of both cationic and anionic dyes. Among the samples, C300 showed the best results for cationic dyes, achieving 98.6% removal of Methylene Blue (MB) and 89.23% removal of Crystal Violet (CV), as well as 75.2% removal of the anionic dye Congo Red (CR) after 60 minutes of contact. These results suggest that biochar derived from cardboard waste, particularly at 300°C, is an effective and sustainable material for dye removal from wastewater, offering a promising solution to reduce dye pollution. Detailed investigation on kinetics isothermal analysis, effect of pH and dosage was carried to understand the underlying mechanism of adsorption.

Keywords: *Water pollution; Dye removal; Biochar; Adsorption method; Cardboard waste; Pyrolysis*

A Multi-Criteria Decision Analysis Framework for Ranking Wastewater Treatment Technologies

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Abstract. The growing complexity of wastewater treatment challenges, driven by stricter environmental regulations and an increasing diversity of contaminants, demands a systematic approach for evaluating and selecting the most effective technologies. With a multitude of emerging technologies available in a similar application domain, decision-makers face the critical need to identify the most promising options for scale-up and industrial adoption. This study presents a comprehensive multi-criteria decision analysis (MCDA) framework designed to objectively rank wastewater treatment technologies from best to worst. The framework integrates both quantitative and qualitative performance metrics, including technical efficiency, economic feasibility, environmental impact, scalability, and technology readiness. Three prominent MCDA methodologies are examined: the Analytic Hierarchy Process (AHP), the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and the VIKOR method. AHP uses pairwise comparisons to derive weighted scores that reflect expert judgments on the relative importance of each criterion. TOPSIS evaluates each technology by measuring its Euclidean distance from an ideal solution, while VIKOR incorporates both the utility and regret measures to provide a compromise ranking. The need for this ranking framework is underscored by the increasing volume of scientific research and technological innovations in wastewater treatment, which complicates direct comparisons between alternatives. Without a structured evaluation, stakeholders risk adopting technologies that may not offer optimal performance across all key criteria. Our results indicate that the proposed MCDA framework facilitates transparent, justifiable rankings and supports strategic decision-making for technology selection and scale-up. By integrating empirical data with expert insights, the framework enables stakeholders to navigate complex trade-offs and prioritize technologies that best meet evolving market and regulatory demands.

Keywords: *Multi-Criteria Decision Analysis; AHP; TOPSIS; VIKOR; Technology Ranking; Wastewater Technology Management*

Fly Ash-Derived Zeolite for the Removal of Calcium and Magnesium Ions from Hard Water

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Abstract: The use of cost-effective materials for zeolite synthesis offers a promising approach to improving water-softening processes. This study explores a novel method for synthesizing zeolite from coal-based fly ash using alkali fusion followed by hydrothermal treatment. This process not only provides a cost-effective means of producing valuable materials but also helps reduce industrial waste. The synthesized zeolite is specifically designed for the removal of calcium and magnesium ions from water. Key process parameters, including fusion temperature, alkali-to-fly ash ratio, hydrothermal treatment time, curing time, and curing temperature, were optimized. The zeolite was characterized using XRD and SEM and compared with commercially available 13X zeolite. The study evaluated the ion exchange efficiency of the synthesized zeolite for calcium and magnesium ions in comparison to commercial zeolite, while its thermal stability was also analyzed to assess its potential applications.

Keywords: *Zeolite; Fly Ash; Hardness; Ion exchange*

A Comprehensive Review of Biodegradable Polymeric Coagulants for Water Treatment

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Abstract: Water contamination poses a significant global challenge, necessitating efficient and sustainable treatment methods. Traditional coagulants, such as aluminium and iron salts, are widely used in water treatment but raise concerns related to residual toxicity, sludge management, and environmental impact. Biodegradable polymeric coagulants (BPCs) have emerged as promising alternatives due to their eco-friendliness, biocompatibility, and effectiveness in removing turbidity, organic matter, and heavy metals. This review critically examines the recent advancements in BPCs, highlighting their sources, synthesis, performance, and mechanisms of action. Natural polymers, including chitosan, starch, cellulose derivatives, and plant-based polysaccharides, have gained attention for their ability to coagulate and flocculate contaminants while minimizing secondary pollution. Furthermore, chemically modified biodegradable polymers, such as grafted or cross-linked biopolymers, exhibit enhanced coagulation efficiency and stability. The mechanisms of coagulation—charge neutralization, bridging, and sweep flocculation are discussed in relation to polymer structure and functionalization. Additionally, key factors influencing BPC performance, such as pH, dosage, and molecular weight, are reviewed. Comparative studies with conventional coagulants demonstrate that BPCs can achieve similar or superior removal efficiencies with lower sludge production and reduced environmental toxicity. However, challenges such as cost,

large-scale production, and long-term stability remain to be addressed. Emerging trends, including nano composite biopolymer coagulants and hybrid materials, offer potential solutions to enhance performance and applicability. This review underscores the potential of biodegradable polymeric coagulants as sustainable alternatives for water treatment. Future research should focus on optimizing their physicochemical properties, improving cost-effectiveness, and facilitating their industrial-scale implementation. The transition toward biodegradable coagulants aligns with the global push for greener technologies, ensuring safer and more sustainable water treatment practices.

Keywords: *Polymeric coagulants; Natural polymers; Coagulation mechanisms, Environmental sustainability*

Evaluation and Kinetic Studies on Biogas Potential of Residual Microalgal Biomass

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Abstract: Residual algal biomass after extracting lipids from microalgae, there is a leftover that still contains organic matter. Instead of being discarded or wasted, this biomass is repurposed for biogas production through anaerobic digestion. Anaerobic digestion is a biological process that breaks down organic matter (such as the residual biomass) in the absence of oxygen. The process produces biogas, which consists mainly of methane (CH4) and carbon dioxide (CO2). Before using the algal biomass for biogas production, the researchers performed a characterization to understand its composition and determine its suitability for anaerobic digestion. This includes assessing the volatile solids (VS) content, which is an important factor in determining the energy potential of the feedstock. To assess how well the algal biomass would perform under different conditions, batch studies were conducted. These studies involved varying the amount of volatile solids in the feedstock, ranging from 1 to 5 g of VS, to see how it affected the biogas production. The performance of the system was then analyzed using first-order kinetics, a mathematical approach to describe the rate of microbial digestion in anaerobic processes. In addition to the batch studies, semi-continuous studies were also performed. This involved introducing different organic loading rates (OLR), which is the amount of VS fed into the digester per unit of time. The rates tested were 0.5, 1, and 1.25 g of VS per liter per day. Semi-continuous operation means that the reactor was continuously fed with new biomass, allowing researchers to study the system's long-term performance. The study concluded that the optimal loading rate for stable performance in the anaerobic digester was 1 g VS. 0.5 L-1. Day-1. This rate provided the best balance between biogas production and system stability, avoiding overloading or underutilizing the system.

Keywords: *Biogas production; algal biomass; kinetics*

A Review on Application of CdO-SnO2 Nanocomposites on Dyes Degradation: A Sustainable Approach to Wastewater Treatment

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Abstract: Environmental and health problems arise from the unintended release of toxins into the environment owing to abundant production and use. These stable, complex contaminants are mutagenic and carcinogenic and affect aquatic ecosystems and individuals. Their tenacity makes removal difficult. While physical, biological, and chemical treatments are widespread, they may not eradicate all dangerous pollutants and cause secondary contamination. The advanced oxidation processes, especially photocatalytic techniques, have attracted the attention of many researchers toward dyes and pollutants degradation. Photocatalytic techniques use hydroxyl radicals and other highly reactive radicals to break down complex organic pollutants into harmless byproducts like CO_2 and H_2O. This review is focused on the function of binary metal oxide photocatalysts with an eye on their increased efficiency. This review especially focuses on CdO-SnO2 composites, which exhibit outstanding photocatalytic activity when exposed to UV light. This review shows how binary systems improve reactivity and flexibility when comparing photocatalyst performance.

Keywords: *photocatalytic; semiconductor; CdO-SnO_2 composite; metal oxide*

Analysis And Treatment Of Dairy Wastewater Using Rotating Biological Contactors

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Abstract: This study focuses on the analysis and treatment of dairy wastewater utilizing a Rotating Biological Contactor (RBC) integrated with Moving Bed Biofilm Reactor (MBBR) media. The experimental setup involved the application of MBBR media to enhance the biological treatment process. Dairy wastewater samples were collected and treated in the RBC system over a specified duration. Key parameters such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, total suspended solids (TSS), and other relevant metrics were monitored to assess treatment efficiency. The results demonstrated a significant reduction in pollutant levels, with a BOD removal efficiency of 72% and a COD removal efficiency of 80% indicating the effectiveness of the RBC-MBBR system in treating dairy wastewater. This research highlights the potential of advanced biological treatment methods in managing dairy waste and contributing to sustainable wastewater management practices.

Keywords: *Dairy wastewater; Rotating Biological Contactor; MBBR media; Biological treatment; Pollutant reduction; BOD; COD; TSS; Treatment efficiency; Sustainable management*

Investigation on adsorption capacity of adsorbent derived from maize for dyes removal from aqueous solution

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Abstract: Climate change poses significant challenges to water resources, necessitating innovative adaptation strategies that enhance resilience and sustainability. This paper explores the development of strategies that leverage green technologies to address the vulnerabilities associated with changing climate conditions affecting water management systems. As climate change leads to altered precipitation patterns, increased water scarcity, and the degradation of existing water infrastructure, it is imperative to implement adaptive measures that not only mitigate risks but also promote sustainable practices. We assess the current vulnerabilities in water resource management, emphasizing the importance of integrating green technologies such as rainwater harvesting, advanced irrigation systems, and eco-friendly wastewater treatment processes. These technologies can significantly improve the efficiency of water use and enhance the adaptive capacity of communities facing climate-related challenges. Furthermore, we discuss the role of policy frameworks and collaborative partnerships among governments, industries, and local communities in fostering an environment conducive to innovation and investment in sustainable water management practices. This paper presents case studies highlighting successful implementation of green technologies in various regions, showcasing their effectiveness in reducing vulnerability and improving water resource resilience. By adopting a multi-faceted approach that combines technological innovation with community engagement and regulatory support, we aim to provide a comprehensive framework for developing effective climate change adaptation strategies in water management.

Keywords: *Climate Change; Water Resources; Adaptation Strategies; Green Technologies; Sustainable Water Management; Vulnerability Assessment*

Phosphate Removal From Wastewater Using Agro Waste Adsorbent: A Review

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Abstract: Phosphorus contamination in aquatic environments has emerged as a major ecological issue, resulting in eutrophication and detrimental effects on water ecosystems. Traditional phosphate removal techniques face challenges, including high expenses, the need for chemicals, and the generation of sludge. Agricultural byproduct-derived adsorbents provide a sustainable, environmentally friendly, and economical alternative for extracting phosphate from wastewater. This review article summarizes the current understanding of agro-based adsorbents for phosphate removal, covering their preparation, characterization, adsorption processes, and methods for regeneration. The efficiency of different agro-based adsorbents, like rice husk, is examined. Additionally, the paper outlines future research avenues and possible uses of agro-based adsorbents in the context of phosphate removal from wastewater. This research highlights the feasibility of utilizing various agro-based adsorbents as an eco-friendly and cost-efficient approach for phosphate extraction from wastewater. The pH range of 4 to 9 usually has a higher adsorption capacity for eliminating phosphate from wastewater. Phosphate is

extracted from waste water by various agro-based adsorbents at varying dosages. The selection of adsorbent materials also affects the contact time. For effective phosphate removal, contact times range from as short as 50 minutes to as long as 240 minutes. The temperature has a significant impact on phosphate removal as well; around 25 ° C to 30 ° Celsius, phosphate removal capability was at its highest. Rice husk is majorly use as adsorbent for phosphate removal in most of the research papers. The majority of the studies were conducted at room temperature, or 25° Celsius. The removal efficiency of phosphate is varying by changing the agro waste adsorbent materials.

Keywords: *Agricultural waste; Wastewater Treatment; Adsorption; Rice Husk; Wheat Husk; Phosphate Removal Efficiency*

Sulphuric-activated Papaya Peel as a Bio-adsorbent for Adsorption of Methylene Blue Dye

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Abstract: This study evaluates the effectiveness of H_2SO_4-activated papaya peel as a natural adsorbent for removing methylene blue dye from an aqueous solution. Papaya peel, a common agricultural waste, offers a low-cost and environmentally beneficial alternative for wastewater treatment. Batch evaluations have been performed under various conditions, including contact time, initial dye concentration, pH, and adsorbent dose. More than 90% dye removal was achieved at pH 6.0, contact time of 120 minutes, initial dye concentration of 10 mg/L, and adsorbent dose of 0.3 g. Adsorption equilibrium results conformed to the Langmuir isotherm model, with a maximum adsorption capacity of 12.13 mg/g, confirming monolayer adsorption. Additionally, the data fits a pseudo-second-order kinetic model quite well (R2 = 0.99), indicating that bio adsorption is a chemisorption process. These findings highlight the potential of H_2SO_4-activated papaya peel as a sustainable and cost-effective adsorbent for wastewater treatment applications.

Keywords: *Papaya peel; Methylene Blue; H_2SO_4 activation; Langmuir isotherm; Eco-friendly adsorbent; Sustainable material*

Characterization and anaerobic co digestion of press mud – A critical review

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Abstract: Press mud, a byproduct of sugar manufacturing, is a nutrient-rich organic waste with potential applications in sustainable energy production. This review critically examines the characterization, composition, and anaerobic co-digestion of press mud to assess its viability as a feedstock for biogas production. Press mud is composed of cellulose, hemicellulose, lignin, and other organic matter, making it a suitable candidate for anaerobic digestion (AD). However, its high lignin content and C/N ratio variability can impact microbial degradation efficiency. Co-digestion with other substrates, such as bagasse, food waste, and slaughterhouse wastewater, enhances biogas yield, process stability, and methane content. Studies have shown that optimized mixing ratios significantly improve anaerobic digestion performance, leading to increased energy recovery and reduced environmental impact. The review highlights key parameters influencing AD, discusses challenges in feedstock variability, and suggests strategies for improving biogas production efficiency. Overall, press mud presents a promising opportunity for sustainable waste management and renewable energy generation, aligning with circular economy principles.

Keywords: *Biogas; Press Mud; Napier Grass; Anaerobic Digestion; Co-digestion*

Optimize Green Technology for Oil Spill Removal

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Abstract: The cleanup of accidental oil spills in aquatic environments remains a significant challenge due to the inefficiency of conventional oil sorbents, which tend to absorb substantial amounts of water along with the oil. Moreover, many existing cleanup techniques can lead to secondary contamination, further complicating environmental recovery efforts. In this study,

the oil absorption capacities of two hydrophobic natural fibres—aquatic lavender (Eichhornia crassipes) and lotus (Nelumbo nucifera)—were systematically evaluated. These materials offer an eco-friendly and sustainable alternative for mitigating oil spills. The investigation focused on their oil absorption efficiencies under laboratory conditions using engine oil, vegetable oil, and diesel oil as test samples. The performance of these fibres was analysed with varying particle sizes (BSS-44, BSS-60, BSS-100, BSS-120, BSS-160, and BSS-200) to determine the influence of particle size on absorption capacity. Results demonstrated that aquatic lavender exhibited superior oil absorption efficiency across all oil types and particle size ranges compared to lotus fibres. The hydrophobic nature and fibrous structure of aquatic lavender likely contribute to its enhanced absorption capabilities. Smaller particle sizes (e.g., BSS-160 and BSS-200) were found to exhibit higher absorption efficiency due to increased surface area, which facilitated better oil adherence. In contrast, larger particle sizes (e.g., BSS-44 and BSS-60) exhibited comparatively lower absorption due to reduced surface area availability. This study highlights the potential of aquatic lavender and lotus fibres as environmentally sustainable sorbents for oil spill mitigation, with aquatic lavender being particularly promising. The natural hydrophobic properties of these fibres, combined with their biodegradable nature, make them a viable alternative to conventional synthetic sorbents. Furthermore, the research underscores the importance of optimizing particle size to enhance oil absorption efficiency. Future studies should focus on scaling up this approach to evaluate real-world applications, including field trials and assessments of cost-effectiveness, as well as exploring the reuse and disposal pathways for these natural sorbents. By leveraging renewable natural fibres like aquatic lavender and lotus, this research contributes to the development of green technologies for managing oil spills while reducing secondary contamination and environmental degradation. The findings could play a pivotal role in advancing the adoption of nature-based solutions for oil spill remediation in marine and freshwater ecosystems.

Keywords: *Oil spill; Aquatic Lavender; Environmental sustainability; Biodegradation; Particle size; and Absorption.*

A Review on Hydrogel Materials for Wastewater Treatment

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Abstract: Hydrogels materials have gaining attention in the field of wastewater treatment for the removal of pollutants such as dyes and heavy metals due to their excellent adsorption capacity. Moreover, inherent characteristics of hydrogels namely biodegradability, easy separation, regeneration and reuse render them effective adsorbents for the removal of toxic contaminant from wastewater. The present review begins with outline of different types of adsorbents used for degradation of dyes and heavy metal removal from wastewater. This review specifically emphasized on recent developments in synthesis of hydrogel materials and their composites. In the following section, adsorption isotherm models and their thermodynamic parameters for the analysis of adsorption mechanism of pollutants on hydrogel adsorbents have been reviewed. Additionally, characterization techniques, as well as regeneration, recovery and reusability methodologies of hydrogel-based adsorbent materials are examined. Lastly, contemporary limitations of hydrogels and solutions for improvement in the view of future prospects are presented. The review provides valuable insights on application of hydrogel materials as a biosorbent for effective removal of harmful pollutants from wastewater..

Keywords: *hydrogels; composites; wastewater treatments; dyes heavy metals*

Stream Flow Simulation for Jarad Sub-Basin of Beas Basin using Snowmelt Runoff Model (SRM)

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Abstract: The Western Himalayas are an important water source for many communities, but climate change affects snowmelt patterns and streamflow. To predict streamflow and understand the associated snow dynamics in a data-scarce situation for the snow-dominated, wooded, hilly Jarad sub-basin of the Beas basin in India's Western Himalayan area, the Snowmelt Runoff model (SRM) was set up. The Jarad sub-basin was divided into 11 elevation zones and snow cover has been computed. The study is motivated by the need to understand the implications of changing snowmelt patterns on water resources, which are critical for agriculture, hydropower generation, and ecosystem sustainability in the region. Snow cover area (SCA), precipitation, and temperature data were collected and analyzed to achieve the objectives. SCA was derived from Google Earth Engine (GEE) JavaScript API and the SCA varies from 15% to 96% in the basin, and precipitation and temperature data were obtained from NASA POWER. To incorporate SRM in the study, WinSRM (Version 1.12) interface was used. Measured discharge of 2016 and 2017 were used as calibration and for validation, 2018 data were used in the current study. The efficiency of the model was evaluated using Coefficient of determination (R^2), and Volume difference (V_D). The Coefficient of determination (R^2), and Volume difference (V_D) during the calibration period were 0.80, 0.84, and 0.40%, -2.37% respectively, and during the validation period were 0.69 and 0.43% respectively. These results showed that the model reasonably captures the streamflow dynamics in the Jarad sub-basin. This study highlights the Snowmelt Runoff Model's ability to simulate streamflow in the Jarad sub-basin. Results extend knowledge of regional hydrological processes

and this research serves as a baseline for understanding the contribution of snowmelt to streamflow and offers valuable insights into freshwater availability.

Keywords: *Snowmelt Runoff Model (SRM); Snow Cover Area (SCA); Google Earth Engine (GEE); Simulation*

Exploring Land Use and Land Cover Transformations in the Vishwamitri River Basin Using Machine Learning: An Advanced Geospatial Approach Towards Sustainable Water Management

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Abstract: Land Use and Land Cover (LULC) change is a globally significant phenomenon, influenced by the increasing human population and rising pressure on natural resources. Monitoring and analysing these changes is vital for efficient environmental planning, conserving resources, and developing mitigation strategies for flood-prone urban areas. This study investigates the dynamics of Land Use and Land Cover (LULC) within the Vishwamitri River Basin, spanning around 5000 sq. km in Gujarat, India, using Landsat imagery from 2024 processed through Google Earth Engine (GEE). The LULC generation was carried out using the Random Forest (RF) model, with projections aimed at evaluating future changes and assessing potential flood hazards in Vadodara. Various machine learning algorithms, including Random Forest (RF), Support Vector Machines (SVM), Gradient Boosted Trees (GBT), K-NearestNeighbours (KNN), Classification and Regression Trees (CART), and Minimum Distance (MD), were employed to evaluate LULC classification performance. The land cover was classified into five categories: water surfaces, developed areas, farming regions, green spaces, and unproductive land. Among these models, RF achieved the highest accuracy (84.5%, kappa 0.78), followed by GBT (84.12%, kappa 0.77), and SVM (83.78%, kappa 0.76) demonstrated moderate performance, while KNN (81.85%, kappa 0.73), CART (77.6%, kappa 0.68), and MD (71.6%, kappa 0.68) recorded the lowest accuracy levels. The findings highlight the critical role of AI/ML-powered LULC analysis in enhancing flood risk mitigation and informing sustainable water management strategies within the basin. By addressing urban flood risks and promoting the sustainable use of natural resources, this research aligns with the United Nations Sustainable Development Goals, including those focused on clean water access, resilient cities, climate change mitigation, and the sustainable management of terrestrial ecosystems. It also advances AI applications for governance and sustainable development in water resource management.

Keywords*: Google Earth Engine (GEE); LULC classification; Machine Learning; Sustainable Cities; Sustainable Development Goals (SDG); Random Forest Model*

ARCSWAT and 1D HecRAS model based framework for flood analysis and management

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Abstract: Floods are annual phenomenon in any river during monsoon period. Hence during monsoon season, a hydrological model based framework is required to prevent flood disasters to lives and properties of people in any watershed. There are various types of flood mitigation measures available such as mathematical model based, hydrological model based, experimental based etc. In this study a combination of a hydrological model (ARCSWAT) and a hydraulic model (One Dimensional HECRAS) is used to propose a Framework for flood analysis and management (FFAM) for the Sabarmati River basin in Gujarat, India, which can be applied for flood mitigation in the downstream area using GIS techniques for proper development of flood-prone areas. In this study two measures have been proposed to manage floods: the first is changing land uses pattern in the catchment using a hydrological model and the second by adding artificial levee structures by using a hydraulic model. In the present study the Dharoi dam is already constructed so flood management can also be done by regulating flood discharges through dam gates in conjunction with the proposed hydrological models

study. This Research paper will help in flood mitigation in the downstream area using GIS hydrological modeling techniques for proper development of otherwise flood-prone areas.

Keywords: *Flood management; Flood mitigation measures; hydrological model; watershed; GIS techniques*

CLIMATE CHANGE INDUCED FLOOD INNUNDATION MAPPING USING H & H MODELS FOR KALUBHADAR RIVER BASIN

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Abstract: Rain is a vital component of the Earth's water cycle, playing a pivotal role in sustaining ecosystems, supporting agriculture, and ensuring water security. Rainfall exhibits considerable variability across regions and seasons. The Kalubhadar River Basin, located in the Saurashtra region of Gujarat, India, experiences a distinct rainfall pattern driven primarily by the southwest monsoon, which occurs from June to September. This basin is critical for the region's water resources, providing water for irrigation, drinking, and supporting local biodiversity. this study employs integrated hydrologic and hydraulic modelling to assess future flood inundation scenarios and their implications for water security under varying climate conditions. Using the SWAT model, basin hydrology was simulated, calibrated (2001–2014), and validated (2015–2020) with gauge data, ensuring accurate baseline conditions reflective of the basin's hydrological characteristics. Future climate projections from CMIP6 (SSP126, SSP245, and SSP585) were utilized to inform both 1D and 2D HEC-RAS simulations, providing insights into how changing climatic conditions may influence flood dynamics and water availability. the findings reveal significant increases in flood extent and magnitude, especially under high-emission scenarios (SSP585), highlighting the basin's vulnerability to extreme weather events. Additionally, the study underscores the risk of water insecurity due to the dual challenges of increased flooding and potential disruptions to the region's water infrastructure. Flood maps identify critical high-risk zones, offering valuable guidance for adaptive water resource management and climate-resilient infrastructure planning. this research underscores the importance of proactive, climate-informed planning to mitigate flood risks and safeguard water security. The refined and validated SWAT and HEC RAS models presented in this study provide robust tools for researchers, water resource managers, and policymakers, enabling informed decision-making for the sustainable management of water resources in the Kalubhadar River Basin.

Keywords*: SWAT; Kalubhadar River; CMIP6*

DETERMINING WATER SURFACE ELEVATION(WSE) OF VISHWAMITRI RIVER FOR CHRONIC BRIDGES OF VADODARA CITY USING HEC-RAS

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Abstract: Flood hazards are one of the catastrophic problems facing by and highly technological societies Throughout the human history, floods have been an integral part of the civilization. Still men have not quite copped well to live with To solve the problem, both structural and non- structural flood mitigation measures have been applied. Well-established, traditional non-structural measures such as zoning, building codes early detection & warning etc. appear today as indispensable complements to structural engineering solutions. The frequency and severity of floods have been to increase in recent decades. which have adverse effects on the environment, economics, and human lives. Bridges can be vulnerable to damage during floods, and it is required to predict realistically the danger level. The catastrophe of such floods can be confronted with the advance prediction of floods and reliable analyses methods. Recently the advancement in computer-aided technology has been extensively used in formulating models used for flood forecasting. The Vishwamitri River of India has experienced the severe flash flooding due to urbanization which unusually changed the catchment's hydrological and hydraulic characteristic. In this study an attempt has been made to develop a Hydraulic Flood Model for Vishwamitri river for chronic bridges of Vadodara city using HEC-RAS software. The developed hydraulic mcxiel using HEC-RAS has been calibrated for two years (1994- at Kala Ghoda, 2024- at Kala Ghoda and Mujmahuda) and validated for two years (2005 and 2019 at Kala Ghoda). We come to an conclusion from our analysis that, all the ten bridges we have taken under the analysis come under the chronic condition to prevent damage to bridges during floods.. The validated hydraulic rnodel has been used to simulate the water surface elevation at various bridges for different recurrence interval. Hydraulic model has been developed, using river cross section data's as an input which are obtained from SRTM DEM (30m resolution) . Developed model is calibrated against different Manning's •n' value as per river bed condition. The validated flood model is analysed for steady flow. Finally. the hydraulic model is run for the different recurrence interval such as & 100 years. Water surface profiles, water levels, discharge, rating curves, stage and flow hydrograph etc. outputs are obtained as a result of simulation scenarios. HEC-RAS simulation result has been Geospatial using RAS-Mapper to create flood maps

in Vishwamitri river for the study reach. The output is extremely useful to support the preparation of evacuation plans and to prevent damage bridges during the floods.

Keywords: *Hydraulic model (HEC-RAS); Vishwamitri river; Vadodara city; WSE; Bridges*

Assessing the Land use/land cover Change and mapping its responses on Hydrometerology for water sustainability in Northern Gujarat, Sabarmati Basin Using Earth observation data

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Abstract: Ongoing climate change and anthtropic land use change are two important factors that affect the riverscape and water resources worldwide. Currently, Land use/land cover change (LULCC) is one of the major global environmental challenges which can be driven by the multiple forces: industiralization, demographic pressure, climate variability and national policies which in turn have a significant impact on regional as well as basin scale. It significantly impact microclimate through its impact on land surface temperature (LST) and evaoptranspiration, which in turn hydrological responses and ecosystem services in that area. These changes in land use practices can pose a threat to environmental quality and ecosystem services to the inhabiting communities. The present study has been carried out in Northern Gujarat, which is encompassing the Sabarmati Basin and witnessing the blooming economy and population growth. The basin is one of the most water scarce region with lowest per capita availability of water has been reported. Thus assessing the land use practices and its response on hydrometrology is very important for water resource Sustainability. In the present work, high resolution Earth observation satellite images (LISS IV) has been used for LULC change between 2006- 2018 and its response on LST and ET has been observed and its interrelationship with various land cover type has been calculated using LANDSAT and MODIS data. LULC change study suggests there is a decrease in 10% of agriculture land and 6% decrease in forest land have been observed whereas an increase in 10% urban sprawal has been observed. The basin is also witnessing an average rise of 2.2°C temperature in summer and there is an increase in ET was observed from 1.5-123.1mm/year to 5.7-142.1mm/year during the study period. The present study will help the policy makers to formulate the policies to ensure the water and food security in the region in current land use practices.

Keywords: *LULC; Sabarmati Basin; Evapotranspiration; Land Surface; Temperature; MODIS*

Synthesis of Zeolite P from Kutch-Sourced Kaolin Clay for the Treatment of Agrochemicals

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Abstract: Wastewater containing harmful pollutants is being dumped into waterbodies on a regular basis causing a negative impact on human health. Various materials and technologies have been established for wastewater treatment. The development of new materials and technologies is still a topic of interest among scientists to overcome the drawbacks of existing resources. Adsorption is most simple and effective method for the treatment of water pollutants. Zeolites are the aluminosilicate materials which are extensively used in the adsorption processes, however, their synthesis from commercial grade precursors is costly and time taking. In this work, we have used natural Kutch-sourced kaolin clay converted it into efficient adsorbent zeolite P. The synthesis of Zeolite P was carried out via hydrothermal approach. The synthesized zeolite P is characterized via various characterization techniques such as Fourier Transform Infrared (FT-IR), X-Ray Diffraction (XRD), and Field-Emission Scanning Electron Microscope (FESEM). It is then investigated for the adsorption of agrochemicals.

Keywords: *Scanning Electron Microscope; adsorption; Fourier Transform Infrared; X-Ray Diffraction;*

Synthesis, Characterization and Application of Zeolite P-PANI Composite for the Treatment of Agrochemical

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Abstract: Water is basic necessity for all humans and animals on earth. Water gets contaminated as a result of various activities such as agricultural, domestic, industrial. The agrochemicals like pesticides, herbicides, fertilizers etc. can pollute the water and pose negative impact on human health and environment. Hence, the earliest remediation of these pollutant is needed. Different treatment technologies such as adsorption, filtration, photocatalysis, etc. have been employed for the removal of these pollutants from wastewater. Adsorption is considered simple yet most efficient method for wastewater treatment. In this work, we have used Kutch-sourced kaolin clay converted it into efficient adsorbent zeolite P. Zeolite P-Polyaniline (PANI) composite is prepared via in-situ polymerization method. The synthesized zeolite P, PANI and the composite are characterized via various characterization techniques such as Fourier Transform Infrared (FT-IR), X-Ray Diffraction (XRD), and Field-Emission Scanning Electron Microscope (FESEM). These materials were then studied for the removal of agrochemical.

Keywords: *Scanning Electron Microscope; adsorption; Fourier Transform Infrared; X-Ray Diffraction;*

Modeling and Optimization of Hydrogen Storage in Metal Hydrides

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Abstract: The increasing demand for efficient and sustainable energy solutions has brought hydrogen storage into the spotlight, with metal hydride systems emerging as a promising candidate. This work focuses on the modeling and optimization of hydrogen storage in metal hydrides using COMSOL Multiphysics. The study involves simulating the thermodynamic and kinetic behavior of hydrogen absorption and desorption processes within metal hydrides, considering factors such as heat transfer, mass transport, and reaction kinetics. Optimization techniques are employed to enhance hydrogen storage capacity, improve charging/discharging rates, and ensure system stability under varying operating conditions. The benefits of this approach include compact and safe hydrogen storage, scalability for diverse applications, and potential integration into renewable energy systems. This work aims to contribute to advancing hydrogen storage technology, addressing the challenges of energy transition and decarbonization.

Keywords*: Modeling; Hydrogen storage; COMSOL; Metal Hydride; Optimization*

Performance Evaluation of Stepped Solar Still with and without Storage for Hot & Dry Climatic Condition

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Abstract: The supply of drinking water is a major problem in underdeveloped countries. Fresh water is a basic human requirement for domestic, international, and agricultural development. 71% of the earth is covered by water, however the drinking water is only limited to 2.5% which includes that frozen in glaciers and underground water. Thus, it is important to harness ways to convert sea or brackish water into the drinking water. Solar still can be used to fulfil the need of safe water supply in different locations at a very affordable cost. The input energy is renewable and hence it is a sustainable alternative for clean water. However, due to lower output and constant cleaning requirements, solar still technology is not standard practice or commercialized. The factors that influence solar still output are solar intensity, wind velocity, depth of water, inlet water temperature, ambient temperature, and absorber plate area etc. This study aims at enhancing the water output by increasing the concentration ratio with the use of reflector. Also the impact of adding different storage provisions (sensible and latent) is investigated for the stepped solar still. The storage integration allows the system to extend the working hours post sun-set. The results show that the system with storage increases water output by around 56 % compared to the conventional solar still. This work demonstrates that, adding the thermal storage to solar still can provide a reliable and efficient way to address water scarcity in hot and dry climate of Gandhinagar.

Keywords: *Renewable Energy; Clean water; Water Scarcity; Sensible heat and latent heat material*

Review on Layered Double Hydroxide for Applications in Environmental Sustainability

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Abstract: The gradual rise in atmospheric concentration of carbon dioxide gas (CO_2) is an important global concern. Several methodologies and technologies are proposed and applied by industries to mitigate the emission of CO_2 into the atmosphere. There are various reports regarding the studies of CO_2 adsorption using various techniques as development of technologies allows everyone to reduce CO_2 which is mandatory in today's society. This paper explores the synthesis, properties and potential application of $MgNO_3$ - $AlNO_3$ layered double hydroxide (LDH), a promising material for various environmental and industrial applications. $MgNO_3$ - $AlNO_3$ LDH is known for its unique structural characteristics, high ion exchange capacity, stability and tunability making it suitable for use in process such as CO_2 capture, wastewater treatment and catalysis. The $MgNO_3$–$AlNO_3$ LDHs are studied for their efficiency in removing pollutants such as heavy metals, dyes, and organic contaminants from water. The Layered Double Hydroxide offers excellent adsorption capacities, attributed to the high surface area, layered structure, and tunable chemical composition which can be leveraged to address environmental challenges, particularly in mitigating pollutant emissions. This review provides in depth analysis of synthesis techniques, structural features, modification techniques of $MgNO_3$ -$AlNO_3$ LDH, emphasizing its role in advancing sustainable solutions for contemporary issues.

Keywords: *Climate Change; Carbon Capture; Co-Precipitation; Layered Double Hydroxide; Mg- Al LDH; Water Treatment.*

Advanced Sustainable Farming with Nano-fertilizing: A Scientific way to Safeguard Water Contamination

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Abstract: Fertilizers are essential for replenishing soil nutrients to meet the growing global population and food demands by boosting crop yields and ensuring food security. However, excessive use of soluble bulk fertilizers negatively affects soil structure, causing compaction, and harms water quality through nutrient leaching, eutrophication, and groundwater contamination. In contrast, nano-fertilizers offer a sustainable alternative with controlled nutrient release, reducing nutrient losses and runoff while enhancing nutrient-use efficiency and crop productivity. Their lower application rates further minimize environmental impacts, promoting healthier ecosystems. Adopting eco-friendly fertilization practices is crucial for achieving high agricultural productivity while preventing water contamination in modern farming systems. This study emphasizes the importance of sustainable farming techniques, focusing on the role of nano-fertilizers in addressing environmental challenges and supporting the global transition to more efficient and responsible agricultural practices. Such approaches are vital for preserving resources and ensuring long-term food security.

Keywords: *Nano-fertilizer; Water contamination; Sustainable farming; Eco friendly; Nutrients*

Sustainable Emission Mitigation Using PCB Plates: A Novel Approach for CO_2 Capture from Vehicle Exhaust

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Abstract: This study explores the use of waste printed circuit board (PCB) plates for capturing CO_2 and reducing harmful emissions from vehicle exhaust systems, advancing an eco-friendly solution for emissions control. Leveraging the unique properties of PCB plates, which contain various metals, the research investigates both physical adsorption and chemical interactions that enhance the capture of CO_2 and other pollutants like CO, SO_x, and NO_x. The mechanisms involve physisorption through surface forces and chemisorption via metal-gas interactions, optimizing pollutant capture. Key parameters, including surface area, gas flow, temperature, and pressure, were systematically analyzed to maximize adsorption efficiency. The catalytic properties of PCB-derived materials also facilitate pollutant transformation, positioning waste PCB plates as sustainable materials for automotive carbon capture and emissions reduction. This work contributes valuable insights into recycling waste materials for environmental applications and highlights PCB plates as a promising adsorbent in the development of green vehicular emission technologies.

Keywords: *Waste Printed Circuit Boards (WPCB); CO_2 capture; Emission Reduction; Pollutant Adsorption; environment sustainability; physisorption*

A Review on Synthesis & Modifications of Layered Double Hydroxide for Applications in Carbon Capture

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Abstract: The increasing concentration of atmospheric carbon dioxide (CO_2) poses a significant global challenge, primarily driven by human activities such as fossil fuel combustion, deforestation, and industrial processes. This rise in CO 2 levels contributes to climate change and necessitates urgent action to mitigate its effects. Various methodologies and technologies have been proposed and implemented across industries to reduce CO_2 emissions, with carbon capture and storage (CCS) being a prominent strategy. Among the innovative approaches, the application of Mg-Al-CO_3 Layered Double Hydroxide (LDH) in carbon capture has emerged as a promising solution. This review presents a comprehensive analysis of the applications and modifications of Mg-Al-CO_3 LDH in the field of carbon capture. The unique structural properties of LDHs facilitate effective CO_2 adsorption, making them suitable for use in various carbon capture technologies. By enhancing the adsorption capacity and stability of these materials, researchers aim to develop efficient, renewable, and sustainable methods for balancing atmospheric CO_2 levels. The findings underscore the critical role that advanced materials like Mg-Al-CO_3 LDH can play in addressing climate change through effective carbon management strategies.

Keywords: *Climate Change; Carbon Capture; Co-Precipitation; Layered Double Hydroxide; Mg-Al LDH; Modifications.*

Carbon Capture Utilization : Membrane Method

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Abstract: Increasing amounts of CO_2 in the atmosphere necessitate increasingly effective technology for capturing and reducing its presence. Membrane-based carbon capture method that is energy efficient, economically effective, and environmentally beneficial have piqued researchers' curiosity. This study compares the ability of organic, polymeric, and synthetic membranes to separate and remove CO_2. The study assesses membrane performance based on key parameters like selectivity, permeability, CO_2/N_2 separation ratio, thermal stability, and chemical resistance. The study evaluates various membrane types under controlled conditions to determine which membrane is optimal for effective carbon collection. The findings are intended to inform the design of nextgeneration membranes for industrial-scale carbon management applications.

Keywords: *Carbon capture Membranes; Polymer membranes; Synthetic membranes; CO_2 separation; Permeability and Selectivity; Climate change mitigation*

CFD simulations to study the effect of novel impeller design and operating parameters: Flow patterns

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Abstract: Processes involving treatment of wastewater including domestic, chemical or pharmaceutical effluents depends on mixing operations. The efficiency of these mixing operations are greatly influenced by the impeller design and operating parameters like impeller speed. In the present work, the effect of impeller geometry and rotational speed on hydrodynamics in stirred tank have been studied. Four different designs namely cross blade impeller (A130), patented impeller (A320), curved blade (CB) and curved blade with disc (CBWD) impellers have been chosen. The performance of these four impeller designs in terms of radial velocity profiles at different 6 different axial positions have been presented each for 5 different speeds. Further, qualitative information in the form of velocity contours and vectors have also been presented. The CFD simulation illustrate the trade-offs various designs for certain applications by highlighting important differences in velocity distribution. The flow patterns a significantly different from the conventional radial and axial impellers used in the industry with significant asymmetry near and away from the impeller. This trend is expected to provide improved mixing efficiency with lower power consumption.

Keywords: *Computational Fluid Dynamics; Stirred vessels; impeller design; flow patterns; mixing*

Multi-phase flow simulation using euler-euler model for waste water-treatment

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Abstract: Water contamination has been a major global problem due to disposal of harmful chemical by-products in water bodies. This has resulted to both water shortage and harmful health effects to people. Despite emerging technologies, they still fall short to overcome this problem completely. So, development of efficient techniques is still required, this research focused on optimal microbubble reactor design by software which gives good understanding of fluid flow and reaction kinetics study of ozone microbubbles with waste when ozone is sparged in waste water. Fluid dynamics and reaction kinetics can be analysed using a fluid simulation of the flow using Euler Euler model based on and Two-film theory as mass transfer theories using reaction-diffusion model. According to literature renewal theory gave over 85% accurate predictions compared to experiment performed under turbulent flow pattern with microbubble size distribution of 20-100μm. Extreme high stirring rate isn't favourable as it increases mass transfer by diffusion at an expense of microbubble coalescence, only ozone-gas phase flow and liquid phase flow with Reynolds number below 2000 and 2000-4000 respectively provided both stable microbubbles and good mass transfer rates. Sparging at the bottom region of cylindrical tank as inlet it provided lower bubble coalescence potential risk, uniform concentration gradient and prevented localized ozone depletion at a single region when performing simulation. This paper will be a good foundation for practical modification of reactors with massive reduced size and faster purification with only an added microbubble generator as an energy input requirement henceforth overall, reduction in capital and operational cost about 60% can be achieved.

Keywords: *Multi-phase flow; Euler-Euler model; Waste water treatment*

Hydrodynamic studies in gas-liquid stirred bioreactor system using CFD simulations

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Abstract: In the present work, CFD simulations have been carried out in a gas-liquid stirred bio reactor using Eulerian-Eulerian approach. The CFD model is first validated with the experimental data of Kordas et al. 2020. An experimental geometry of a dual-impeller (essentially a Rushton Turbine) has been considered and the axial and radial velocity and gas holdup profiles have been evaluated for different superficial gas velocities (Reynolds numbers 1000 – 40000) and different impeller speeds (0.1-13 s-1). The gas holdup was observed to increase with increase in superficial velocity and speeds at an optimum combination. Qualitative flow patterns in terms of velocity vectors for the vertical central plane are compared with the single phase velocity vectors. Mixing efficiencies are observed to be 60-70% higher than that of the single phase. Quantitative radial velocity profiles also provide better mixing even for lower speeds for which the single phase profiles show significantly lower mixing. The shear near the impellers is reduced by 50% signifying that the system can be used for biological applications involving bacterial species having a challenge to survive in high shear regions..

Keywords: *Optimization; Fluid Mechanic; Multiphase Flow; Hydrodynamics; Fluid Flow*

Hydrodynamics in wastewater treatment processes involving air-water systems: Experimental measurements and CFD simulations

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Abstract: Antimicrobial resistance has been growing into a concern over the past few years. Advanced Oxidation Processes like electro-peroxone have proven to be an effective way of mineralizing contaminants (like pharmaceutical drugs) in water. Hydrodynamics of gas in the liquid plays a major role in understanding the oxygen requirement for effective radical generation that is crucial for the performance of the electro-peroxone process. The present work focuses on the study of hydrodynamics of the gas in the liquid without actual reactions using experimentation and CFD simulations. The study was carried out both for single and two phase. Single phase experiments and simulations consisted of water+dye as dispersed phase and water as continuous phase in laminar regime. Quantitative results in terms of mixing time were studied while qualitative results in terms of velocity vectors to understand the flow field was studied. Two phase Eulerian-Eulerian model is used for the CFD simulations to understand the hydrodynamics of air in water while corresponding experiments have been performed in the presence of instant introduction of dye. Experiments and simulations were in turbulent regime. The mixing time from the experiments and simulations were compared and showed good agreement. The flow field, hold-up and turbulence parameters obtained from the simulations provided sufficient insight of the transient phenomena from

start of the run to the steady state. The CFD model predictions were in good agreement (~13% deviation) from the experimental data. The CFD model development is expected to contribute to scaleup of the process.

Keywords: *Hydrodynamics; wastewater treatment; computational fluid dynamics; advanced oxidation process; antimicrobial resistance*

Optimization of removal of pharmaceuticals from water using graphene nanoplatelets

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Abstract: Pharmaceutical pollution in water bodies is a growing environmental concern, as these compounds can pose significant risks to both human health and aquatic life. Effluent from wastewater treatment plants often serves as a source of such contamination, which, when discharged into larger water bodies, contributes to environmental pollution. Various methods have been proposed to treat pharmaceutical contamination in wastewater, with adsorption being one of the common techniques. Graphene and graphene based nanomaterials have emerged as an effective adsorbent for the removal of contaminants including pharmaceuticals from water. In this study, the removal of two pharmaceutical compounds, sulfamethoxazole (SMX) and acetaminophen (AMX) using one such graphene-based nanomaterial, Graphene Nanoplatelets (GNPs) was analyzed using secondary data. The treatment using GNPs was optimized through polynomial regression modeling in R programming. The primary factors influencing removal, including pH, GNP dosage, the initial concentration of pharmaceutical compounds, and contact time, were systematically examined. A polynomial regression model was fitted to analyze the interactions between these factors and to predict the conditions that maximize the treatment efficiency. The results of the regression analysis provided optimal conditions for the treatment process, enabling the identification of the most effective parameters for achieving high removal rates of these pharmaceutical pollutants.

Keywords: *Emerging contaminants; graphene nanoplatelets; pharmaceutical contamination; water treatment; machine learning*

Analysis And Design of Sewerage Network For Khamgaon City Using Sewer GEMS

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Abstract: Sewer GEMS is an advanced modelling and development software specifically designed for sewer networks. This software enables designers to execute their tasks with remarkable speed, efficiency, and cost-effectiveness. This study will explore the application of Sewer GEMS alongside Autodesk Civil 2D in assessing the sewerage systems within the Khamgaon city of buldhana district of Maharashtra. The assessment of the sewer system was carried out by analysing the total flow within the system. The system facilitates calculations for various models and generates longitudinal sections, reports, and cross-sections, which are essential for understanding the design of hydraulic networks for sewers. Typically, sewer design encompasses manholes, pumps, conduits, and other appurtenances; however, this study emphasizes an economically viable design that relies on gravity, thereby eliminating the need for pumps. The sewer system is very complicated to design, as there are many essential parameters/checks to be satisfied simultaneously, i.e., slope, velocity, invert level of pipes and manholes, excavation limitation, maintenance, and costing of the project. Among the various software options available, "Sewer GEMS" stands out as particularly favoured due to its distinctive advantages. Sewer GEMS is a user-friendly software application designed for engineers to analyse and design sewer systems, incorporating integrated hydraulic tools. Furthermore, it is compatible with AutoCAD and Geographic Information System (GIS) tools. The software ultimately delivers design specifications, including invert levels and pipeline diameters, along with the depth and invert levels of manholes. Ongoing research focuses on the development of a sewerage collection network utilizing "Sewer GEMS."

Keywords: Sewer GEMS; Slope; Velocity; Conduit; Manhole; Outfall; invert levels

Agricultural Waste-derived Nanomaterials and Their Modification for Wastewater Treatment: Achieving Sustainability through Circularity of Materials

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Abstract: Wastewater containing heavy metals and toxic chemicals is produced in large quantities due to the fast growth of industrialization and urbanization. Scientists, lawmakers, and regulators are therefore keeping a closer eye on developments in economical, environmentally friendly wastewater treatment technologies. Sustainable development is unavoidable, and treating wastewater with agricultural waste has always been a creative way to reach sustainable development objectives. Instead of being burned in open fields, which results in several environmental issues like soil erosion and air pollution, these wastes can be a valuable resource when they are transformed into beneficial uses like composts, biochar (BC), environmental adsorbents for pollutant removal, and natural fertilizers. Recent developments in the practice of nanomaterials made from agricultural waste for pollution removal, monitoring, and environmental cleaning are evaluated in this chapter. This section highlights the most promising research areas. It addresses the main obstacles to using a range of techniques, including ion exchange, reduction, and adsorption, with inexpensive agricultural waste materials to remove organic dyes, toxic ions, and other contaminants. Nano-activated carbon derived from agricultural waste and its modified forms have high porosity, a sizable surface area, and distinct surface functional groups, which make it a viable and sustainable substitute for wastewater treatment applications in the future. To increase these adsorbents' adsorption capacity and reusability, several modification techniques have been put forth. Another promising substance, cellulose, has been thoroughly investigated for chemical and mechanical modification to produce cellulose-based nanomaterials because of its many qualities, natural availability, biodegradability, and non-toxicity. Excellent water purification properties make cellulose-based nanomaterials a promising option for wastewater purification. This review provides a comprehensive overview of pristine, surface-functionalized cellulosic nanomaterials and nanocomposites for use in flocculation, membrane filtration, and sorption processes used in wastewater treatment. A summary of the difficulties and prospects for the safe use of nanomaterials derived from agro-industrial biowaste for wastewater treatment is provided.

Keywords: Wastewater; cellulose; filtration; adsorption; nanomaterials; agro-industrial waste

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Designing Cellulose-based Materials using Novel Approaches for Wastewater Treatment: A Critical Review

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Abstract: Natural materials have a great potential for enhancing the water purification process while keeping the costs minimal. Cellulose is the largest available natural polymer on earth. The Cellulosic material family is estimated to be a potential member for water purification due to its proven adsorption capacity for the removal of contaminants, its availability in versatile forms and the ability to be fabricated in vivid formats starting from a nanoparticulate form and ending with a complex membrane-like structure. The past research work for improving the water treatment efficiency of cellulosic focuses on using their advantageous active sites for holding the chemical moieties which further help in binding the pollutants on these sites. This review summarizes the trending research efforts to modify cellulosic materials to improve wastewater treatment efficiency. Secondly, this critical review also proposes the crafting of cellulosic materials using never-before-explored approaches providing an insight into the performance of such modified cellulosic materials for treating wastewater based on these unexplored modification methods, various morphological forms and the sizes of cellulosic forms.

Keywords: *Wastewater; cellulose; biomass; extraction; toxicity*

Surge Analysis and Mitigation Measures for a Jetty Pipeline Using Pipenet Vision

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Abstract: Piping is an essential element of transportation in the petroleum and petrochemical industries. Surge analysis is one of the primary testing's of pressure changes in the pipeline that can lead to the failure or rupture of the pipeline. Essentially surge analysis is done to prevent the mishap due to pressure fluctuations. Surge analysis is followed for the safety prediction of any pipeline against rupture due to surge pressure. The current study reports the case study for surge analysis of a jetty pipeline of approx. 3.5km that carries chemicals from the jetty to the storage tank. The pipeline analysis was carried out using PIPENET Transient module version 1.11. The study includes the effect of various factors like joints, elevations, fittings, and support in the pipeline. The surge analysis for the 16-inch Mono-Ethylene Glycol (MEG) pipeline

and the 18-inch Propane product pipeline is done in the study. The surge analysis of the pipeline was carried out based on the existing data for the valve at the jetty area and the storage tank. Multiple cases when the storage tank is full or empty, and valve opening impact on the surge pressure are also studied. Mitigation procedures for maximum surge pressures were applied to decrease the surge pressure within the allowed pressures for the selected product pipelines. Recommendations are given based on case to case basis.

Keywords: *Surge Analysis; PIPENET; Pipe Safety; Transient Flow; Surge Mitigation*

Effective Disposal of Wastewater from Hydraulic Fracturing Operations in Oil and Gas Wells

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Abstract: The effective disposal of wastewater generated from hydraulic fracturing (fracking) in oil and gas wells is a critical environmental challenge that necessitates innovative management strategies. This paper presents a comprehensive overview of current methodologies for the treatment and disposal of fracking wastewater, emphasizing the importance of centralized wastewater management systems. Hydraulic fracturing processes utilize significant volumes of freshwater, leading to substantial quantities of wastewater, primarily categorized as flow back and produced water. These waste streams are often contaminated with a variety of pollutants, including total dissolved solids (TDS), heavy metals, and organic compounds, posing risks to surface and groundwater resources. Recent advancements in centralized treatment facilities demonstrate their potential to efficiently manage wastewater by integrating treatment processes such as primary separation, secondary flotation, and reverse osmosis. These facilities can process wastewater from multiple wellheads, optimizing resource use while minimizing environmental impacts. Furthermore, the incorporation of alternative water sources into the fracking process can significantly reduce freshwater consumption and enhance sustainability. This study aims to highlight effective disposal techniques and the role of regulatory frameworks in shaping wastewater management practices in the fracking industry. By analysing case studies and existing literature, we propose a model for sustainable wastewater management that balances economic viability with environmental protection.

Keywords: *Hydraulic fracturing; wastewater management; centralized treatment; environmental sustainability; flowback water; produced water*

Assessing LULC changes and its impact on the LST and NDVI in Lakhisarai district, Bihar

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Abstract: Today, the use of remote sensing (RS) data and geographic information systems (GIS) for detecting and monitoring both immediate and long-term changes is crucial. These technologies provide essential insights into current land use/land cover (LULC), land surface temperature (LST), and the normalized difference vegetation index (NDVI), helping to track spatial and temporal variations. The study examined changes in Land Use and Land Cover (LULC) in Lakhisarai district, Bihar, over a 10-year period from 2008 to 2018 and assessed their impact on various environmental factors. During this period, shifts in land use, such as urbanization, agricultural expansion, and deforestation, were closely analyzed to understand their effects on the local ecosystem. Spectral radiance model, adapted to derived LST from the respective satellite data and the other Environmental Indices were computed accordingly. Over the decade, LULC changes in the area showed significant shifts: Water bodies (WB) decreased by 17.75%, Forest cover (FC) by 29.32%, Mixed vegetation (MV) by 3.42%, Barren land (BL) by 20.62%, Built-up areas (BA) increased by 38.52%, and Scrubland (SD) dropped by 18.78%. The most notable change was the expansion of built-up areas, which correlated with higher land surface temperatures (LST). A strong positive correlation ($r = 0.87$, $p = 0.002$) between the Normalized Difference Built-up Index (NDBI) and LST highlights the effect of impervious surfaces. Additionally, vegetation health, indicated by changes in NDVI, showed a significant negative correlation ($r = -0.85$, $p = 0.002$) with LST.

Keywords: *LULC; LST; GIS; NDBI*

Electrochemical Decolorization of RR120 Using Lab Prepared Mixed Metal Oxide Electrode: Comparison of NaCl and Na_2SO_4

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Abstract: A lab-prepared mixed metal oxide (MMO) electrode with a mixed metal oxide loading of 1.65 gm/cm2 was used for this investigation. The Ti/RuO2-SnO2-Sb2O5 electrode was made using a titanium plate as the base metal. The electrode was created using the standard thermal decomposition (STD) technique. Different dye concentrations (50–125 mg/L) were electrochemically decolorized for two hours at different current densities (1, 5, and 10 mA/cm2) and electrolyte doses (2, 4, 6, and 8 g/L) at 2,5,7 (raw), and 9 pH. The most often used electrolytes in electrochemical treatment are NaCl and Na2SO4. Depending on the pH of the solution, both NaCl and Na2SO4 produce different oxidizing species. These oxidizing species directly affect energy consumption as well as the effectiveness of the electrochemical treatment. Hence, both the supporting electrolytes (NaCl and Na2SO4) were compared at a fixed dosage of 4 g/L. This comparison study showed 97.69, 99.74, 99.51%, dye decolorization after 2 h with NaCl electrolyte for 1, 5, and 10 mA/cm2 CD for 100 mg/L dye solution. To achieve this much removal with NaCl electrolyte, around 4.38, 7.93, and 10.76 KWh/Kg dye removed of energy were consumed. On the other hand, the Na2SO4 showed 31.94, 56.01, and 66.5 %, dye decolorization for 1, 5, and 10 mA/cm2 CD after 2 h for 100 mg/L dye solution. Similarly, Na2SO4 has demanded around 15.5, 78.14, and 91.19 KWh/ Kg dye removed energy. With relatively lesser decolorization efficiency, the energy consumption with Na2SO4 was found to be very large in comparison to NaCl. Thus, Na2SO4 was proven to be less effective when compared with NaCl for the studied dye and experimental conditions.

Keywords: *Electrolyte; Hydroxyl Radical; Sulphate Radical; Peroxodisulphate; Precursor*

Investigation on Dye Adsorption onto Acid Activated Adsorbents Derived from Peel Waste

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Abstract: This study inspects the effectiveness of bio-adsorbent derived from phosphoric acid-treated pomegranate peels in removing methylene blue (MB) dye from an aqueous solution through batch experiments. Results indicate a removal efficiency of over 92% at pH 6.0, using an adsorbent dosage of 0.25 g/100 mL and an adsorbate concentration of 10 mg/L. The adsorption process follows the Temkin isotherm model. Kinetic analysis shows a strong fit to the pseudo-second-order model ($R^2 = 0.99$), suggesting chemisorption as the dominant mechanism.

Keywords: *Pomegranate peel; Methylene blue dye; Bio-adsorbent; Isotherm; kinetics.*

Health hazard concerns due to trace metal presence in groundwater from urbanized Kanpur city, Uttar Pradesh

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Abstract: Water contaminations are constantly on the rise due to urbanisation and industrialisation. The unsupervised and untreated sewage disposal from the factories release toxic heavy metals into surface water or open land. These metals then seep into groundwater through percolation and cause water pollution. Heavy metals such as Cobalt (Co), Copper (Cu), Chromium (Cr), Lead (Pb), Manganese (Mn), Iron (Fe), Nickel (Ni), Cadmium (Cd), and Zinc (Zn) affects severe health issues in the human body. Dermal or oral prolonged ingestion of Cr results in lung cancer and also liver and kidney damage. Cu deposition in the body target brain, and gastrointestinal tracks also in combination with Zn. Thirty-four groundwater samples were collected to assess these metals using ICP-MS. Those data were then put in different health-related calculations to numerically understand the severity of the contamination and its effects on human health. High hazard indices were seen in Kanpur for very few samples. Cr and Mn were in excess quantity which could pose a risk to health for both adults and children. Heavy metal pollution index calculation showed a low value, 30 compared to the alarming level value of 100. Geo-accumulation indices were computed to understand the enrichment of heavy metals particularly in soil/sediments. Even with a limited number of samples, the soil value showed strongly polluted for Ni and extremely

polluted for Cr. In conclusion, strict implementation of rules and regulations for waste disposal is needed to control pollution.

Keywords: *Groundwater contamination; Trace metals; Health hazard; Risk assessment*

Biogenic silver Doped Magnesium Oxide Nanoparticles: A Green Approach to the Textile Wastewater Treatment and Bacterial Inhibition

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Abstract: In this study we synthesized silver-doped magnesium oxide nanoparticles (Ag/MgO NPs) and magnesium oxide nanoparticles (MgO NPs) using Citrus Limon and Tamarindus Indica outer layer extracts respectively. The flavonoids and tannins present in this extract act as natural reducing agents, demonstrating an eco-friendly synthesis method that serves as an alternative to chemical and physical methods. Synthesized Ag/MgO NPs and MgO NPs were fully characterized using ultraviolet-visible spectroscopy, Fourier transform infrared spectroscopy, X-ray diffraction and scanning electron microscopy. The synthesized Ag/MgO NPs and MgO NPs were found to have average size of 60 nm and 39 nm, respectively. These nanoparticles were used for the photocatalytic degradation of complex textile dyes, including Dispersive Yellow, Reactive Blue, and Dispersive Navy Blue, as well as actual wastewater samples collected from a local textile industry. The degradation study revealed that Ag/MgO NPs exhibited higher efficiency than MgO NPs and also having a good antibacterial activity against different bacterial species, including E. coli, B. cereus, and M. Luteus.

Keywords: *Green synthesis; Silver doped magnesium oxide nanoparticles; Photocatalytic degradation; Textile wastewater treatment*

Synthesis of Two-Dimensional MXenes for the Removal of Dyes from Industrial Wastewater

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Abstract: Wastewater often contains high concentrations of various organic contaminants, including dyes, heavy metals, and non-dissolving compounds. Effective purification techniques are essential before disposal to mitigate environmental and health risks. The increasing presence of synthetic dyes in wastewater has raised concerns, highlighting the need for efficient removal methods. MXenes, particularly Ti_3C_2, have emerged as promising materials for dye removal due to their unique two-dimensional structure and high surface area. MXenes are synthesized using hydrofluoric acid by selectively etching metal layers from MAX phases—layered transition metal carbides and carbonitrides. The delaminated MXenes were characterized through various techniques such as FESEM, EDX, XRD, FTIR, and UV-visible spectroscopy. These nanosheets demonstrate excellent adsorption capabilities for various organic dyes, including crystal violet, methylene blue, and malachite green. Studies indicate that optimal dye removal occurs at a contact time of approximately 60 minutes, with a maximum adsorption capacity of around 4.6 mg of dye per gram of MXene. The adsorption process is influenced by factors such as dye concentration and MXene dosage. Additionally, the reusability of MXenes without significant performance loss highlights their potential as a sustainable solution for wastewater treatment, offering a promising approach to addressing water pollution challenges.

Keywords: *MAX Phase (Ti3AlC2); MXene (Ti3C2); Dyes; Adsorption*

A Review on Different Types of Desalination Technologies.

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Abstract: It is a fact that the world's population has significantly increased due to that the availability of freshwater for all required activities, industrial use, agriculture, and domestic use, has decreased due to sudden rise in the demand. In addition to these factors, the major source of water is in the ocean and seawater. All these factors make desalination a key solution to global water demands. In this study the importance and classification of desalination techniques are shown. The methods covered are Mechanical Vapour Compression (MVC), Multi-Effect Distillation (MED), Multi-Stage Flash (MSF), Humidification Dehumidification (HDH), Reverse Osmosis (RO), Secondary Refrigerant Freezing (SRF) along with its mechanism and working. The efficiencies of different methods are also compared for its commercial feasibility and cost effectiveness. The environmental impacts are considered along with its mitigable solutions to make desalination a more

sustainable technology. Recent advancements in desalination technologies have also offered many alternative approaches that provide a roadmap towards greener desalination. This review article will be beneficial for all the stakeholders in the desalination industry.

Keywords: *Desalination; Multi-Effect Distillation (MED); Multi-Stage Flash (MSF); Multi-Stage Flash (MSF); Reverse Osmosis (RO); Environmental Impacts*

Electrochemical Method for Sustainable Degradation of Organic Dye Contaminated Wastewater Using Plastic Chip Electrode

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Abstract: The rapid growth of industrial activities produces considerable waste, including resilient organic dyes which threaten ecosystems. Eliminating these hazardous substances from water prior to discharge is vital for mitigating environmental harm. Environmental remediation requires affordable and durable electrodes for efficient pollutant degradation. Plastic chip electrodes (PCE) are now gaining momentum in various kind of electrocatalytic experiment. In this study, electrochemical removal of organic dye contaminated wastewater using PCE was investigated. The effects of initial dye concentration, solution pH and current density were examined. The maximum removal efficiency (99.9%) was obtained for 9 pH, with initial dye concentration 5 mg/L with an operating time of 60 min. The results suggest that PCE offer a viable and economical approach for treating dye-contaminated wastewater.

Keywords: *Plastic chip electrode; Electrocatalysis; Dye degradation; Wastewater treatment; Sustainable Approach*

Improvement of Water Governance through Frameworks on Institutional Collaboration, Involvement of Stakeholders, and Adaptive Policy

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Abstract: Water is a vital resource, but growing challenges like scarcity, pollution, and climate change make its management more critical than ever. This study explores how institutions, communities, and stakeholders can work together to ensure fair access to water while protecting it for future generations. It focuses on integrated water resource management (IWRM), innovative policies, and governance practices that address today's pressing issues. The importance of building resilience in water systems is highlighted, especially in the face of uncertainties like natural disasters, pandemics, and changing weather patterns. The study also looks at how water governance can connect with other sectors, like urban planning and energy, to create more holistic and sustainable solutions. Finally, it recommends practical ways to improve water policies through community participation, smart planning, and adaptive frameworks that bring global goals in line with local realities.

Keywords: *Integrated water resource management; adaptive frameworks; community participation*

Waste Enhancer for Bitumen Property Improvement

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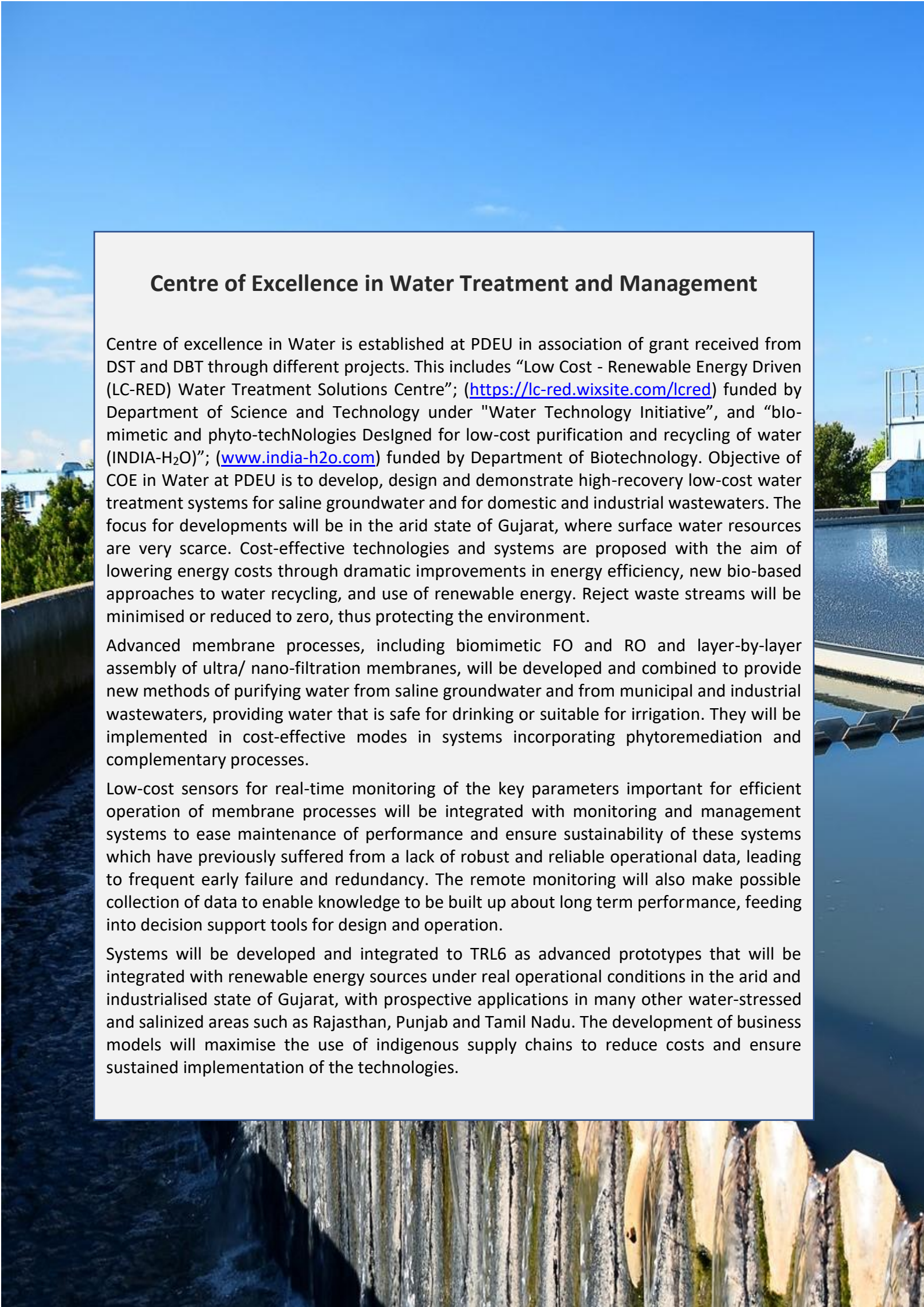
Abstract: Bitumen is a heavy distillate product of crude oil distillation. At the Global level, Bitumen is well known for road pavement construction. World today road transportation has increased which has lead to an increase in demand of Bitumen for road construction. But Due to heavy traffic and high load vehicles roads can not able to withstand for long-term. For that Enhancers are used to improve property of Bitumen. Enhancers can be Waste material, Chemical solvent, Nanomaterial etc. Now a days Nano Technology are use in vary ways because of their small size, high surface area, strength and many more. The same thing goes for Waste Material there is a problem with waste deposal because it covers valuable land. Different kinds of literature have been reported for property Enhancement by Nano Materials and Waste Materials.

Keywords: *Bitumen; Nanomaterial, Silica, Lignin*



Centre of Excellence in Water Treatment and Management

Centre of excellence in Water is established at PDEU in association of grant received from DST and DBT through different projects. This includes “Low Cost - Renewable Energy Driven (LC-RED) Water Treatment Solutions Centre”; (https://lc-red.wixsite.com/lcred) funded by Department of Science and Technology under "Water Technology Initiative”, and “bIo-mimetic and phyto-techNologies DesIgned for low-cost purification and recycling of water (INDIA-H_2O)”; (www.india-h2o.com) funded by Department of Biotechnology. Objective of COE in Water at PDEU is to develop, design and demonstrate high-recovery low-cost water treatment systems for saline groundwater and for domestic and industrial wastewaters. The focus for developments will be in the arid state of Gujarat, where surface water resources are very scarce. Cost-effective technologies and systems are proposed with the aim of lowering energy costs through dramatic improvements in energy efficiency, new bio-based approaches to water recycling, and use of renewable energy. Reject waste streams will be minimised or reduced to zero, thus protecting the environment.

Advanced membrane processes, including biomimetic FO and RO and layer-by-layer assembly of ultra/ nano-filtration membranes, will be developed and combined to provide new methods of purifying water from saline groundwater and from municipal and industrial wastewaters, providing water that is safe for drinking or suitable for irrigation. They will be implemented in cost-effective modes in systems incorporating phytoremediation and complementary processes.

Low-cost sensors for real-time monitoring of the key parameters important for efficient operation of membrane processes will be integrated with monitoring and management systems to ease maintenance of performance and ensure sustainability of these systems which have previously suffered from a lack of robust and reliable operational data, leading to frequent early failure and redundancy. The remote monitoring will also make possible collection of data to enable knowledge to be built up about long term performance, feeding into decision support tools for design and operation.

Systems will be developed and integrated to TRL6 as advanced prototypes that will be integrated with renewable energy sources under real operational conditions in the arid and industrialised state of Gujarat, with prospective applications in many other water-stressed and salinized areas such as Rajasthan, Punjab and Tamil Nadu. The development of business models will maximise the use of indigenous supply chains to reduce costs and ensure sustained implementation of the technologies.

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