The 10th International Conference on Water Resources and Environment Research (ICWRER 2025)

9 - 11 December, 2025

Jointly organised by
Karunya Institute of Technology and Sciences, India
and
University of Waterloo, Canada

Impact of Climate Change on Hydrology, Ecology and Food Systems

Abstract Proceedings

Editorial Team

Karunya Institute of Technology and Sciences,
Coimbatore – 641114, India
ISBN 978-93-93522-74-0

Preface

A couple of years ago, Prof. Kumaraswamy Ponnambalam of the University of Waterloo enquired with the Water Institute of Karunya Deemed University (KITS) whether the Tenth ICWRER Conference could be hosted by the University in Coimbatore. He also mentioned that the First Conference in 1993, immediately after the Dublin Conference and the Earth Summit, was held at the University of Waterloo in honour of Prof. T. E. Unny, the renowned stochastic hydrologist from India. The event to be held at the Karunya campus from 9-11 December 2025 is the First ICWRER Meet in the country.

Water security has become a significant concern for nations worldwide. On its part, the Government of India is committed to achieving the SDGs, and the Ministry of Jal Shakti and other agencies have taken up several initiatives. The growing demand for water due to rapid urbanization and agricultural activities necessitates the sustainable management of water resources. Many areas in the country are under water stress and scarcity. Climate change is feared to exacerbate existing problems, mainly due to increased intensity and frequency of hydrologic extremes, sea-level rise, and snowmelt.

Integrated Water Resources Management (IWRM) is a process for sustainable development that allocates and monitors water resource use, considering social, economic, environmental, and institutional objectives. There is a need to assess the efficacy and efficiency of the various techniques and models attempted so far, and also to evolve new ones to address specific and general problems. The case studies on these projects and schemes are expected to throw light on the future course of action to be initiated.

Wastewater generation is a multifaceted issue influenced by domestic, industrial, agricultural, and emerging activities. Each source presents unique challenges, necessitating tailored management and treatment strategies to safeguard environmental and public health. By acknowledging and addressing the diverse sources of wastewater, we make significant strides toward a cleaner, healthier, and more sustainable future. Emerging contaminants, viz., microplastics and endocrine disruptors, are increasingly recognized for their potential health impacts and environmental persistence.

The aquatic and terrestrial ecosystems are facing threats of different types and dimensions, leading to their degradation and disappearance; the biodiversity of ecosystems, especially aquatic ecosystems, is facing multiple challenges. These are also to be addressed, and experiences shared with a congregation of experts and other stakeholders.

The *ICWRER-2025* is expected to provide a common platform for experts in water and environment to meet, interact, share their thoughts, and offer their views on future action. Our primary focus has been on students and scholars in the field of water and environment, as well as other stakeholders, who we believe will contribute effectively to future research, academia, policy formulation, and project implementation.

The Co-chair and I are thankful to all those from the University of Waterloo and Karunya Institute of Technology and Sciences, and to several experts from different parts of the world who have supported this event, as well as to the delegates – academic and professional - who have shown great interest in this Conference.

We now look forward to very fruitful deliberations at the *ICWRER-2025*, through effective interaction and the contribution of ideas and solutions to address problems faced by the water and environment sectors, finally saving and sustaining our planet and humanity in particular.

E J JAMES
Conference Chair, *ICWRER-2025*

30 November 2025

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Theme 1

Climate Change Impacts on Water Resources and Ecosystems

1. Agroclimatic Analysis of North Karnataka to Identify Optimum Rainfall Pattern for Selected *Kharif* Crops and Choice of Crops for Rainfall Patterns

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Abstract

Rainfall plays a very important role in rainfed agriculture system because it is the main source of soil moisture required for crop growth and production. Among the weather variables, the inter-seasonal and intra-seasonal fluctuations of rainfall play a major role in a year. Therefore, it is necessary to generate usable information on temporal and spatial distribution of rainfall on different time scales (week, month, *nakshatra*, season and annual) to optimize farming strategies for achieving food sustainability. For this purpose, 1) Developed a database of rainfall in North Karnataka i.e. Daily rainfall data (mm) for 153 rain Guage stations of North Karnataka - 1951 to 2013; for subsequent years till 2017 and future climatic scenario dataset for 2021-2050 was from CMIP Phase 5(CMIP-5) 2) Identification of shifts of rainfall pattern and change in cropping system. 3) Mapping of spatio-temporal variations on GIS platform: Data mapping is done by Arc GIS 10.4.1 software. For estimating production of maize, the cubic model was identified as suitable model in Ballari, Bidar, Dharwad and Vijayapura districts, whereas power model was the best fit for Bagalkot and Haveri districts; Based on the results, the future line of work is suggested to develop this type of analysis in all important crops, which will helps to develop suitable area and production models; there is need for quantification of rainfall variability patterns, which is more important than trend alone or qualitative assessment and analysis at Hobli level would help in microlevel agricultural planning.
Key words: CMIP: Coupled Model Intercomparison Project; SW: South-West; NE: North-East; GIS: Geographic Information System; Hobli: Village

2. Assessing Nonstationary Meteorological and Hydrological Droughts Using Lag-Correlation of N-SPI and N-SRI in the *Bharathapuzha* River Basin

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Abstract

Accurate drought assessment in regions with high climatic and hydrological variability requires modeling approaches that reflect the nonstationary nature of hydroclimatic processes. This study focuses on the Bharathapuzha River Basin, which extends from the

rain shadow regions of Tamil Nadu across the humid Western Ghats to the coastal plains of Kerala, encompassing diverse climatic zones. To capture the evolving characteristics of drought, non-stationary drought indices are developed using the Generalized Additive Models for Location, Scale, and Shape (GAMLSS) framework for the period 1983–2020.Two key indices are constructed: the Nonstationary Standardized Precipitation Index (N-SPI), representing meteorological drought, and the Nonstationary Standardized Runoff Index (N-SRI), representing hydrological drought. Global climate drivers such as ENSO, IOD, and NAO were selected as covariates based on significant correlation analysis with monthly rainfall and streamflow values. These indices are evaluated across multiple time scales (3, 6, 9 and 12 months) to understand their responsiveness to short- and long-term drought conditions. A detailed lag-correlation analysis is conducted between N-SPI and N-SRI to investigate the temporal relationship and response delay between rainfall deficits and streamflow reductions. Particular emphasis is placed on identifying dominant lag correlations, with preliminary analysis highlighting the significance of the 1-month lag difference. The nonstationary indices show clear advantages over stationary methods in detecting the onset and persistence of drought, and in reflecting the spatial heterogeneity of drought propagation across the basin. This study highlights the utility of incorporating non stationarity and lagged hydroclimatic relationships in drought monitoring frameworks, providing a more detailed understanding of drought propagation.

Keywords: GAMLSS, spatial heterogeneity, Global Climate Drivers, lag-correlation; drought propagation

3. Assessment of Future Runoff Scenarios Using SDSM and HEC-HMS for Sustainable River Basin Management in a Humid Tropical River Basin

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Abstract

Climate change provides significant challenges to hydrological systems, which demands the use of modelling tools to predict future runoff for effective river basin planning. This study integrates the Statistical DownScaling Model (SDSM) and the Hydrologic Engineering Center-Hydrologic Modelling System (HEC-HMS) to assess the impact of projected climate variability on Periyar river basin runoff. Historical rainfall data from 1986 to 2005 were used to calibrate and validate SDSM and it enabling the generation of future daily precipitation under a selected Representative Concentration Pathways, RCP 4.5. These downscaled scenarios were then input into HEC-HMS, which was configured using basin characteristics derived from DEM, land use, and soil data. The model was calibrated and validated with observed streamflow data from 1990 to 2022 to ensure reliability. The integrated method highlights the value of combining statistical downscaling with hydrological modelling to forecast long term hydrologic responses. This methodology can

serve as a decision-support tool for policymakers, water resource managers, and planners. And this facilitating adaptive strategies for sustainable water resource management in the context of a changing climate.

Keywords: Climate Change; downscaling; integrated modelling; RCP scenario; runoff

4. Building Climate Resilient Stormwater Infrastructure in Singapore

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Abstract

This paper outlines the 3-pronged approach adopted by the Public Utilities Board (PUB), a statutory board under the Ministry of Sustainability & the Environment (MSE), to manage the twin challenges, by provision of drainage in advance of urban developments, implementation of flood protection measures and continual drainage improvements to be in line with climate change needs. Singapore, a tropics island city-state with a limited area of 700km2, experiences precipitation throughout the year. In the densely built-up urbanized areas, surface runoff is a major concern during intense rain events especially as almost a third of the country including the vital central business district lies less than 5m above sea level. PUB has adopted the Source-Pathway-Receptor approach which include a range of intervention measures to build resilience for Singapore's stormwater system, as there is a challenge in terms of space with drains and canals adjacent to urban buildings and infrastructure. Maintenance of the system such as by controlling sediment flow into the drainage system as well as active monitoring by placement of CCTV with water flow level meters amongst other measures, are components that complement the overall network. By harnessing the assets in a holistic setup and working with other statutory agencies in a collaborative manner, has actively contributed to the Blue-Green plan whereby the country becomes a City of Gardens with urban stormwater managed as part of the Active, Beautiful, Clean Waters (ABC) programme. A stormwater drain upgrading project in which the existing concrete structure was reconstructed to accommodate higher runoff and future raising of ground levels as well as provided with a vegetated swale to treat runoff is shared for practical application. This work was performed in collaboration at workplace by the author.

Keywords: stormwater infrastructure, nature-based solution, therapeutic plants.

5. Changes in Hydro-geochemistry due to the Floods – A Case Study of Southwest Punjab, India

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Abstract

In the present study, the groundwater chemistry has been assessed for the year 2023 floods by sampling for the years 2022 and 2024 in a semi-arid southwest region of Punjab. The water samples were taken from the 34 piezometers varying in depths from >10 m to 37m. Water table has been found shallow and presumed that the high influence of floodwaters that quickly reach the groundwater table, on groundwater quality parameters like pH, EC and ions. It was observed that the values of EC increased in post-flood period. The Gibb's plot indicates through comparison between the pre-flood (2022) and post-flood (2024) data a significant geochemical shift towards evaporation dominance in most piezometers. This trend suggests an increasing salinity in the groundwater system. When comparing the data from both years on the USSL diagram, it is evident that water quality has deteriorated. A majority of the piezometers showed a noticeable shift toward higher salinity (C3–C4) and increased sodium hazard (S3–S4) zones. Piper plot indicated water chemistry is evolving towards greater sodium enrichment and salinity. These trends indicates that the groundwater is becoming less suitable for irrigation purposes, posing potential risks to soil structure, crop productivity, and long-term agricultural sustainability without appropriate management interventions. Continuous monitoring and management will be essential to prevent further degradation of groundwater quality, especially for irrigation use. There are only few studies related to the flood impact on groundwater systems, the data will be very useful for the policy and planning needs in the context of climate change in the Punjab.
Keywords: Shallow water levels, Groundwater quality, Gibb's plot, Piper plot, Semiarid, Punjab flood 2023.

6. Climate Change Dynamics: Challenges for Water Resources and Agricultural Productivity

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Abstract

Climate change has emerged as one of the most significant global challenges of the 21st century, profoundly affecting natural resources and agricultural systems. This review article explores the multifaceted impacts of climate change on water resources, crop growth, and agricultural productivity. Rising global temperatures, altered precipitation patterns, and increased frequency of extreme weather events such as droughts, floods, and heat waves are drastically influencing water availability and quality. These changes disrupt the hydrological cycle, leading to increased evapotranspiration, reduced groundwater recharge, and altered river flows, thereby threatening the sustainability of irrigation systems and freshwater supply for agriculture. Crop growth is highly sensitive to climatic variables such as temperature, rainfall, and CO_2 concentration. Elevated temperatures can accelerate crop

phenology, shorten growing periods, and reduce grain filling duration, adversely affecting yield. Moreover, changes in rainfall distribution and intensity may lead to water stress or excess moisture conditions, both detrimental to crop health. While higher atmospheric CO_2 may enhance photosynthesis in some crops (CO_2 fertilization effect), the overall benefits are often negated by nutrient limitations, pest outbreaks, and heat stress. Strategies such as improved water-use efficiency, development of heat and drought-tolerant crop varieties, integrated water resource management, and climate-smart agriculture are essential to mitigate adverse effects. Policymaking must prioritize sustainable land and water management to ensure food security under changing climatic conditions. Understanding the interconnected nature of climate change impacts on water and agriculture is critical for developing long-term solutions that safeguard productivity and resource availability for future generations. This review also examines region-specific vulnerabilities and adaptive responses, emphasizing the need for climate-resilient agricultural practices.

Keywords: Agricultural productivity, Climate change, Climate-smart agriculture, Evapotranspiration, Food security, Heat and drought stress

7. Estimation of Evapotranspiration using Satellite based Priestley Taylor Model over Different Climate Zones of Karnataka State, India

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Abstract

Evapotranspiration (ET) plays a crucial role in regulating the hydrological and energy cycles of terrestrial ecosystems, particularly in monsoon-driven regions like Karnataka, India. This study investigates the spatial and temporal variability of ET across three climatically distinct basins the Bennihalla River Basin (semi-arid), Haladi River Basin (humid), and Cauvery Sub-basin (semi-humid) by integrating MODIS remote sensing data with the Priestley–Taylor model. The assessment shows how climatic gradients, topography, and land use/land cover (LULC) influence ET patterns across these regions. To capture vegetation and soil moisture stress, LST–Fv scatterplots were constructed using both triangular and trapezoidal approaches, reflecting the wet and dry edges associated with latent heat flux. In the Bennihalla Basin, persistently low ET and sparse vegetation were observed due to post-monsoon soil moisture deficits. The Haladi Basin demonstrated high and stable ET supported by dense forests and abundant rainfall, with evaporative fractions approaching unity. The Cauvery Sub-basin displayed transitional behavior, with ET declining from humid highlands to drier plains, influenced by a mixture of croplands, forests, and settlements. Validation against MODIS, GLEAM, ERA5, and GLDAS products shows the highest agreement in the Cauvery Sub-basin (MODIS yielding R^2 = 0.71 and RMSE = 1.01 mm/day), while GLEAM performed moderately well in the Haladi

Basin (R^2 = 0.23; RMSE = 0.34 mm/day). The Bennihalla Basin, being water-limited, demonstrated weaker agreement across all products (max R^2 < 0.28; RMSE range 0.70–2.69 mm/day). Overall, this study highlights the utility of remote sensing–based Priestley-Taylor modeling for estimating ET in climatically diverse regions and underscores its potential for climate-adaptive water resources management in monsoon-influenced landscapes.

Keywords: Evapotranspiration, MODIS, Priestley–Taylor model, Remote sensing, Triangular and Trapezoidal approaches.

8. Incorporating Hedging Rules into the Fletcher-Ponnambalam Method for Reservoir Operation Optimization

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Abstract

The Fletcher-Ponnambalam (FP) method is an explicit stochastic optimization approach developed for the management and operation of storage systems, such as surface water reservoirs. Unlike traditional methods, it does not require scenario generation or discretization of state variables, common challenges in stochastic programming. While the FP method avoids the curse of dimensionality typical of stochastic dynamic programming, it still involves complex integral calculations related to the probabilities and statistical moments of state variables, which can be mathematically demanding in some cases. Moreover, the method assumes known inflow probability distributions, which may not always be available or may require strong assumptions. Previous applications of the FP method to reservoir operation have primarily relied on open-loop constant release policies or S-type linear decision rules to simplify the integral computations. This study introduces a novel contribution by incorporating a hedging rule as the release policy within the FP framework. Additionally, the need for assuming specific inflow distributions is avoided by approximating integral solutions using historical inflow samples. Application of the proposed methodology to a major reservoir in Brazil shows close correspondence between optimization and simulation results.

Keywords: reservoir management; statistical moments; stochastic programming; storage optimization; Sobradinho reservoir

Impact of Climate Change on Dryland Farming Systems of Kerala: Adaptation Strategies, Challenges and Innovations

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Abstract

Dryland farming systems in Kerala, particularly in the districts of Palakkad, Wayanad, and Idukki, are facing severe disruptions due to climate change and evolving land-use patterns. Erratic monsoons, delayed rainfall and increasing temperature extremes have led to frequent crop failures, especially in rain-fed crops like pulses, millets and tubers. This study investigates the tangible impacts of climate variability through field-based data, farmer testimonies, and institutional reports. The study further explores the adaptation measures undertaken by farmers, including crop diversification, use of drought-tolerant varieties, soil moisture conservation techniques, and integrated farming practices. Real-life cases, such as the shift by farmers in Attappady from traditional ragi cultivation to short-duration crops, illustrate adaptive changes at the grassroots. Similarly, farmer collectives in Wayanad have adopted contour bunding and mulching techniques to conserve soil moisture during prolonged dry spells. However, challenges persist, including limited access to drought-resilient seed varieties, lack of timely weather forecasts, and fragmented policy support. The study highlights how institutional backing, targeted policies, and community innovations jointly influence resilience in dryland farming. The findings underscore the need for location-specific climate-smart agricultural practices and stronger knowledge-transfer frameworks. This paper highlights the importance of participatory approaches and localised innovation in sustaining dryland farming under changing climatic conditions in Kerala. The insights provided aim to guide policymakers, researchers, and practitioners in formulating effective adaptation strategies that are economically viable and environmentally sustainable.

Keywords: Climate-smart agricultural practices, Community Innovations, Crop Diversification, Drought-tolerant varieties, Dryland farming, Sustainable agriculture.

Impact of Climate Change on Pollutant Transport in Groundwater System: A Mathematical and Hydrogeological Perspective

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Abstract

In the present work, a one-dimensional pollutant transport equation with first-order decay, zero-order production, and linear sorption are considered. The model incorporates climate change effects through variable recharge and temperature-dependent transport parameters. Both analytical solutions using the Laplace transform and numerical solutions using the Crank–Nicolson method are developed for simplified cases. Simulation results demonstrate how climate change scenarios can alter the velocity and spread of solute plumes, potentially increasing contamination risk. This study highlights the importance of integrating climate

variability into solute transport modeling to support sustainable groundwater management under changing environmental conditions.

Keywords: Advection; Dispersion; Groundwater contamination; Numerical solution; Sorption

On the Variation in Runoff Coefficient over Ganga River Basin: Insights from a Water Budget Perspective

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Abstract

The Ganga River Basin is the largest and most densely populated river basin in India and it experiences significant variations in hydrological processes over the past few years because of the rising impacts from climate change and anthropogenic activities. As climate change alters precipitation patterns and human activities intensify, understanding the runoff coefficient (RC, a response variable in the water cycle) variations from a water-balance perspective is critical for sustainable water resource management in the basin. This study aims to quantify the long-term variations in RC across the Ganga River Basin from a water budget perspective over the past two decades by leveraging multi-source datasets of precipitation, runoff, and terrestrial water storage changes from ensemble of satellite-based products, in-situ measurements, reanalysis, and hydrological simulations. In order to reduce uncertainties associated with individual datasets, the ensemble mean approach is used to ensure robustness of results. Furthermore, we delve into the driving mechanisms behind these changes by analyzing the contributions of Evapotranspiration Coefficient (EC) and Storage Coefficient (SC) to RC variability. The annual average values of precipitation, runoff, evapotranspiration and storage changes were 1139.75 mm, 465.12 mm, 638.01 mm, and -10.36 mm, respectively, during 2003 to 2021. The average annual coefficients obtained included RC of 0.410, EC of 0.572, and SC of -0.013. The trend analysis of these coefficients revealed that the RC exhibited an increasing slope of 0.012 per year, leading to a substantial 52.17% increase over the study period. The EC represents a negligible declining trend (slope ≈ –0.007) and the storage coefficient (SC) remains relatively stable with minor fluctuations. These findings underscore the importance of continuous monitoring of runoff dynamics over the Ganga River Basin for informing sustainable water resource management strategies.

Keywords: Anthropogenic activities; Climate change; Ensemble mean approach; Evapotranspiration Coefficient (EC); Storage Coefficient (SC).

Prioritization of Climate Change Adaptation Strategies among Vegetable Farmers- a Gender Disaggregated Analysis

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Abstract

Among the sectors impacted by climate change, agriculture is particularly vulnerable, with vegetable crops facing heightened risks. Changing climatic conditions have led to frequent crop failures, reduced yields, declining quality, and increased incidence of pests and diseases, making vegetable cultivation increasingly unprofitable. To address these challenges, it is essential to develop effective climate change adaptation strategies that also take into account gender-specific perceptions and roles in vegetable production. The study assesses prioritization of climate change adaptation strategies among vegetable farmers of Palakkad district, Kerala. Data collection was conducted among 80 male and 80 female farmers with minimum ten years' experience in vegetable cultivation, selected from four randomly selected blocks. Adaptation strategies were examined under four components namely, crop management, soil and fertility management, water management, pest and disease management, financial management and other practices, using the Analytical Hierarchy Process (AHP), among male and female farmers. It was found that the most substantial strategy among male farmers was the usage of organic manure (global priority- 0.13) and that of females was crop rotation (global priority- 0.12).
Keywords: Climate resilience; adaptive behaviour; Analytical Hierarchy Process (AHP); small holder farmers; gender-based differentiation

Recovered Water from Residential Houses - A Neglected Source in the Planning off Urban Water Supply

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Abstract

Generally, the planning of urban water supply revolves around finding water sources, building many infrastructures for treatment and storage and building other infrastructures for distribution and intermediate storage. But the infrastructure at the household level to individual water-use stations for water treatment, storage and supply are very deficient.

Much of the supplied water is wasted because of the deficient infrastructure in the residential homes.

The poor infrastructure of the water storage systems in the residential household had led to wastage of supply water by overflow occurrences sometimes from the houses at sometimes. In a study conducted in four residential colonies, overflow occurrences had happened in 86% houses in one colony, 24% houses in another colony, 46% houses in another colony and 100% houses in another colony. The duration of overflow also ranged from 5 minutes to 39 minutes adding wastage of treated water. The urban water supply planners must offer a proper storage system and get them installed in the household.

The suppled water received at the residential house is sometimes contaminated due to distribution pipe rusting or when cleaning of the water lines is undertaken. So, majority of the houses have installed inefficient RO purifiers at the residential houses for treatment. In a study in Delhi, it was found that RO purifier wastes 70% of the potable water supplied. This deficient treatment system is causing wastage of 26 KL/year of the potable water for each household. The water supply company must offer a treatment filter to be fixed before the water storage tank, to remove the acquired contamination by the distribution lines. The poor infrastructure at the water-use stations in the residential houses leads to wastage of the supplied water due to inefficient design of the utensils wash-station, wash basin faucets, geysers and pipe layouts. From a study in Delhi it was found that a separate urinal flush would reduce the wastage of toilet flush water by 74%; A sensor-based faucet in the wash basin would save 65% of water used by the faucet; Modified utensil-wash stations could save 61% of the water used in the kitchen-wash station; Modified geyser arrangement could save 10 KL/year of potable water per house. A saving of 25 liters per capita per day can be realized in toilet flush use, with separate urinals. The water supply company must develop the best infrastructure for all the water-use stations and offer it to the water users. In a study on water use in washing machines, it was found that 70% of water can be reused by treating rinse water by electro coagulation treatment set up for the washing machine. The water supply company must develop this rinse water recycler for washing machine and offer this to the water users.

Streamflow Variability under Natural and Regulated Conditions: A Case Study from Godavari Basin

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Abstract

Understanding streamflow variability under different flow regimes, such as natural and regulated conditions, is essential for effective water resource management. This study investigates four unregulated and four regulated stations in the Godavari Basin using statistical and descriptive analyses, including trend, homogeneity, stationarity, and noise test. Unregulated stations show stable, homogeneous flow with random fluctuations,

reflecting natural variability. In contrast, regulated stations exhibit non-stationary, non-homogeneous patterns with a negative trend and absence of random noise, indicating human intervention. To explore this further, time series from regulated stations were segmented at change points identified through homogeneity tests. Analysis revealed that flow before the change point resembled unregulated behavior, while flow after showed clear signs of regulation. The identified change point likely reflects major infrastructure developments, such as dams or reservoirs. Overall, the two flow regimes differ significantly and should be treated as distinct systems. Thus, it is hoped that this type of analysis and regime classification can support improved hydrological modelling and more effective water management.

Keywords: Flow Regulation, Homogeneity analysis, Noise Analysis, Stationarity Analysis, Trend Analysis.

The Importance of Geological Field Work in Recharge Area Demarcation for Spring Shed Management: A Case Study in Karbi Anglong, Assam, India

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Abstract

Springs are lifeline of the hilly people in aspect of water as they are solely depending on it. Due to climate change and land use land cover (LULC) changes, springs start to dry up causing an alarming situation for the rural households. Therefore, this study aims to conduct a detailed geological field work to understand the basic characteristics of springs with very poor discharge in Karbi Anglong, Assam, India and to investigate the methods for rejuvenating the springs. Three springs were selected viz., Lunse Ronghang, Ramsapthar and Thekerajan serves approximately 1400 populations covering nine villages. Rainfall analysis from 2015 to 2021 showed a declining trend which directly impacts spring recharge. The monsoon rainfall recharges the springs, while during the lean period spring discharge decreases and dries frequently. The LULC study infers that the brushwood cultivation replacing the natural vegetation may be a cause of declining recharge during monsoon. A critical study of the geological features was conducted to identify the spring typology and recharge areas were demarcated considering the spring type. The recharge interventions were identified from the slope analysis considering the water demand. Based on the amount of slope, vegetative and engineering measures were selected. Staggered contour trench with dimension 2×1×0.6 m is identified as an appropriate structure to be implemented for the three springs since the slope of recharge areas are less than 30%. To ensure the sustainability of the springs, vegetative measures to be implemented as a second line of defence to control erosion and soil stability.

Keywords: brushwood cultivation; climate change; discharge; LULC; spring

Time Series Analysis of Rainfall Data of the Thamirabarani River Basin

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Abstract

This study aims to analyze the rainfall data over the Thamirabarani River basin. The gridded rainfall data from 1901 to 2023 for this study were downloaded from the India Meteorological Department (IMD), Pune. The analysis of rainfall data at 8.50 N and 77.50 E coordinates within the Thamirabarani River Basin has been carried out using various tests, including trend, homogeneity, and stationarity. The results indicate that the Mann-Kendall (MK) and Spearman's rho correlation (SRC) tests show no trend for both annual and monthly seasonal time series. In addition, the Innovative Trend Analysis (ITA) test reveals a decreasing trend for annual and daily time series analysis. This shows that the ITA outperformed the MK and SRC tests. The results of the homogeneity test show that the time series is homogeneous during annual and monthly seasonal analysis, whereas non-homogeneous for daily time series analysis. However, rainfall time series exhibit stationarity for annual, seasonal, and daily time series analyses. The chaotic analysis using False Nearest Neighbors (FNN) shows that the rainfall has a higher dimension, which indicates that the process is very complex and needs an advanced hydrological model to predict the future values.

Keywords: False Nearest Neighbors (FNN); Homogeneity; Innovative trend analysis (ITA); Mann-Kendall test; Stationarity.

Theme 2

Water Security and Risk Management

1. Application of Geo-electric method for Groundwater Exploration in Deccan Basaltic Terrain of North Maharashtra, India

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Abstract

The major objective of this research is to locate groundwater occurrences in the study area using integrated geophysical methods. Water is distributed unequally throughout time and location. There is no state-wide water scarcity, but a few locations and talukas are chronically water-stressed because regional water demand has increased more than twice as fast as population growth in the last three years. Village grampanchayats play a crucial role in delivering safe drinking water and household clean water on a regular basis via piped water delivery systems. Water scarcity limits access to safe drinking water and basic hygiene practices at home, schools, and health-care facilities. The study area (Rajapur Village) is located in the Yeola Tehsil in the Nashik District of Maharashtra State. The normal annual rainfall in the district varies from about 500 mm to 3400 mm. The study of negative departures of the annual rainfall over normal reveals that major part of the district (about 75%) falling east of Western Ghats comprising almost entire Sinnar, Niphad, Surgana, Kalvan, Satana, Chandwad, Yeola talukas and parts of Dindori, Peint and Malegaon talukas can be categorized as drought area. The average annual rainfall for the period 2002 to 2011 ranges from about 476.7 mm (Devali) to 3508.1 mm (Igatpuri). Due to shortage, Rajapurgram panchayat provides insufficient water once every 15 days via tankers. Tanker fees are rising as day-to-day demand rises in less populous communities. Villagers use bicycles, motorbikes, and carts to carry water three kilometers from the government headquarters each day. In order to remedy this, the grampanchayat excavated a new open well three kilometers from Govthan, 60 feet deep, downstream of the Wadpati percolation talav. At least once every two days, the new source might not supply water, nevertheless. Vertical Electrical Soundings confirm the weak current densities of over 20% seen in the fourth and fifth profiles. The interpreted findings suggest shallow groundwater potential zones 38 meters from the source. According to the study, three 42-meter-long horizontal bore wells are dug into potential zones 10 meters below the source. The horizontal bore wells supplied the source with water in less than 48 hours. The integrated results are useful in providing a comprehensive image of the study area's surface and subsurface structures, as well as groundwater potential in the study area. This helped in sustainable development of study area as well as community located in the nearby region.

Keywords: Scarcity, Electrical Resistivity soundings, VLF profiles, Potential zones, Sustainable solutions

2. Assessment of the Industrial impact on Water Quality and Heavy Metal Contamination in Cuddalore district

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Abstract

Cuddalore district, a major industrial hub on India's southeastern coast, showcases a diverse industrial profile encompassing chemical manufacturing, agro-processing, textiles, and fisheries, which contributes significantly to local economic growth but also raises serious concerns regarding environmental degradation and heavy metal pollution. This study assessed 128 water samples from industrial zones, analysing both physicochemical parameters and heavy metal concentrations to evaluate the contamination risks and sources. The results revealed notable variations in physiochemical parameters, including pH ranging from 4.35 to 9.01, electrical conductivity (EC) ranging from 206 to 2493 µS m^{-1}, total dissolved solids (TDS) ranging from 131.84 to 3256.22 mg L^{-1}, calcium ranging from 34.5 to 128 mg L^{-1}, magnesium ranging from 19.6 to 64.5 mg L^{-1}, and chloride ranging from 122.7 to 316.9 mg L^{-1}. Additionally, 65 representative samples were analysed for heavy metals via Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), revealing detectable levels of iron (Fe) concentrations ranging from 0.005 to 0.157 mg L^{-1}, lead (Pb) from 0.002 to 0.029 mg L^{-1}, and nickel (Ni) from 0.001 to 0.055 mg L^{-1}. While cadmium (Cd) and chromium (Cr) were also recurrently found, indicating chronic level contamination. These findings highlight cumulative contamination from industrial discharge, presenting severe ecological and public health risks. The study underscores the need for improved effluent management, continuous environmental monitoring, and remediation strategies. Future research should integrate soil contamination and metal bioavailability assessment for comprehensive risk evaluation in this industrially significant region.

Keywords: Cuddalore, water quality, heavy metals, industries, ecological risk.

3. Climate-Resilient Little Millet–Pulse Intercropping: A Sustainable Strategy for Yield and Soil Fertility Enhancement in Rainfed Ecosystems

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Abstract

Climate variability and frequent dry spells threaten the stability of rainfed agriculture, demanding resilient cropping systems that optimize resource use and sustain productivity. Integrating pulses with climate-resilient millets offers a sustainable solution to improve food security, soil fertility, and system resilience under unpredictable rainfall conditions. A field experiment was conducted during the *rabi* season of 2023–2024 at the Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, to evaluate suitable pulse combinations and row ratios for improving the productivity and ecological resilience of little millet (*Panicum sumatrense* L.) under rainfed conditions.

The experiment, laid out in a randomized block design with eleven treatments and three replications, included little millet intercropped with black gram, green gram, red gram, cowpea, and Bengal gram at 4:1 and 6:1 ratios along with a sole millet control. Among the treatments, little millet + black gram (4:1) recorded superior growth and yield attributes—plant height (133.6 cm), dry matter production (5943 kg ha^{-1}), and grain yield (1326 kg ha^{-1})—along with higher microbial activity (46.94 × 10^6 CFU g^{-1} bacteria) and nutrient uptake (N – 40.8, P – 5.7, K – 33.5 kg ha^{-1}). The little millet + cowpea (4:1) system effectively suppressed weeds (8.4 m^{-2}) and improved post-harvest soil fertility (N – 339, P – 47.6, K – 197 kg ha^{-1}).Overall, the intercropping of little millet with black gram or green gram at a 4:1 ratio enhanced system productivity, nutrient cycling, microbial diversity, and weed control—key indicators of climate-resilient agroecosystems. Hence, millet-based pulse intercropping can serve as a viable adaptation strategy for strengthening climate resilience, resource-use efficiency, and sustainability in rainfed agriculture.

4. Environmental Impact of Chromium Waste and Hydrogeological Assessment of COPR Sites in Rania-Khan Chandpur, India

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Abstract

We have performed field scale assessment of Chromium (Cr) contamination in soils and groundwater originating from hazardous chromite ore processing residue (COPR) dumps in Rania-Khan Chandpur, India. Site-specific groundwater analysis indicates total chromium concentrations exceeding 35 mgL^{-1}, with most samples having Cr concentrations over the permissible limits. Similarly, the Cr contamination in surface water has been found more than 40 mgL^{-1}. Cr concentrations in soil and COPR increased with increasing the depth of the subsurface. We found maximum concentration up to 48000 mg Kg^{-1} at ground level. To minimize the possible health risks associated with Cr contaminated drinking water and irrigation water, these findings underscore the urgent need for remediation and increased monitoring efforts in areas.

Keywords: Chromium, Hydrogeology, Subsurface, Kanpur, India

5. Groundwater Quality Evaluation and Non-Carcinogenic Risk in the Chilika Coastal Aquifer, Eastern India

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Abstract

Coastal aquifers are particularly susceptible to degradation due to intense human activity, rapid urban development, excessive groundwater withdrawal, and restricted natural recharge. This study evaluates groundwater quality, non-carcinogenic health risks, and hydrogeochemical processes in the coastal aquifer surrounding Chilika Lagoon in Ganjam district, Odisha. Fluoride (F^-) concentrations range from 0.5 to 2.35 mg/L, with 14 samples exceeding 1 mg/L and 6 samples exceeding the permissible limit of 1.5 mg/L. The Fluoride Pollution Index (FPI) lies between 1.5 and 3.5, with 32 % of samples showing high fluoride pollution. Nitrate (NO_3^-) concentrations range from 0 to 61.35 mg/L, and 9 samples exceed 50 mg/L. The Nitrate Pollution Index (NPI) varies from –1 to 2.05, with 26 % of samples showing medium and 6 % significant pollution. The Pollution Index of Groundwater (PIG) ranges from 0.27 to 8.49, indicating 6 % of samples with medium to significant pollution and 94 % within desirable quality. The Entropy Weighted Water Quality Index (EWQI) ranges from 4.2 to 313.2, with 16 % of samples categorized as poor to very poor quality and unsuitable for drinking. Health risk assessment reveals Hazard Index (HI) values between 0.16–1.98 (adults) and 0.16–1.90 (children), with 39 % of samples exceeding HI > 1 for both age groups. Geochemical analysis indicates that weathering of K-feldspar-rich silicate rocks governs fluoride enrichment, while elevated nitrate levels reflect anthropogenic contamination.
Keywords: FPI; NPI; THI; Water quality; Chilika Lake

6. Hydrochemical Characteristics of Groundwater Resources in the Water Stressed Areas of Palakkad District, Kerala

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Abstract

The groundwater resources in the critical (Chittur and Malampuzha) semi-critical blocks (Pattambi and Thrithala) of Palakkad, Kerala were studied to assess the quality and quantity. During the pre-monsoon period (2024 & 2025), 85 groundwater samples were collected randomly from these blocks (58 dug wells and 27 bore wells). The depth to water level varies from 0.70-10.65 m bgl in the dug wells of critical blocks and 0.58-12.85 m bgl

in semi-critical blocks and it varies from 7.93-57.17 m bgl in the bore well from critical blocks and 0.35-50.25 mbgl in semi-critical blocks. Insitu physico-chemical parameters were monitored and the samples were transported to the laboratory for analysis of major cations, anions, and bacteriological content. The analysis reveals varying levels of chemical parameters across the blocks studied. The water samples from the critical blocks predominantly exhibit alkaline pH in 2024 and acidic in 2025, while the semi-critical block shows acidic pH for both 2024 and 2025. Several samples exceed the permissible limits for drinking by BIS for the measured parameters like EC, TDS, salinity, turbidity, TH, Ca, Mg, Cl, Na, K, Fe, SO_4, and F. The chittur block is found to be a fluoride-contaminated area, with six samples exceeding acceptable fluoride levels in 2024 samples (1.05-1.27 mg/L) and also one sample above the permissible limit (1.56 ppm) as per BIS. The source of fluoride in groundwater is mainly from the rock hornblende biotite gneiss, clay minerals, and micas. The Hill Piper diagram showed the groundwater is predominantly of Mg-HCO3, Ca-HCO3, Na-HCO3 and Na-Cl types, revealing variations in the dug well and bore well water samples in each of the blocks during 2024 and 2025. Bacteriological analysis indicated the presence of total coliforms in most of the dug wells with E. coli in some of the bore wells and dug wells in the critical blocks. Groundwater level trends in bore wells warranted the urgency for implementing restoration strategies (GWR) resulted from higher levels of exploration and extraction. Integrated water management strategies are essential for the sustainable use of ground water resources in the region.

Keywords: Critical and semi-critical blocks; Fluoride contamination; Groundwater chemistry;
Pre-monsoon season; Palakkad District, Kerala

7. Long-Term Trends in Groundwater Depletion: A Case Study from Kasaragod Block, Kerala, India

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Abstract

Groundwater plays a crucial role in meeting water demands for irrigation, drinking, and industrial use across India. According to the Central Ground Water Board (CGWB) report, groundwater levels in many regions have been depleting rapidly due to over-extraction, particularly in agricultural areas. While Kerala's groundwater condition is better than most Indian states, certain urban and coastal regions show depletion due to rising demand. The groundwater situation in Kasaragod block has become critical due to over-extraction for agricultural and domestic needs. CGWB reports reveals significant groundwater decline in the block during dry seasons, and is further intensified by irregular rainfall, inadequate recharge, and unsustainable usage. Present study aims to examine the spatial distribution of groundwater level trends and identifies water-scarce panchayaths over a decadal period by employing Man-Kendall, Sens' slope, SWI, and Spatial Interpolation techniques across fifteen dug wells across Kasaragod block from 2013 to 2022. The analyses reveal both upward and downward trends in groundwater levels, highlighting the aquifer system

responses to changing seasonal climatic conditions. The results underscore how different regions react distinctly to contrasting climate patterns, such as excessive rainfall or prolonged drought. The Spatial interpolation of various hydrogeological parameters corroborates a widespread decline in groundwater levels, underscoring the critical need for sustainable water management in the study area. The study highlights the need to identify the sustainable water resource management and an immediate intervention such as improved water management strategies and recharge techniques, are necessary to prevent further deterioration of groundwater resources in the region.

Keywords: Groundwater decline; Mann-Kendall; Sen's slope estimator; Trend Analysis; Water Resources Management

8. Low-cost Solutions for Water Management

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Abstract

In India, nearly six-lakh students graduate as Engineers every year (TOI) and nearly 35 million people lack access to safe water as per water.org. The significant difference in the numbers, despite being challenging, can be addressed through innovation and *Technological improvements* over time. *Affordability* is the root cause of innumerable people lacking basic water facilities even after years of Independence. The purpose of the study is exploring '*Atmospheric Water Harvesting'* that works by cooling the humid air, causing the water vapor to condense and form liquid water. The monsoon and water harvesting are time-bound activity; however, harvesting water from atmospheric humidity, particularly during summer when temperatures and humidity are high. A qualitative research study of projects YAWA and WARKA for feasibility and process was undertaken. The dual purpose of YAWA, working towards *uplifting agricultural and communal needs* through innovations focused on turbine techniques infused with atmospheric humidity. While the WARKA water project addresses *water scarcity* with a broader vision of community resilience. The Indian regions with similar climatic and context can serve as a base to experiment and implement the projects that shall provide realistic and cost effective solutions for millions of lives.

Keywords: Technological improvements, Affordability, Atmospheric Water Harvesting, Uplifting agricultural and communal needs, Water scarcity

9. Multi-dimensional Context of Urban Water Strains

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Abstract

Water is a precious and intangible resource, a vital component for survival of living creatures. The gratuitous natural water supply is pure and sufficient for human needs but not for commercialized and politicized greed by the time, it reaches the concrete jungles of urban areas. The purpose of the study was to address *Water stress; Water poverty* and *Water literacy* are trilateral phenomenon for urban water crisis. Connecting the dots related to SDG 3: Good Health and Well-being; SDG 6: Clean Water and Sanitation; SDG 13: Climate Action and SDG 15: Life on Land for sustainable lifestyle. A *technical study* of the top most populated cities Tokyo, Delhi, Shanghai, Dhaka, Cairo and Sao Paulo on parameters of population-climate-continent. A *comparative study* of planned and unplanned urban areas to explore the root cause of the difficulties experienced. A *contextual study* of the cities that overcame water challenges (demand and supply) using novel strategies. Some of the challenges among *unplanned urban areas* include outdated infrastructural systems, unplanned rapid urbanization, over extraction of ground water and inefficient water management. Whereas, some of the challenges among *planned urban areas* include deforestation, prolonged dry periods, demand outstripping supply and water rationing. However, in both scenarios high consumption per person/ per day was among common challenges. Traditional and modern methods are instrumental in overcoming the issues through timely practice and patience. Desalination, water shut-off and recycling act as something better than nothing in achieving the potential issues seamlessly.

Keywords: Water literacy, Water poverty, Water stress, Unplanned and Planned Urbanization

10. Numerical Modelling of Contaminant Transport in the Aquifer Systems near the Orsang River, Gujarat

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Abstract

Groundwater is a crucial resource for semi-arid regions like Chhota Udepur and Jetpur Pavi taluka in Gujarat, India. However, its quality is increasingly threatened by contamination from agricultural runoff, industrial discharges, and natural geochemical processes. This study focuses on the area between the tributaries of the Orsang River, aiming to assess the extent and transport of nitrate contamination in the region's aquifers a major concern due to its harmful effects on human health. A combination of Geographic Information System (GIS) tools and numerical groundwater models (MODFLOW and MT3DMS) was used to simulate groundwater flow and nitrate transport over a 10-year period. The study incorporated extensive groundwater quality and hydrometeorological data collected between 2001 and 2020 from the CGWB, GWRDC and NRDWP of Central government

program. A multi-layered MODFLOW model was developed using the Groundwater Modeling System (GMS). The model was calibrated with field observations to reduce errors between observed and simulated groundwater levels. The initial steady-state model was used to set starting conditions for the transient simulation, while the MT3DMS module modeled nitrate transport using parameters like hydraulic conductivity, porosity, and longitudinal dispersivity. Nitrate concentrations in the study area ranged from 190 to 262 mg/L, far exceeding the permissible limit of 45 mg/L that showed high contamination in both shallow and deep aquifers, with the most affected areas located near agricultural zones and along the Sukhi, Bharaj, and Orsang tributaries. Nitrate concentration in the upper aquifer decreased from 220 mg/L to 132 mg/L, while levels in deeper aquifers increased, indicating downward migration of contaminants. Groundwater heads ranged from 91.5 to 111.5 meters above mean sea level, with a balanced inflow and outflow of approximately 237 m^3/day and a negligible model error of 0.0001%. The direction of contaminant transport aligned with the general groundwater flow toward the southwest. Long-term monitoring and mitigation strategies are critical to safeguarding groundwater quality in this ecologically sensitive and agriculturally intensive region.
Keywords: Groundwater, Contaminant Transport, Nitrate, MODFLOW, MT3DMS.

11. Recharge Potential in the Water-stressed Balijana Block of Goalpara District, Assam, India: A GIS Based Approach

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Abstract

Groundwater depletion is a common issue in recent time due to various natural and anthropogenic reasons. This study aims to investigate the cause of groundwater declination and recharge potential of the Balijana block, Goalpara, Assam using Remote sensing and GIS. The necessary thematic maps were prepared and studied viz., geology, geomorphology, elevation, LULC (2018 and 2023), Normalized Difference Vegetation Index, Normalized Difference Water Index, slope, aspect, lineaments and overburden depth. Geologically and geomorphologically the region comprised of both high and low groundwater recharge potential zone. The Assam-Meghalayan gneissic complex comprised a half of the region with rest is undifferentiated quaternary sediments, whereas only small part comprised of alluvial plain and flood plain and the rest are inselberg like morphology. However, the higher slope of >20% promotes runoff efficiency. Moreover, Expansion of built-up areas and agricultural land have altered the recharge potential. Growth of rubber plantation may be a key cause which can attributed to the depletion of groundwater because of their very high-water retention capacity. The region hosts a higher overburden depth towards SEE and lowest towards N and SW indicating higher groundwater potential towards SEE direction. To enhance the groundwater recharge, river bank filtration may be an effective method in the bank of river Brahmaputra. Depending on the slope, engineering

measures such as staggered and continuous contour trenches may be implemented. The defunct wells in the region may be converted to recharge wells through rainwater harvesting. Afforestation and soil conservation practices may be adopted in the steeply sloping region.

Keywords: groundwater depletion; LULC; overburden; remote sensing; thematic maps

12. Role of Clay Barriers in Modulating Saline Intrusion: A Stable Isotope and Hydrochemical Study from a Coastal Aquifer, Eastern India

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Abstract

Groundwater salinization is a critical challenge in many tide-dominated coastal regions, where dynamic river–sea interactions and storm surges compromise freshwater availability. To unravel these processes, hydrochemical and stable isotope approaches were applied in a coastal aquifer system of eastern India. The aquifer is bounded by the Kushabhadra River in the south and the Kadua River, a tidal backwater body in the north. Results reveal contrasting hydrogeological controls on salinity distribution. A narrow stretch parallel to the coast remains remarkably fresh, despite its proximity to the sea, because it behaves as a perched aquifer. A laterally continuous clay layer restricts saline water ingress from below and laterally, while its upper portion remains unconfined and sustained by local recharge. In contrast, inland parts of the aquifer are highly vulnerable: tidal activity and frequent storm surges drive episodic seawater penetration, causing salinity to rise dramatically. In this study, Total dissolved solids were found to have a large variation (50 to 5000 mg/l), with ionic ratios and stable isotope signatures ($\delta^{18}O$, $\delta^{2}H$) clearly indicating seawater intrusion in the affected zones. These findings highlight how stratigraphic barriers can preserve freshwater lenses even along exposed coastlines, while inland stretches, hydraulically linked to tidal rivers, remain susceptible to salinity ingress. The study provides valuable insight for developing targeted groundwater protection and management strategies in similar coastal environments.

Keywords: Groundwater salinization, Perched aquifer, Seawater intrusion, Stable isotopes, Coastal hydrogeology

13. Scope and Challenges in Implementation of Artificial recharge Schemes for Sustainable Groundwater Resources in Hard Rock Terrain of Deccan Trap Basalts

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Abstract

The irregularity in monsoon has severely affected the water availability at surface and sub-surface systems. In this scenario Groundwater is a prime source of fresh water sustaining life. It is a principal source of drinking water in rural areas of Maharashtra. About 85% rural water supply is from groundwater resources. Surface sources are not sufficient and convenient to reach all villages for drinking, domestic and irrigation purpose. Groundwater is the most preferred source of water on account of its universal availability, dependability, reliable, safe, free from pathogenic bacteria and suspended matter and too low capital cost. Dependence on ground water is increasing day by day as groundwater accounts for most of the increase in net irrigated area in the country. Water is extracted from dugwells, as well as from medium and deep bore wells. Increasing demand of groundwater and its extraction from shallow and deeper aquifers has resulted in ever increasing stress and due to uncontrolled extraction of groundwater there is depletion of groundwater levels. The natural groundwater recharge in hard rock formations of Deccan Trap basalts in Maharashtra is uncertain and sufficient to balance the continuously increasing demand. Hence in drought prone area of Marathwada region water scarcity is a regular phenomenon faced by village population. Drinking water sources go dry in summer and water is supplied by tankers. Artificial recharge is widely recognised as the primary measure for augmenting groundwater resources. Groundwater recharge is a technique by which infiltrated water passes through the unsaturated zone and meet saturated zone rising the water table. Different direct and indirect methods of groundwater harvesting techniques can be applied for recharging. These techniques arrest the runoff water and enhance groundwater availability for use. Hence by managing aquifer recharge using suitable conventional and unconventional low cost methods it is possible to strengthen the source and thereby overcoming scarcity of water. In the present studies Parbhani district of Maharashtra has been selected for implementation of artificial recharge schemes which has several significant operational challenges including site suitability, land availability, and water quality concerns. For successful implementation stakeholders participation and governance is also necessary.

Keywords: Drinking water scarcity, artificial recharge, challenges

14. Study of Variation in Physico-Chemical Parameters Controlling the Water Quality of Wetlands in Khultabad Region of Maharashtra

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Abstract

Wetlands are essential for preserving the hydrological cycle, the diversity of the world's ecosystems, the regulation of the climate, and human wellbeing. Humans can benefit directly from wetlands ecosystems in addition to receiving indirect services from them. The world is experiencing serious environmental issues due to the rapid depletion of natural resources, posing a threat to ecosystems. The wetland resource is mainly contaminated from sewage or wastewater disposal, encroachment, commercial and industrial activity. In view of this current study compares the water of wetlands in Khultabad tehsil of the Aurangabad district of Maharashtra. The samples were collected in Pre-monsoon in January 2022. A total of 28 water samples were analyzed collected from wet lands situated in the central part of Aurangabad district, Maharashtra. The samples were tested for pH and temperature, electrical conductivity, turbidity, total dissolved solids, dissolved oxygen, chemical oxygen demand (COD), biological oxygen demand (BOD), total hardness, bicarbonate, chlorides and nitrate. For developing suitable policies and carrying out priorities, knowledge of the fundamental and integrated facts on wetlands is crucial. All the selected parameters are showing higher values due to the continual discharge of waste effluents into it. According to the study, there should be urgent action is needed to restore water quality and support any long-term plans for wetland restoration.
Keywords: Physico-chemical parameters, Water quality, Wetland, Aurangabad

15. Sustainable Groundwater Management in Coastal and Terrestrial Zones Impacted by Salinity and Pollution

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Abstract

Groundwater is a vital resource sustaining human populations, agriculture, and ecosystems in both coastal and inland regions. However, it faces growing threats from over-extraction, industrial effluents, agricultural runoff, and seawater intrusion, leading to widespread degradation. Globally, approximately 24 million km² (16% of the land area) are affected by high groundwater salinity, with West and Central Asia being among the most impacted regions. In addition, contamination from volatile organic compounds, heavy metals, pathogens, nitrates, pesticides, and emerging pollutants presents complex management

challenges. Ensuring the sustainability and quality of groundwater requires site- and contaminant-specific interventions. This talk will focus on strategies such as Managed Aquifer Recharge (MAR), Submarine Groundwater Discharge (SGD) characterization in coastal zones, and in-situ remediation of polluted aquifers. In coastal regions, MAR supported by freshwater sourced from potential SGD zones can reduce seawater intrusion and enhance freshwater availability by manipulating subsurface hydraulics. In terrestrial areas, in-situ remediation techniques, such as engineered bioremediation for hydrocarbon-contaminated aquifers, can facilitate large-scale restoration. This talk highlights the field-scale application of bioremediation methods for restoring contaminated groundwater systems. Similarly, Permeable Reactive Barriers (PRBs) equipped with well screens have proven effective in removing geogenic contaminants like arsenic and fluoride under field conditions. Advanced monitoring approaches, including the use of proxy indicators correlated with complex pollutants, further strengthen the ability to manage groundwater quality effectively. Collectively, these integrated strategies offer promising solutions to the pressing challenges of groundwater degradation under increasing anthropogenic stress.

Keywords: Groundwater management, Managed Aquifer Recharge, Submarine Groundwater Discharge, Groundwater Contamination, Remediation

16. Systemic Risk and Resilience on Small Island Developing States: Investigating the Water Metabolism of Malé, Maldives

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Abstract

Water metabolism is defined by patterns of water flowing into, within, and out of a socio-ecological system and may entail risks and cascade effects across spatial, temporal and sectoral scales. A better understanding of these patterns and their associated risks can inform climate adaptation mechanisms, improving systemic resilience for climate vulnerable regions such as Small Island Developing States (SIDS). These risks can be understood as socio-metabolic risks, a subset of systemic risks associated with critical resource availability, circulation, and distribution of costs and benefits. This study is aimed at developing a framework to analyze socio-metabolic risks associated with water metabolism within SIDS and will take Malé, Maldives as a case study. Quantitative water accounts will be assembled and used to develop indicators focused on availability, access and reliability. To capture varied and local perspectives on risk, both top down and bottom up data collection will be employed using data from utilities and industries as well as a household survey. The drivers and impacts of the determined system dynamics will be explored through qualitative analysis using insights from focus groups on water security

and expert interviews. A detailed system map will be created presenting the function of the water systems in Malé and the socio-metabolic risks that accumulate and cascade throughout. Currently, there is limited systemic analysis of the urban water system of Malé and as such this work will develop relevant insights on which to base resilience and adaptation efforts in the future.

Keywords: Climate Vulnerability; Socio-Hydrology; Socio-Metabolic Risk; Stakeholder Engagement; Water Security

17. Urban Area Extraction and its Impact on Water Surface Area in Coimbatore City

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Abstract

Urbanization significantly impacts the availability and quality of water resources, often leading to the reduction of water spread areas (WSA) as built-up environments expand. This study employs the Normalized Difference Built-up Index (NDBI) to analyze urban growth in Coimbatore City and its effects on WSA around local tanks from 2000 to 2021. NDBI, derived from satellite imagery, effectively distinguishes built-up areas by highlighting surfaces with low vegetation cover. The research identifies a significant urban growth, from approximately 55.97 km² in 2000 to 171.54 km² in 2021, particularly evident between 2000 and 2010 in Google Earth Engine platform. Despite urban encroachment leading to WSA reduction, restoration initiatives, particularly under the Smart City Mission from 2017, have positively influenced WSA recovery in some tanks. Notably, while urban areas around certain tanks decreased, others like Kurichi tank experienced a marked increase in both urban development and WSA, attributed to successful restoration efforts and community awareness. This analysis underscores the complex interplay between urbanization and environmental management in urban settings.

Keywords: Urbanization, Water Spread Area, NDBI, Google Earth Engine

Theme 3

Advanced Technologies in Water Resources Management

1. Advanced Machine Learning-Based Nitrate Prediction in Groundwater: Integrating Spatial, Seasonal, and Anthropogenic Drivers in Tiruvannamalai District, Tamil Nadu

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Abstract

The safety of drinking water and the sustainability of agriculture are threatened by groundwater nitrate (NO_3^-) contamination, which is mostly caused by excessive fertilizer use, agricultural runoff, and human activity. To forecast and map the seasonal nitrate concentrations in Tiruvannamalai District, Tamil Nadu, this study proposes a machine learning (ML)-based system. Fourteen hydrochemical parameters were examined in 360 groundwater samples, in addition to spatial variables such as elevation, rainfall, soil type, land use/land cover (LULC), and NDVI. Nine machine learning techniques were trained and assessed using R^2, RMSE, and MAE. These algorithms included random forest (RF), light gradient boosting (LGBM), eXtreme gradient boosting (XGB), decision tree, support vector machine, multilayer perceptron, linear regression, polynomial regression, and K-nearest neighbors. Performance was highest for RF and LGBM, with RF obtaining R^2 = 0.94, RMSE = 0.49, and MAE = 1.30. Specifically, nitrate hotspots were found in agricultural areas with low water tables using inverse distance weighting (IDW) mapping. Key predictors identified by feature importance analysis included land use, water table depth, EC, and NO_3^-. A 25% decrease in fertilizer use might greatly enhance groundwater quality, according to a scenario simulation. Using agricultural waste, a GIS-based decision-support tool is suggested to visualize seasonal nitrate risk zones and provide solutions like permeable reactive barriers and optimal fertilizer application to assist targeted interventions. A useful framework for data-driven, climate-resilient groundwater management in nitrate-sensitive areas is provided by this integrated method, which also increases the accuracy of nitrate predictions.
Keywords: Agricultural runoff; Ensemble models; Geospatial analysis; Remote sensing; Water quality.

2. An Effectual Water Quality Index Forecasting using Dual Multi Scale Attention Network with Garra Rufa Fish Optimization Algorithm

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Abstract

Water quality (WQ) plays a vital role in sustaining ecological balance and supporting life. However, increasing industrialization, urbanization, and agricultural activities have significantly degraded water sources, threatening public health and environmental sustainability. Traditional methods for Water Quality Index (WQI) prediction often struggle with limitations such as high computational costs, low accuracy, and the inability to handle nonlinear and multivariate time-series data effectively. To address these challenges, this research introduces a novel model—Dual Multi-Scale Attention Network with Garra Rufa Fish Optimization (DMSAN-GRFO-WQIP)—for accurate WQI prediction and classification. The proposed approach utilizes the Water Quality Index Prediction dataset as input, which is pre-processed using Altered Phase Preserving Dynamic Range Compression (APPDRC) to reduce noise and recover missing values. The DMSAN architecture captures both short- and long-term dependencies in the multivariate time-series data, while the GRFO algorithm optimizes the network parameters, enhancing the model's predictive precision. The system classifies WQ status into categories such as excellent, good, medium, bad, and unsuitable for drinking. Performance is evaluated using multiple metrics including RMSE, MAE, accuracy, precision, recall, and F1-score. Comparative analysis with existing models, such as Robust Machine Learning Algorithms (RMLA-WQIP) and Hybrid LSTM-Sparrow Search Optimization (HLSM-SSO-WQIP), demonstrates the superior effectiveness of the proposed method. The findings suggest that DMSAN-GRFO-WQIP provides an efficient, robust, and scalable solution for real-time WQI prediction, aiding sustainable water resource management and decision-making.
Keywords: Water Quality Index (WQI); Multivariate Time-Series Data; Environmental Sustainability; Altered Phase Preserving Dynamic Range Compression (APPDRC); Machine Learning Algorithm

3. Analytical Solution for 2D Coupled Unsaturated-Saturated Groundwater Flow

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Abstract

Numerical solutions have gained significant focus in the field of groundwater recharge. However, much research has not been done in this area to develop analytical solutions for a coupled unsaturated-saturated flow model. Here we present a mathematical model to describe 2-D steady unsaturated-saturated flow in an unconfined aquifer, where we have a specified recharge at the ground surface and partially penetrating drainage on one side of the aquifer. The model incorporates Richards' equation and groundwater flow equation for unsaturated flow and for the saturated zone, respectively, and the Gardner constitutive

model for unsaturated soil properties. Conditions of head and flux at the water table are used. Variable separable method and Fourier expansions are used to derive analytical solutions. A quantitative tool is introduced to calculate the head at various locations within the flow domain. The validity of this solution was confirmed by comparing it with a numerical solution obtained using MATLAB. Maximum error obtained was 3.96% and the variation in head values within the domain aligns with established knowledge of groundwater flow proving the solution to be ready-to-use in real scenario. Sensitivity analysis is also conducted to gain insights into the factors affecting the head at saturated zones. It can be observed that the head at saturated zone changes drastically when ratio of unsaturated to saturated depth is less than 0.8 or product of unsaturated depth and unsaturated exponent is less than 1. Head is most sensitive at the far end from the drainage.
Keywords: Fourier expansions; Gardner model; Mathematical model; Steady state; Variable Separable Method.

4. Analyzing Groundwater Dynamics in the United States using Complex Networks Concepts

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Abstract

Groundwater is a vital freshwater resource for domestic, agricultural, and industrial uses, especially in arid and semi-arid regions where surface water is scarce. However, modeling groundwater systems remains challenging due to their inherent complexity, governed by subsurface geology, climate variability, and human activities. To address this, the present study applies complex networks theory—a robust framework for analyzing large, nonlinear systems—to investigate spatial interactions within groundwater level data. A groundwater network is constructed using daily groundwater level data from 200 wells across the United States for the period 2010–2020, sourced from the US Geological Survey (USGS). Each well functions as a node, and connections are established based on the correlation of groundwater levels. Five key network measures—clustering coefficient, degree centrality, closeness centrality, betweenness centrality, and shortest path length—evaluate the network structure and help identify influential wells and regions of strong or weak connectivity. The Louvain method is used to detect community structures by maximizing modularity. These communities reveal clusters of wells with similar hydrological behaviour, likely influenced by shared recharge zones or subsurface conditions. The results highlight regions with high interconnectivity, indicating vulnerability to collective depletion, and regions with isolated behaviour, suggesting localized recharge mechanisms. Overall, the study demonstrates that

complex networks offer a powerful tool to uncover hidden spatial patterns in groundwater systems. The insights derived help identify priority areas for monitoring and support the sustainable management of groundwater resources across large regions.

Keywords: Groundwater dynamics; Complex networks; Correlation; Louvain algorithm; Groundwater levels.

5. Application of Microwave Remote Sensing Data for Reservoir Water Spread Area Estimation

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Abstract

Sediments carried by the rivers are deposited in the reservoirs and cause several detrimental effects, which include loss of storage capacity, upstream aggradations, effect on water quality and impairment of hydro-equipments. The deposition of sedimentation not only reduces the capacity but also the water-spread area at the entire water level of the reservoir. Optic satellite data has long been in use to estimate the water-spread area at different water levels of a reservoir, which in turn can be used to quantify the revised capacity of the reservoir. However, due to the presence of clouds in the optic satellite data during monsoon and cyclonic season it is not possible to map the water spread area of a reservoir. To overcome this problem, microwave Synthetic Aperture Radar (SAR) data has been used in this study which has the ability to penetrate the cloud, and hence the information beneath the cloud can be easily ascertained. Microwave satellite data (Sentinel 1-SAR) pertaining to Somasila reservoir contain twelve SAR images for the period 2020-21, between the water level near MDDL and near FRL has been used to estimate the revised capacity of Somasila reservoir in this study. The pre-processing techniques were applied to all the twelve SAR, dual-polarized (VV+VH) data. From the VV+VH processed data, a thresholding methodology was used to identify the water pixels. The processed microwave data contain water pixel values ranging from -34.17 dB to -16.28 dB, these pixels were extracted and the water spread area occupied by all the twelve SAR images were estimated. These water spread areas were used in a simple volume estimation Prismoidal formula and the volume between twelve different water levels were calculated. The estimated volumes have been added to assess the revised capacity between the near MDDL and near FRL water levels for the period 2020-21. Based on the analysis, the revised capacity of Somasila reservoir has been estimated.

Keywords: Synthetic Aperture Radar (SAR), Sentinel-1A and 1B, dual-polarization, Water spread area, Reservoir capacity estimation.

6. Assessing Groundwater Resources in Central Kerala, India: A Multivariate Statistical Approach

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Abstract

The availability and quality of drinking water in rapidly growing cities in developing countries is often restricted. This is due to the competing demands from various sectors, such as industry, municipal supplies, and agriculture. Three Seasons of data were generated for 13 parameters at 70 different locations of Thrissur Ponnani Kol (central Kerala) for which multivariate statistical technique,Pearson's correlation coefficient, cluster analysis (CA), Factor Analysis, and principal component analysis (PCA) were performed. Water pollution to understand the complex data set and proportioned pollution sources, and since then used to collect information from a monitor network water quality a study was conducted. The chemical relationships were visualized by CA based on PCA scores of the 3 seasonal samples. On the basis of similarity in water quality three important sampling season Pre-monsoon, Monsoon and Post monsoon were identified. This study showed the predominant reasons for degradation of water quality in general due to inflow of effluent brought in from inland, domestic, agricultural and saline seeps with results from residents living in Kanoli plot and Chettuva estuary of groundwater. Perspectives regarding environmental monitoring key considerations when using straightforward but effective statistics to gain insight in complex aquatic systems provided by these results.
Keywords: Groundwater, principal component analysis, Cluster Analysis, Thrissur Ponnani Kole

7. Assessment of Groundwater Storage Potential Zone using GIS and Fuzzy Logic in Alluvial Terrain North Part of Maharashtra, India

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Abstract

The main goal of the study is to use GIS and fuzzy logic methodologies to identify areas having potential for groundwater storage in northern parts of Maharashtra. The total amount of groundwater held in confined and unconfined aquifers is known as groundwater storage potential (GWSP). GWSP play a vital role in supporting commerce, agricultural, and domestic acts directly or indirectly. The current study focuses on the technique for defining

the GWSP zone by combining GIS and fuzzy logic to the obtained feature theme while considering the significant impact of subsurface occurrence in the alluvial terrain river basin of northern Maharashtra, India. Thematic layers for slope, geology, runoff, geology, land use and land cover, soil pattern, and weathering zone were developed using GIS and remote sensing images and other collateral information. The study's findings showcase that 61.94% of the land has a high GWSP zone, while 16.48% of it has a moderate GWSP zone. While 21.58 is in the low GWSP zone category. By superimposing point layer groundwater fluctuation well on the GWSP zone map, which is in good treaty with the output map, the work is tested.

Keywords: Groundwater Storage Potential Zone, GIS, Fuzzy logic, Alluvial terrain, Maharashtra

8. Carbon Auditing of Innovative Fibre Reinforced Plastic (FRP) Check Dam in Comparison with Reinforced Cement Concrete (RCC) Check Dam for Soil and Water Conservation

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Abstract

Environmental impacts of various construction projects are increasingly gaining attention, especially the projects involving construction materials with high carbon dioxide emissions. Reduction of such emissions using alternative material is becoming one of the crucial aspects in this field globally. Carbon auditing is one of the most important steps towards carbon neutrality of these projects.

In general, permanent soil and water conservation structures are being constructed using Reinforced Cement Concrete (RCC) with raw material *viz.,* cement, steel reinforcement *etc* and have high carbon footprints. To counter this, the check dam was designed and constructed using alternate material called Fibre Reinforced Plastic (FRP), with comparable structural properties. When used as structural material, FRP members exhibited high strength, light weight, great corrosion resistance and excellent mechanical properties. Basic carbon footprints were analysed for FRP check dam as against the RCC check dam. This included the computations of emissions in terms of carbon equivalent from the production of materials and/or ex-situ fabrication, transportation and construction activities of the structure. The analysis reflected that, the total CO2 emission for the construction of FRP check dam was 2981.51 kg CO2 eq whereas for the construction of RCC check dam 8078.30 kg CO2 eq. Just by changing the construction material from RCC to FRP, the CO2 equivalent emission got reduced by 63.09 per cent without compromising the structural strength. Comparing the FRP check dam with RCC check dam the reduced carbon emission of FRP structure is equivalent to the CO2 absorbed by 232 trees.

Keywords: Carbon Auditing; Carbon Footprint; CO2 equivalent; Environmental Impact; Emissions.

9. Complex Networks for Hydrologic Modelling

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Abstract

Modeling hydrologic systems has always been a challenge, due to the complex, nonlinear, and interconnected nature of the various components. Complex network theory provides new avenues to study large dynamic systems and, therefore, has been finding increasing applications in hydrology in recent years. Until now, many different concepts and methods of complex network theory have been applied to study various processes and problems associated with hydrologic systems. The network concepts include clustering, centrality, adjacency, community structure, and distance, among others; the hydrologic processes include, for example, rainfall, streamflow, evapotranspiration, and sediment transport; examples of problems studied are spatial and temporal connectivity, propagation, classification, prediction, and evaluation of climate model simulations. Some attempts have also been made to couple complex network theory with other theories to further advance such applications. While these efforts have certainly yielded encouraging outcomes, there still remain a number of challenges in applying complex network theory to real hydrologic systems. The challenges range from the difficulty in establishing an appropriate criterion for formation of network to identifying the type of network based on the network measures to properly interpreting the results in terms of physics and dynamics of hydrologic systems. The present study offers an overview of the applications of complex network theory in hydrology and the associated challenges. Based on this overview, the study also provides some specific directions to further advance research in this domain.

Keywords: hydrologic systems; complexity; network theory; small-world network; prediction

10. Evaluation of Water Turbidity Index in the Godavari River, Andhra Pradesh (2021-2025): A Remote Sensing Approach Using Landsat 9 on Google Earth Engine

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Abstract

This study focuses on the evaluation of spatial and temporal dynamics of the Water Turbidity Index (WTI) of the Godavari River, Andhra Pradesh, from 2021 to 2025, using Landsat-9 satellite imagery and Google Earth Engine analysis. Annual WTI values were derived from surface reflectance bands and categorized into five turbidity classes ranging

from Very Low (<0.7) to Very High (>1.4). The analysis shows seasonal turbidity fluctuations, with pronounced increases during the monsoon period (July-September) and in zones adjacent to urban and industrial developments. A progressive increase in moderately to highly turbid zones, and a decline in very clear water areas, were evident post-2022, with 2024 recording the highest average turbidity. This corresponds with regional hydrological events and major infrastructure activities such as the Polavaram project, Godavari-Banakacherla project. The study underscores the escalating sedimentation and pollution challenges impacting the river's health. The findings highlight the need for effective sediment management, pollution control strategies, and continuous turbidity monitoring to support sustainable water resource management. The integration of remote sensing with GEE provided a robust framework for capturing spatiotemporal variations in turbidity, enabling informed decision-making. This work contributes critical insights for policymakers and stakeholders involved in irrigation planning, drinking water safety, and aquatic ecosystem conservation within the Godavari basin, ensuring the long-term viability of developmental projects in Andhra Pradesh.

Keywords: aquatic ecosystem; hydrological events; sedimentation; spatiotemporal variations; water quality monitoring.

11. Evaluation of Morphometric and Hydrological Characteristics of the Valapattanam River Basin using Geospatial Techniques

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Abstract

Understanding the hydrological characteristics of a river basin is fundamental for effective watershed management. This study presents a comprehensive hydrological evaluation of the Valapattanam River Basin (VRB), an interstate river basin in Southern India, through morphometric analysis and identification of existing drainage patterns. The Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global Elevation (30 m) Digital Elevation Model (DEM) was processed using ArcGIS 10.5 software for this purpose. Based on hydrogeological and geomorphological conditions, the basin was divided into four sub-regions (R1, R2, R3, and R4). The drainage patterns identified in these regions were found to be distinct, with dendritic in R1, parallel in R2, a combination of dendritic and rectangular in R3, and coastal-influenced drainage characteristics in R4. Several morphometric parameters, including linear, areal, and relief aspects were analyzed to assess the hydrological behavior of the basin. The VRB is identified as a 5th-order basin, suggesting minimal structural disturbance, and has a low mean bifurcation ratio of 2.21. The form factor, circulation ratio, and elongation ratio indicate a circular to sub-circular basin shape. A low drainage density of 0.37 km/km² points to coarse drainage texture and highly permeable subsurface materials. Furthermore, lower stream frequency suggests higher infiltration potential, reduced surface runoff, and gentler slopes.

Keywords: ArcGIS; DEM; Drainage Patterns; Valapattanam River Basin; Watershed

12. Flow Standardization for A-Frame NFT-Hydroponics as a Component of SMART Aquaponics System

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Abstract

Aquaponics is a multi-trophic system integrating RAS and hydroponics, wherein bioremediated nutrient-rich aquaculture wastewater is utilized for growing high-valued crop in vertical farms in controlled environment. Flow rate can be the major designing factor of the hydroponics for maximizing the water and nutrient utilization thereby avoiding precipitations and algal growth inside the NFT channels. This study dealt with standardization of flow rate for NFT-hydroponics as a component aquaponics proposed for GIFT-Lettuce production pair. The prime objective was to optimize flow rate for healthy growth of lettuce plants, preventing algal growth and sedimentation in the NFT channels ensuring safe quality of water back to aquaculture unit. Different flow rates of synthetic nutrient solution *viz.,* 1.0 L min-1, 2.0 L min-1 and 3.0 L min-1 were tested for cultivating Iceberg variety of lettuce. Water quality parameters like pH and TDS were maintained within optimum range throughout the study. Everyday water quality data like Nitrate-nitrogen (NO3-N), Phosphates (PO43-), and Potash (K) content was used for standardizing nutrient management in hydroponics. The analysis revealed that the physiological parameters *viz.,* plant height, number of leaves, leaf area index, chlorophyll content, fresh weight and total yield showed higher values for the flow rate of 2 L min-1 than the other tested flow rates. Study reflected that maximum marketable yield of lettuce was achieved for the flow rate of 2 L min-1 followed by 3 L min-1 and 1 L min-1 and can be considered as ideal for the system operations.

Key words: Aquaculture wastewater; GIFT; Lettuce; Nutrient uptake; RAS; Vertical Farming.

13.GIS based Spatial-Temporal Distribution of Water Quality Parameters and Heavy Metals in Surface Water of Coimbatore

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Abstract

Effective monitoring and prediction of surface water quality are crucial for sustainable management. This study investigates the spatio temporal distribution of physicochemical parameters (pH, temperature, Hardness, TDS, TSS) and heavy metals (Pb, Cd, Cr, Cu, Zn, Ni) in Coimbatore's surface waters, addressing significant ecological and health risks. Water samples, analyzed using MP-AES for metals, revealed distinct spatial patterns with significantly elevated Pb, Cd, and Cr levels near industrial discharges, urban areas, and major roads. Multiple sites exceeded CPCB and WHO drinking/bathing water standards, indicating substantial toxicity risks. The contamination status and potential health implications were rigorously assessed using statistical indices: Contamination Factor (CF), Contamination Degree (CD), Pollution Load Index (PLI), and Ecological Risk Index (ERI). Geographic Information System (GIS) mapping was employed to elucidate the spatial and temporal distribution patterns of both water quality parameters and heavy metals. Results demonstrate clear links between anthropogenic pressures and pollution hotspots, highlighting the urgent need for targeted interventions. The integrated approach combining MP-AES analysis, statistical risk assessment, and GIS visualization provides a comprehensive understanding of water quality dynamics essential for future monitoring and resource protection in the region.

Keywords: Heavy metal; pollution index; prediction model; remote sensing; surface water

14. GIS based Subsurface Water Quality Assessment for Industrial and Agricultural activities: A Case Study of Nandurbar district, India

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Abstract

The study of subsurface water quality to evaluate its aptness for agricultural, industrial practice has become essential due to the variability in rainfall intensity and uncertainty in its distribution. In view of this, the geochemical properties of 30 groundwater samples, including electrical conductivity (EC), pH, total dissolved solids, major cations, and anions, are measured and evaluated suitability. The suitability for irrigation purpose advised by appraisal of various cultivation water quality parameters such as sodium percentage (Na%), sodium adsorption ratio (SAR), Kelly's ratio (KR), residual sodium carbonate (RSC), magnesium adsorption ratio (MAR), and permeability index (PI). The industrial applicability was analysed using the Langelier saturation index (LSI), Ryznar stability index (RSI) and Larson–Skold index (LSkI). Geographic information systems (GIS) used the analytical results to produce the numerical spatial dispersion of the indexes. The comprehensive technique of suitability evaluation indicates that subsurface water in the research region is ideal for cultivation. Also, the spatial variation maps of LSI, RSI and LSkI illustrations that most pre-monsoon period samples were largely unaffected by minor scaling and corrosive potentials. Hence study indicates that, continuous monitoring of quality groundwater resources can play major role for achieving the goal of sustainable development of the region.

Keywords: Subsurface water quality, Industry, Agriculture, Shahada Tehsil, India

15. GPS Based Advanced Gravity Pull Technology (AGPT) for Groundwater Exploitation

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Abstract

Groundwater detection devices are working on combination of various geological, geophysical, remote sensing, methods. There are several instruments works on resistivity/magnetic field to detect the subsurface layers in strata. We are proposing Advanced Gravity Pull Technology (AGPT) to measure the changes in gravity using GPS at different positions, which will be used to analyze the groundwater mapping at study area. A trained person with an AGPT device will walk around the study area boundary and use GPS positions to locate high value gravity pull points in the field. All the same high value gravity pull points will be connected by moving with GPS trackers. These high value gravity pulls and the corresponding GPS positions will be mapped with the study area and connected with the same high value pulls. Crossing points with high gravity pull values were selected and recommended for drilling bore-wells and wells.

AI introduced in the system employs deep learning algorithms such as Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs) for processing spatial and gravitational data. These models classify subsurface anomalies and correlate gravitational gradients with hydro-geological parameters. AI also integrates real-time GPS data with historical geological datasets to enhance prediction accuracy. This technical synergy between AGPT and AI drastically improves efficiency in identifying high-potential aquifer zones.

Keywords: AI based water Detector; Advanced Dowsing; AGPT; Groundwater Aquifers Mapping; GPS

16. Gradient Descent Optimization Supports the Generation of Reservoir Operation Plans

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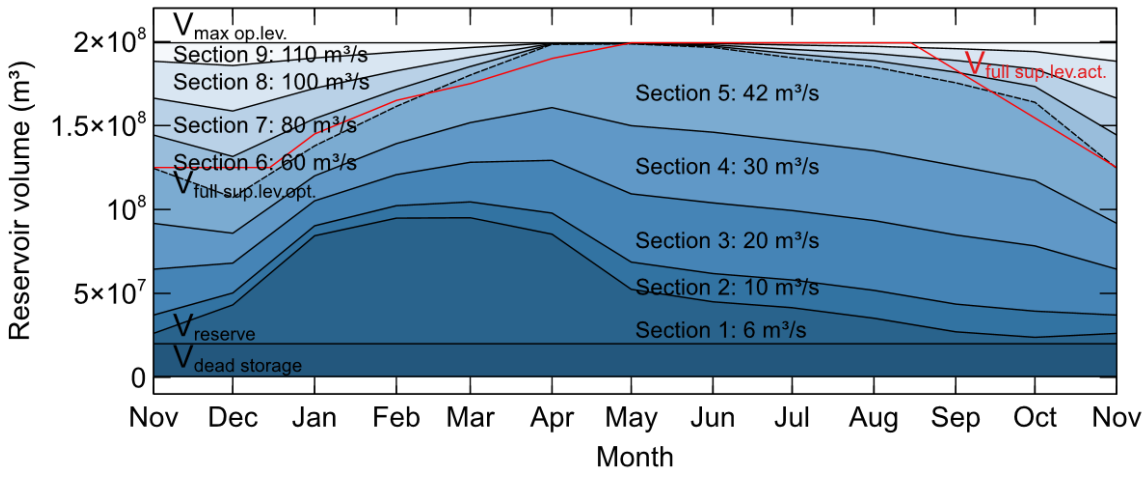
Abstract

The operating of large multi-purpose reservoirs means balancing conflicting use functions: during the dry season the reservoir must be filled to a level such that there is always enough water to supply the water users. During the flood season the filling level must be low enough such that the reservoir can catch a flood wave in order to prevent flood damage. How do reservoir operators know how much water to release when? Usually, there is an operational protocol that tells the operators how much water to release during the different seasons throughout a year. A reservoir optimization model can support the generation of such a release plan. But an optimization model can only provide solutions that are specific to a certain situation given with the input data. To transform such period-of-record solutions into a generic solution, we apply statistical methods and additional post-processing steps. The result is an operational plan that is easy to use, robust and self-correcting as a day-to-day decision support for reservoir operators. We present a method to generate a reservoir operation plan by means of gradient descent optimization.
Figure:



Volume-release plan generated with gradient descent optimization

Literature: Marth, I.; Becker, B. (2023): Gradient descent optimization supports the generation of reservoir operation plan. STAtOR Vol. 24 (2023) No. 3–4 pp. 4–9.

17. Groundwater Quality for Sustainable Use: A study based on Geospatial and Statistical Analysis from Reddiyachatram Firka, Dindigul District, Tamil Nadu

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Abstract

Groundwater is vital for drinking and irrigation in Reddiyachatram Firka, Dindigul district, Tamil Nadu. This study aimed to assess the suitability of groundwater for drinking and irrigation. Twenty-seven water samples were collected, and the physicochemical parameters were analyzed using standard recommended methods. Physiochemical parameters such as total hardness, Calcium, Magnesium, Sodium, Potassium, Chloride, Nitrate, Bicarbonate and Fluoride exceeded the most desirable limit. The Piper plot represents the water types Ca^{2+}–Mg^{2+}– Cl^{-}. Gibbs revealed that evaporation crystallization is the major factor affecting groundwater chemistry. Wilcox indicated that the water was suitable for irrigation. The Water Quality Index indicates that 46% of the water is poor, 27% good, 20% excellent, and the remaining 7% is very poor. Irrigation indices such as Na% and SAR indicate that the groundwater is suitable for irrigation, whereas the Kelly ratio and residual carbonate pose significant risks. Pearson correlation matrix were carried out to identify the trends and relationship between water chemistry. The research indicates

the need for proper treatment before consumption and regular monitoring for sustainable irrigation use.

Keywords: Groundwater Quality, Water Quality Index, Irrigation Indices, Sustainable Irrigation

18.Groundwater Exploration and Assessment from Electrical Resistivity Tomography Technique for Prospecting and Development of Groundwater Resources in Varied Geological Settings, India

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Abstract

The electrical resistivity and induced polarization (IP) tomography technique now a days most widely used geophysical exploration technique for groundwater assessment, delineation, prospecting and development in different geological settings of our country. This state-of-the art technique is often used for groundwater and shallow geo-exploration due to its wider spectrum of resistivity coverage from <1 Ohm.m to several thousands of Ohm.m as well as chargeability, which encompasses all types of geological formations and rock types in our country. The exploration and prospecting of groundwater resources from near surface layers/zones to ~200 – 250 m depths in varied and complex hydrogeological conditions mainly in hard rocks regions is a challenging and crucial task for exploration and sustainable groundwater development. This unique electrical resistivity and IP tomography equipment have the capability of best quality data acquisition in real-time as well as display in real-time for better analysis in the field itself and authentic and reliable geological interpretation of the subsurface geology, hydrogeology, geological structure(s) and mineralized zones. The major advantages and the powerful ability of electrical resistivity and IP tomography in displaying the continuous resistivity and chargeability continuous maps as true inverse models of the subsurface geology, mineralized zones, identified different lithologies, contact & shear zones, fault structure(s), mapping the thickness of the weathered geological formations/regolith, makes this technique a unique geophysical tool for hydrogeology, groundwater and shallow subsurface geological mapping including mineral exploration studies and scientific research in various geological settings of the country.

This technique have numerous applications like continuous mapping of the subsurface geological formations and hydrogeological conditions as well as the large data density measurements and the subsequent efficient data processing technique, data analysis, the requisite inverse modeling of the measured dataset for thorough assessment and evaluation of the subsurface resources and the comprehensive interpretation of the resistivity and chargeability true resistivity and chargeability models for groundwater and the related geological structures, which controls the groundwater movement and its availability in

various geological settings. The research and fieldwork carried out in different parts of the country covering all types of geology for groundwater exploration, assessment, prospecting and the copious findings of groundwater sources after the validation of the electrical tomography results at a number of sites/areas through borehole drilling programme in different varieties of the hard rock regions as well as the complex geological settings are the significant achievements in the field of exploration geophysics for groundwater as well as - the direct benefit to the urban and rural populous of the society of our country. The overall research hightlights and exemplify the applied research work and sustainable groundwater resources both for the drinking and agricultural purposes.

Two recent significant work with interesting results and findings are presented here in this paper. On study area in Ghaziabad, Uttar Pradesh India was taken up where there is a critical problem of groundwater especially for drinking purposes. Taking it as a challenge and started looking carefully and then applied groundwater exploration studies and its assessment combining geology, hydrogeology, borehole lithology, hydrogeomorphology and high resolution geophysics for detailed mapping the subsurface rock strata and aquifer status. Electrical Resistivity Tomography traverses was laid in a planned way keeping the deposition history of the rock formation in mind and subsequently resistivity data mapping was performed at seven sites within the alluvium formation for hydrogeological characterization. The significant results and findings from the true inverted resistivity tomography models revealed interesting features in terms of groundwater repository!. The hydrogeological interpretation suggested the potential groundwater zones are situated between 30 to 160 m depths where the resistivity of the saturated alluvium formation is <60 Ohm.m. It was thoroughly studied that groundwater at shallow depths <50 m is negligible and is not existing and hence intends to explore the deeper aquifer > 50 m, which is the aim and target for long term availability and sustainability of groundwater resources. This finding from resistivity tomography results is in agreement with the spatial plot analysis where the results of the aquifer resistivity were used and its correlation with depths, which clearly revealed that the deeper aquifer is more prospect for groundwater exploitation. In addition, the evolution of groundwater potential zonation map of the area and surroundings; clearly highlights the variation in degree of groundwater potential zones based on the integrated analysis of the various thematic maps of the study area. Later, in July-August 2022 at CSIR-HRDC, Ghaziabad, our significant results and findings are enthusiastically validated by borehole drilling at two recommended sites. Two boreholes of large diameter 0.55 m! (exceptional in groundwater hydraulic) are drilled based on the high resolution geophysical and hydrogeological study and their integrated results up to a depth of 131 m. Both the boreholes are giving equally high yielding (head of 3") discharge of groundwater equivalent to ~8000 liter/hr at the drilling time, and subsequently yielded more discharge when actual regular pumping of groundwater for exploitation of the resources with a submersible pump of 10 HP capacity. Thus, satisfying the critical need of groundwater resources of CSIR-HRDC and the surrounding area of Ghaziabad by providing the sustainable groundwater resources and achieved sustainable development goals (SDG). The other research area being thoroughly studied in Haryana state, where although groundwater is packed in large volume of thick alluvium aquifer especially in

northwestern India, is critical in terms of groundwater exploration, prospects and its large variability in terms of depths and availability of groundwater within the aquifer system. Nevertheless, the near surface water in this semi-arid region was highly exploited in the past and the mankind is regressly shifting towards the deeper groundwater resources. This is an alarming call for the judicious management of groundwater resources for its sustenance. Depth to water table ranges from 18 to 76 m bgl in the alluvium region of six district's developmental blocks in Kurukshetra and Yamunanagar of Haryana state. The wide range of depth to water table variation indicates strong bearing of structural controls and hence necessitates to understand the subsurface geological and hydrogeological settings on a regional scale for cost-effective exploitable groundwater resources and its sustainable management plan. The main thrust is to understand the structural setting of alluvial sand and its implication to the groundwater occurrences in the semi-arid region of northwestern India. The present work presents high resolution electrical tomography study carried out in the alluvial plains lying between different hydrogeological units in parts of Ghaggar and Yamuna basin covering Kurukshetra and Yamunanagar area. The detailed interpretation of resistivity models considering the hydrogeological and geological scenario deciphered buried channel sand (dry sand signature), unsaturated sand, distorted sand structure, clay dominated sand zones, compact sand, recharge conduit source and thick dry sand layer(s). Interestingly, the interpreted resistivity models of Galedwa, Urnai and Pratapgarh clearly revealed highly distorted sand structure(s) and upwelling thick sand indicating presence of neo-tectonic activity. Considering above, hydrogeological interpretation and inferred characteristic zones, subsurface lithology was classified into six distinct classes i.e., clay, sandy-clay, sand with gravel, saturated sand with clay, thick sand and unsaturated sand. The characteristics resistivity of these layers/formations are 1 – 8 Ω.m, 19 – 146 Ω.m, 70 – 164 Ω.m, 3 – 90 Ω.m, 50 – 1500 Ω.m and 30 – 345 Ω.m respectively. Further, the above analyzed depth wise sectional lithologies were interpolated in order to conceptualize the aquifer system in the form of three-dimensional strip-logs, fence and solid models for better regional hydrogeological understanding, development and management of the groundwater resources in the study area.

Keywords: Electrical Resistivity Tomography, Varied Geological Settings, Groundwater Exploration, Prospecting & Development, India

19.Identification of Groundwater Potential Zones using Remote Sensing and GIS for Kurnool district

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Abstract

The growing demand for groundwater due to rapid urbanization and agricultural activities necessitates the sustainable management of water resources. This study aims to delineate groundwater potential zones in the Kurnool district of Andhra Pradesh using remote sensing and Geographic Information System (GIS) techniques. Various thematic layers such as land use/land cover (LULC), slope, soil type, drainage density, and rainfall were generated using satellite data and ancillary sources. Data was collected from open sources such as USGS (DEM, Landsat 9), FAO (Soil), GSI (Geology), and CRU (Rainfall). The analytical Hierarchy process (AHP) was used to assign weights to each factor based on its influence on groundwater occurrence. A weighted overlay analysis in ArcGIS was performed to integrate these layers.

Keywords: GIS, Groundwater, Kurnool, Remote sensing, River

20. Integrated GIS-Based Multi-Criteria Decision Analysis for Groundwater Potential Mapping in Coimbatore District, Tamil Nadu

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Abstract

Groundwater plays a vital role in supporting agricultural, domestic, and industrial activities, especially in semi-arid regions like Coimbatore where surface water availability is limited. This study aimed to delineate Groundwater Potential Zones (GWPZs) using an integrated geospatial and multi-criteria decision analysis approach, combining Geographic Information System (GIS) and Analytical Hierarchy Process (AHP). In order to determine their impact on groundwater occurrence, eight thematic layers including lithology, geomorphology, slope, digital elevation model (DEM), soil texture, land use/cover, rainfall, and drainage density were chosen and assigned weights. The resulting GWPZ map divided the area into five categories such as Very Poor, Poor, Moderate, Good, and Very Good. The majority of the district (74.4%) was covered by the Moderate zone, which denotes fair recharge conditions. The dependability of the model was confirmed by validation utilising 131 well sites and Receiver Operating Characteristic analysis, which produced an Area Under Curve value of 0.76. The findings show that groundwater availability is strongly influenced by lithology, LULC, and drainage density. This research provides a precise and affordable approach for evaluating groundwater, offering crucial information for managing

sustainable water resources and implementing artificial recharge techniques in areas with limited data.

Keywords: Analytical Hierarchy Process (AHP), Geospatial Techniques, Groundwater Potential Mapping, Multi-Criteria Decision Analysis (MCDA), Validation (ROC–AUC)

21. Integrated Study of Remote Sensing, GIS, Geophysics and Fuzzy-AHP for Delineating Ground Water Recharge Potential Zones in the Hard Rock, District Hamirpur, Uttar Pradesh

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Abstract

This study aims to identify groundwater recharge potential zones in the water-stressed Hamirpur District of Uttar Pradesh using the Fuzzy-AHP (Analytic Hierarchy Process) technique. An integrated hydrogeological investigation was conducted to delineate the groundwater potential zones. This investigation was based on a scientific analysis of various factors, including drainage patterns, hydro-geomorphology, lithology, soil characteristics, land use and land cover, geo-resistivity data, and their interrelationships. Thematic layers, such as drainage, canals, surface water bodies, geomorphology, lithology, lineaments, soil, and land use/land cover, were created using satellite imagery from Sentinel-2B. Exploring groundwater in hard rock terrains presents a significant challenge due to the complexity of such environments. To address this, an integrated approach utilizing advanced remote sensing and Geographic Information Systems (GIS) proves to be an efficient and result-oriented method for studying, developing, and managing water resources. The Hamirpur district of Uttar Pradesh, India, is characterized by hard rock terrain. In this study, remote sensing, GIS technologies and Geophysical technique were employed to delineate and classify groundwater potential zones effectively. In this study a standard methodology is proposed to determine groundwater potential using integration of Remote Sensing, GIS and Geophysical technique. The composite map is generated using GIS tools. Accurate information to obtain the parameters that can be considered for identifying the ground-water potential zone such as geology, slope, drainage density, geomorphic units and lineament density are generated using the satellite data and survey of India (SOI) toposheets of scale 1:50000. It is then integrated with Fuzzy-AHP in ArcGIS. Every class in the thematic layers were placed into one of the following categories viz. (a) Excellent (b) Good (c) Moderate and (d) Poor depending on their level of groundwater potential. Considering their behaviour with respect to groundwater control, the different classes were given suitable values, according to their importance relative to other classes in the same thematic layer. Understanding groundwater recharge zones is crucial for sustainable water management and protection of water quality in the stressed regions of

Hamirpur District. This study provides valuable insights for local authorities and stakeholders involved in groundwater management in the Hamirpur District, by highlighting potential areas for recharge and addressing water scarcity issues. The methods developed can be adapted and applied to other regions facing similar groundwater challenges, potentially improving water resource sustainability on a larger scale. The results indicated that, in the Hamirpur District, 17.01% of the area was classified as having excellent groundwater potential, 10% as good, 20% as moderate, and 43.48% as poor groundwater potential.

Keywords: - Ground Water Potential, Fuzzy-AHP, ROC Curve, Remote Sensing, GIS, Resistivity Data, SRTM Image, DDR-3 Machine, Sentinel 2B merge data.

22. Investigating the Evans Blue Dye Colour Removal Efficiency of Clay Incorporated Polyether sulfone Membranes using Dead-End Filtration

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Abstract

Abstract: In the present day, water treatment is a significant global concern due to the proliferation of industrial pollution sources. In this study is focused on the Evans blue dye, in several industries it is the most significant contributors to these pollutants. This study investigates the removal efficiency of Evans blue dye (initial concentration: 20 ppm) and the development of a novel polymeric membranes using polyether sulfone (PES) nanocomposite membranes incorporating nano clay as modifiers under dead-end filtration conditions. The feed solution pH was adjusted from 7S to an acidic value of 3.6 to evaluate membrane performance at lower pH, which strongly influences dye-membrane interactions. Membrane variants included PES control, PES/nano clay, PES/kaolin, and PES/MMT composites, all fabricated via phase inversion with pore-forming additives. UV-Vis spectrophotometric analysis at 607.2 nm tracked dye concentration in permeate samples collected at intervals up to 70 minutes. Compared to the unmodified PES membrane, the PES/nano clay showed a pronounced improvement in dye elimination, with more than 47% removal achieved just 10 minutes into filtration, and efficiencies approaching or exceeding 99% after one hour. Kaolin and montmorillonite composites also show a high performance, though the nano clay stood out for its combination of rapid and sustained dye rejection. Alterations in membrane increases hydrophilicity, improves pore structure, and electrostatics resulted in greatly improved rejection of anionic dye (Evans blue) at acidic pH. These findings highlight the real-world potential of PES nanocomposite membranes for dye removal from polluted water, emphasizing their robust applicability in environmental remediation and sustainable wastewater treatment.

Keywords: Nano clay, Montmorillonite, Kaolin, Polyether sulfone membranes, dyes.

23. Land Use and Land Cover Change Detection & Demarcation of Groundwater Potential Zones using RS & GIS – A Case Study of Jalgaon district, Maharashtra state

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Abstract

Analysis of land use change has become an important factor in the development strategies for natural and environmental resource management. The main aim of this case study was to demonstrate the land use land cover changes that happened between 2006 and 2012 in the area of Jalgaon district of Maharashtra, India. The study used LISS-III images for the period of 2006 and 2012, respectively. A pixel-based supervised image classification technique was used for classification of imageries. Images taken from these satellites are then processed under GIS software which helps in determining land use and land cover.
The technique is being used extensively in generating valuable information on forest cover, water-body, vegetation, and land-use pattern. During the study, it's been observed that the Agricultural land and other protected areas are mostly dominated by Urbanization (land cover) and other infrastructural purposes. This study highlights the need to address the expansion of residential areas through careful local planning and to design appropriate future land management options.
Keyword: - Remote sensing, GIS, Supervised image classification, Land use land cover, Urbanization.

24. Modelling and Scenario Analysis for Evidence-Based Groundwater Management in the Ganga Basin

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Abstract

Groundwater is a critical component of the water resources in the Ganga Basin, supporting irrigation, domestic use, and rural livelihoods. However, intensive groundwater extraction, primarily for agriculture, is increasingly threatening the long-term sustainability of groundwater in the basin. These pressures are further compounded by the impacts of climate change, including shifts in monsoon patterns and evapotranspiration rates. Policy and regulatory frameworks for sustainable groundwater management in the basin are evolving. Robust decision support tools and methodologies including groundwater modelling are essential for enabling evidence-based planning and management. This study presents a groundwater modelling application for the Ganga Basin that integrates improved estimates of recharge and other water balance components. The modelling framework based on the MODFLOW code combines multiple lines of evidence, including long-term groundwater level observations, satellite-derived data from the GRACE mission, and ICWRER 2024(TNR-10pt) hydrological inputs. An uncertainty-based approach is used to calibrate the model and assess the reliability of key outputs, strengthening the basis for scenario analysis. The analysis showed declining trends in groundwater levels and storages across the region specially in the northwestern parts of the alluvial system. The model is further applied to evaluate groundwater use and climate scenarios, illustrating its value for assessing policy options and guiding groundwater management strategies at regional and sub-basin scales. This case study highlights how data-driven, uncertainty-aware groundwater models can support sustainable groundwater use and inform regulatory development in large, complex basins such as the Ganga.
Keywords: groundwater; modelling; uncertainty; calibration

25. Optimal Allocation of Generating Units and Pump Units in the Niagara Falls Multi Reservoir Hydropower System

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Abstract

The Niagara River is an important and stable source of hydropower thanks to its consistent water supply and significant hydraulic head. The operation of hydropower generation assets on Niagara River must obey unique operational constraints: during tourist and non-tourist hours diversion is regulated and the available storage water is shared between Canada and the United States of America. We present an operational Decision Support System for hydropower scheduling on the generation unit level. The system integrates near real-time hydrological and operational data, optimization models producing a schedule that meets energy generation targets, environmental requirements, and regulatory compliance. The

Decision support system is based on Delft-FEWS. It supports multiple use cases: day-ahead scheduling, business planning, monthly energy forecasts, hindcasting and water conditions variance accounting functionality. The optimization models are based on the open source package RTC-Tools. The largest optimization model has 26 generating units and a Pumped Generating Station with 3 pump-turbine units. Varying turbine efficiency in dependence on head and discharge is accounted for by hyperplane constraints. As the governing equations are implemented in the optimization models in linearized form, simulation companion models re-calculate the schedule with more accurate nonlinear equations.

26. Para Sight: A Deep Learning Approach for Climate-Linked Waterborne Parasite Detection

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Abstract

Freshwater systems have been severely affected due to drastic climatic variations arising due to the frequency of pollution events and increased cases of waterborne illnesses. The surge in microscopic parasites like Giardia lamblia and Cryptosporidium is one of the most alarming effects, particularly in rural and underdeveloped areas with inadequate water treatment facilities. Traditional microscopy is inefficient, skill-dependent, and challenging for large-scale surveillance, when it comes to accurately recognizing these parasites. To address this gap, the proposed system introduces ParaSight, a deep learning-based system designed to automatically detect multiple types of waterborne parasites from microscopic water sample images. The framework, utilizes transfer learning, with pre-trained CNN architectures like ResNet and EfficientNet, fine-tuned on a curated dataset of parasite imagery. Targeted data augmentation improves the model's performance, while Grad-CAM, which draws attention to the image's key areas and encourages decision-making transparency, makes the model easier to understand. In contrast to traditional models, ParaSight is suitable for real-time diagnostics and remote testing stations since it can be implemented on low-power devices, provides multi-class categorization, and is computationally efficient. The system is able to distinguish between infected and clean samples with a precision of over 96%. This work offers a scalable approach that is climate resilient and focuses on water quality management, along with deep learning to a significant environmental health issue. The proposed system provides a novel approach for reducing the increasing risk of parasite-related water contamination in critical ecosystems by integrating AI, environmental monitoring, and public health.

Keywords: Climate change, Deep learning, Ecosystem health, Explainable AI, Microscopy, Waterborne parasites, Water quality

27. Study on the Effect of Variations in the Suspended Sediment-size Distribution on the Efficiency of Settling Basin in a Hydropower Project

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Abstract

A settling basin in a hydropower project is provided close to the head works to facilitate settlement and exclusion of undesirable sediments from entering the water conductor system. The suspended sediment load and its characteristics in the river, such as concentration, sediment-size distribution and petrography, largely decide the scale and complexity of the problem. The paper is a case study of a run-of-river hydropower project built on the river Satluj. Physical model study of the underground settling basin has been carried out at CWPRS, Pune. The geometry of the settling basin is simulated on a numerical model. The calculated values of overall settling efficiency from the numerical model and the results from the physical model study show good agreement. The average suspended sediment-size distribution in the river, in terms of coarse, medium and fine sediments have undergone a change over the years. An attempt has been made to numerically assess the effect of the variations in the sediment-size distribution values on the overall settling efficiency of the settling basin, for the given sediment concentration. The simulation is carried out for sediment concentration ranging from 1000 ppm to 10000 ppm. The total sediment load, and individually the coarse, medium and fine sediments, that is likely to pass the turbine, has been estimated and results presented and discussed in the paper.

Keywords: characteristics; concentration; numerical model; parts per million; simulation

28. Satellite-based Spatial Assessment of Vegetation Tolerance to Ocean-Induced Soil Salinity in the Hamburg Coastal Zone, Eastern Cape Province, South Africa

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Abstract

Coastal vegetation plays a critical role in ecosystem stability, biodiversity conservation, and climate regulation, yet its spatial response to soil salinization, particularly from ocean-induced processes, remains poorly quantified, particularly in the Global South regions. This study assessed vegetation tolerance to soil salinity in the Hamburg coastal zone, Eastern Cape, South Africa, using an integrated approach combining remote sensing, geostatistics, and field-based measurements. Sentinel-2 satellite imagery was used to derive the Salinity Index (SI) and Normalized Difference Vegetation Index (NDVI) to estimate spatial variability in soil salinity and vegetation condition. In addition, field campaigns involving 50 georeferenced sampling points provided in situ data on soil electrical conductivity (EC), nutrient profiles, and vegetation density, supporting empirical model development and validation. The results reveal significant spatial variability in soil salinity (EC ranging from 3.69 to 5.11 dS/m) confirmed by a Bayesian one-sample t-test ($p < 0.001$), and strong predictive performance of the SI for estimating EC ($R^2 = 0.72$; validation $R^2 = 0.786$). NDVI values ranged from -0.492 to 0.766, indicating spatial heterogeneity in vegetation condition. The linear regression revealed a weak and statistically insignificant relationship between soil salinity and NDVI ($R^2 = 0.063$), indicating that vegetation distribution is not primarily constrained by salinity stress. Soil and plant nutrient profiles also exhibited significant spatial variation, yet only nitrogen (N) showed a strong soil-plant correlation ($R^2 = 0.90$). Other nutrients, such as phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and zinc (Zn), show minimal soil-plant uptake correspondence ($R^2 < 0.05$). The findings indicate that although soil salinity varies significantly across the coastal landscape, it exerts limited influence on vegetation condition and plant nutrient composition, pointing to species-level resilience or alternative environmental drivers.
Keywords: Spatial assessment; vegetation tolerance; soil salinity; remote sensing.

29.Spatial Estimation of Methane Emission Using Remote Sensing and DNDC Model in Cauvery Delta Zone

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Abstract

Rice cultivation may become a potential contributor to the enhancement of global warming. Flooded rice fields are the third largest source of agricultural emissions and contribute about 10-30 per cent of the global methane arising from anaerobic decomposition of organic matter. Precise estimation of methane emission from rice fields at regional scale depends on accurate assessment of rice area and the corresponding time of flooding in those fields. Multi temporal Sentinel 1A satellite data at VH polarization with 20 m spatial resolution was

acquired between August to January during 2020-21 at 12 days interval and processed using MAPscape-RICE software to generate Rice area and Start of Season maps. The DeNitrification-DeComposition (DNDC) model was used for spatial estimation of methane emission from six districts of Cauvery Delta Zone and validated with field level estimates. Rice area and Start of the Season map was generated using a rule-based classifier approach utilizing parameterization with a classification accuracy 91.5 per cent and a kappa score of 0.83 during 2020. DNDC model estimated the methane emission rate of 42.10 and 42.13 kg ha-1season-1with a total methane emission of 19.86 Gg during 2020. DNDC model along with remote sensing-based rice area and SoS can be used as a tool for precise and near real time assessment of methane emission at regional and country level which is used to assess large scale mitigation strategies on contribution to GHG from rice fields through remote sensing.

Keywords: DNDC; Methane emission; Remote Sensing; Rice; SAR

30.Variation in Gravitational Pull: New Advanced Technology for Groundwater Resources Mapping

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Abstract

Groundwater is water found in the pore spaces of rocks. Due to uncertainty of rain, farmers have to use water sources, such as Canal wells, bore wells etc. Dowsing is a term used in the traditional way of searching ground water. The dowsers use different materials for the dowsing. In experiments on dowsing the metal wire crosses each other where the dowsers remarks. The movement of the rod is because of a sudden increase in gravitational pull of earth. This increase in gravitational pull of earth is because of groundwater stream below it. There are natural indicators of ground water, which are having their few twigs with unusual growth. The unusual growth of twigs of trees is due to increased gravitational force on these twigs. This increased gravitational force acting on twigs is because of the ground water stream below it. The unusual growth is related to the Growth Index Ratio (GIR). The GIR value is greater than one; there is a possibility of ground water stream. The advanced device to measure varying gravitational pull at any position will be developed for analyzing groundwater quantity at that position. This variation in gravitational pull at a particular point is selected for water resources mapping and this point was tested by ADMT 300S / PQWT water detector. It is found good results are obtained by using variation in gravitational pull as well as techniques for ground water exploitation. Case study of Sound through field of a farmer from Solapur India is studied. We made a scientific study of the incident here. It was found that bubbles of water mixed with mud and air were coming up in the area.

Keywords: ADMT, Groundwater Aquifers Mapping, New Groundwater detection Techniques, PQWT, Traditional Dowsing

31. Vulnerability Analysis of Groundwater using GIS based Drastic Model

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Abstract

Due to industrialization and cultivation activities particularly use of fertilizers, pesticides and fumigants have been recognized as one of the non-point sources of contaminants which leach out different contaminants of agricultural soil through unsaturated zone and groundwater zone results in contamination of groundwater and soil, which is a serious negative threat in rural as well as urban regions. In order to determine the groundwater vulnerability and analyze the risk, GIS based vulnerability indexing technique (DRASTIC) is chosen for the whole Telangana state as study area, which determines the zones of vulnerability and is useful in the preparation of strategies to reduce the ill effects of the factors causing ground water pollution. Seven DRASTIC parameter layers based on parameters like groundwater influencing parameters were prepared. Each parameter was assigned rates and weights. By overlapping the layers in ArcGIS, the vulnerability map was created. By multiplying each rate of the parameters with its weight and summing for all the parameters. DRASTIC index number is calculated. It was found from the created vulnerability maps of Telangana state that the study area was re-categorized into various vulnerable zones. High groundwater vulnerability areas were found to be mostly in the floodplains of large rivers such as the Godavari and Krishna. Moderate vulnerability areas were predominantly seen in Telangana's central districts, including Medak, Warangal, and Sangareddy. Low vulnerability zones, in areas such as Adilabad, Nizamabad, and Karimnagar, are defined by deeper aquifers, clayey soils, steeper slope, and low recharge.
Keywords: DRASTIC, GIS, Groundwater, Telangana, Vulnerability.

32. Water Quality Assessment of Selected Tanks in Coimbatore District Using Remote Sensing approach

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Abstract

Monitoring water quality is essential for ensuring the sustainability of freshwater resources, especially in regions facing rapid urbanization and increasing water demand. Surface water

bodies like tanks play a critical role in supporting domestic, agricultural and ecological needs, making their regular assessment vital. This study aims to assess the surface water quality of selected tanks in Coimbatore district, Tamil Nadu, using remote sensing-derived indices and GIS-based spatial analysis. Multi-temporal satellite imagery from Sentinel-2 was processed to extract spectral indices indicative of water quality parameters, including the Normalized Difference Water Index (NDWI), Modified NDWI (MNDWI), Normalized Difference Turbidity Index (NDTI) and Floating Algae Index (FAI). These indices were analysed to detect variations in turbidity, algal bloom presence and suspended particulate matter over time. GIS tools were used to visualize spatial patterns and correlate water quality indices with land use and potential pollution sources in the surrounding catchments. The results revealed seasonal variations and highlighted areas of concern, particularly where anthropogenic activities are prominent. The study demonstrates the utility of remote sensing indices in monitoring water quality, identifying pollution hotspots, and supporting data-driven water management strategies in the region.

Keywords: Water Quality, Tanks, Remote sensing and GIS

Theme 4

Disaster Management and Resilience

1. Advanced SAR-GIS Approach for Flood Mapping and Post-Flood Crop Assessment

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Abstract

Floods are among the most frequent and destructive natural disasters, significantly affecting human lives, infrastructure, and agricultural productivity. Timely and accurate flood assessment is crucial for effective disaster response, mitigation planning, and agricultural risk management. This study aims to assess flood inundation and its impact on crop failure using advanced geospatial tools and Sentinel-1A Synthetic Aperture Radar (SAR) data. Sentinel-1A SAR, with its all-weather and day-night imaging capability, enables consistent monitoring of flood-prone regions even under cloudy conditions where optical sensors fail. A systematic methodology was developed, involving preprocessing of SAR images, threshold-based classification to extract water bodies, and GIS-based spatial analysis to map flood extent. The flood mapping results were validated using field data and high-resolution reference imagery, achieving an overall accuracy of 89.6%, which confirms the reliability of the approach. In addition to delineating flooded areas, the study integrated land use and crop data to evaluate the extent of agricultural damage. The analysis revealed significant crop failure in areas affected by prolonged waterlogging, particularly in low-lying agricultural fields. The results demonstrate the effectiveness of integrating SAR data with geospatial techniques for rapid flood assessment and post-disaster crop damage evaluation. This approach provides critical insights for government agencies, disaster response teams, and agricultural planners, supporting timely decision-making and resource allocation. The study highlights the potential of satellite-based monitoring as a cost-effective and scalable solution for flood risk management and agricultural resilience planning in vulnerable regions.

Keywords: Crop loss assessment; Flood mapping; SAR; Sentinel 1A

2. Analysing the Extent of Salinity Intrusion along the Coastal Areas of Malappuram district in Kerala using Principal Component Analysis and Zonal Statistics Method

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Abstract

The study estimates the extent of salinity intrusion conceptualised as a spatial stochastic process by using remote sensing and GIS tools for about 30 years along the coastal areas of Malappuram district, Kerala. Satellite data from 1994, 2003, 2014, and 2024 were used to compute the indices, including NDVI, GVI, NDII, SAVI, and NDMI. Multivariate statistical techniques such as zonal statistics and Principal Component Analysis (PCA) were applied to determine the principal variable influencing salinity intrusion along the study area. The health of the vegetation was used as a proxy for the estimation of the extent of salinity, as vegetation growth can be affected by salt stress. The proposed method using satellite images was a useful and fast approach to determine salinity intrusion in the study area.

Keywords: Salinity intrusion; Principal Component Analysis (PCA); Zonal Statistics; Vegetation health; Malappuram.

3. Artificial Neural Network Approach for Flood Forecasting Using Rainfall Memory and Land Surface Variables in Thoothapuzha River Basin, Kerala

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Abstract

Floods are among the most devastating natural disasters, causing widespread damage to infrastructure, loss of life, and disruption of livelihoods. Accurate and timely flood prediction is critical for minimizing these impacts and supporting effective disaster preparedness and management. Traditional flood forecasting models predominantly rely on precipitation data as the primary input, often overlooking other influential hydrometeorological variables such as land surface temperature and soil moisture conditions. In this study, two Artificial Neural Network (ANN) models were developed to forecast discharge in the Thoothapuzha River Basin in Kerala, India—an area frequently affected by intense monsoonal flooding. The first model used present-day rainfall, earth skin temperature, and surface soil wetness as input variables. The second model extended this by incorporating a three-day rainfall sequence namely present-day, previous-day, and pre-previous-day rainfall along with the same thermal and soil parameters. This inclusion was based on a basin-specific analysis that identified a three-day lag time between rainfall and its impact on discharge response. Results show that the second model significantly outperformed the first in predicting peak flows, underscoring the importance of temporal rainfall memory in flood generation. The study highlights that integrating multi-day rainfall, surface temperature, and soil wetness enhances model performance and provides a more realistic representation of basin response, which is essential for operational flood forecasting. These findings advocate for a more holistic approach to input variable selection

in data-driven hydrological modeling, especially in regions with complex hydrological dynamics like Kerala.

Keywords: Earth Skin Temperature; Surface soil wetness; Multi-day Rainfall; Hydrologic modelling.

4. Assessing Flood Risks through Frequency Analysis and Stage–Discharge Modeling of the Jhelum River, Kashmir, India

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Abstract

Floods are among the most significant hydrological hazards, with far-reaching impacts on infrastructure, population, and the economy. This study conducts a flood frequency analysis (FFA) of the Jhelum River in the Kashmir Valley using Annual Maximum Flood (AMF) data from 1990 to 2020 across five gauging stations. Data suitability was checked using Pettitt Test, Standard Normality Homogeneity Test (SNHT) at $\alpha = 0.05$ and Double Mass Curve Analysis. Three statistical distributions - Gumbel, Log-Pearson Type III (LP-III), and Log-Normal (L-N) - were applied to model flood frequencies. Goodness-of-Fit (GoF) was evaluated using Kolmogorov-Smirnov, Anderson-Darling, and Chi-Squared tests via EasyFit software, with further validation using HEC-SSP for curve fitting.

In parallel, Stage-Discharge relationships were developed for each station using the Generalized Reduced Gradient (GRG) optimization method and performance evaluation was checked with Pearson's Correlation Coefficient ($r > 0.85$) and Nash-Sutcliffe Efficiency ($NSE > 0.75$), for all stations. Predicted discharges and corresponding water levels were found to exceed current conveyance capacities and danger levels for return periods as low as 5 years, indicating a heightened flood risk under current hydrological conditions. These findings emphasize the need for updated floodplain management and infrastructure planning in the Jhelum basin. Integrating statistical modeling and hydraulic optimization provides essential insights for real-time flood forecasting, early warnings, and resilient water management.

Keywords: Flood; HEC-SSP; Jhelum River; Return Period; Statistical Modeling.

5. Assessing the Plastic Pellet Contamination in the Ashtamudi Estuary following a Shipwreck in the Arabian coast

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Abstract

The inadvertent release of plastic pellets due to the MSC ELSA-3 shipwreck off the coast of Kerala has raised serious environmental concerns particularly in Indian coastal regions. The container vessel sank approximately 38 nautical miles off the coast of Kochi on 25 May 2025, resulting in the spill of an estimated hundreds of tonnes of plastic nurdles (resin pellets) into the Arabian Sea. By 27 May, large volumes of these pellets began washing ashore on Trivandrum beaches—Kochuveli, Thumba, Vettukad, Varkala and Shanghumugham—prompting urgent ecological concern. This study investigates the post-spill distribution and contamination of plastic pellets along the Ashtamudi Estuary and Trivandrum coast, assessing the environmental impacts on marine and estuarine ecosystems. The QGIS-based spatial maps generated through this study not only provided insight into the dispersion trends and sedimentation hotspots of plastic pellets in the affected regions but also serve as a valuable predictive tool. These spatial datasets, when integrated with seasonal wind and current data, can significantly enhance preparedness and response strategies in case of future marine spill events. Hence, the geospatial framework established in this research can form the basis for real-time tracking, vulnerability mapping, and mitigation planning in similar coastal contamination scenarios.

6. Density-Dependent Flow Modeling in Coastal Aquifers Under Climate Change

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Abstract

Coastal groundwater is a critical water resource for larger population around the world, providing drinking water and supporting coastal ecosystems. However, due to its location at the land-ocean interface, this resource is highly vulnerable to both land-based and marine impacts of climate change, as well as anthropogenic activities. These influences can alter not only the quantity of groundwater available but also its quality and how it moves through the environment. Climate change is expected to significantly affect coastal groundwater systems through a combination of rising sea levels, increased coastal flooding, and shifts in rainfall and drought patterns. These changes can disrupt the delicate balance between fresh groundwater and encroaching seawater, a process known as seawater intrusion.
In this study, we focus on the coastal aquifers of the southern Indian peninsula, where climate projections indicate a significant alteration in average rainfall with greater variability in wet and dry seasons. These trends alter groundwater recharge pattern and found to increase the risk of seawater intrusion in the coastal zones. Furthermore, global sea levels are projected to rise by about 0.49 m by 2100, with a possible range of 0.20 to

0.86 m, intensifying concerns about SWI as mentioned by the Intergovernmental Panel on Climate Change (IPCC). To address these challenges, this work assesses seawater intrusion using density-dependent flow models and provides a foundation for future remedial, measures to increase fresh water availability of the Indian peninsular coastal regions. It is also proposed to delineate Submarine Groundwater Discharge (SGD) in the coastal aquifers for sustainable management of the groundwater resources under changing climatic conditions.

Keywords: Coastal groundwater; density dependent model; seawater intrusion; sea level rise; climate change

7. Extreme Weather Events Resilience of Polish and Chinese Cities in the Context of Revitalization

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Abstract

Extreme weather events pose a growing threat to human health, infrastructure, and natural resources, with urban areas being particularly vulnerable. Projections indicate a continuing increase in the intensity and frequency of such events. In recent years, Poland has experienced numerous instances of heavy rainfall, strong winds, and heatwaves, which have resulted in significant material losses and threats to public safety. At the same time, many vulnerable urban areas are experiencing revitalization processes that greatly change land use and surface characteristics, sometimes changing the function and form of the urban environment. This study looks at how urban revitalization strategies include adaptation to climatic risks and evaluates the function of such investments in strengthening urban resilience to severe weather occurrences. The research uses meteorological and geospatial analysis over eight case studies—six Polish towns and two Chinese cities. Case selection was determined by the significance of recent revitalization projects, prior experience with extreme weather conditions, and the availability of high-quality meteorological data. The study looks at surface changes brought on by revitalization and studies institutional decision-making procedures on urban renewal as well as risk management. This work provides knowledge of the interaction between revitalization and climate resilience. This research has been funded by the National Science Center under the grant number: 2022/47/D/HS4/01313.

Keywords: adaptation; investments; meteorological extremes; urban areas; vulnerability

8. From Drop to Crop: Innovations in Water Management for Food Resilience

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Abstract

Water is mostly consumed by the food and agricultural industries. Primary food production is where water is used the most. Water is generally utilized in agriculture to irrigate crops. One of the main problems facing the globe today is the scarcity of water, which is expected to get worse in the future due to climate change. Addressing this issue is essential for places impacted by water scarcity since water availability and accessibility are the most important variables limiting crop productivity. Significant water use for irrigation is anticipated in the context of fierce competition between agribusiness and other economic sectors as a result of growing water shortages and drought brought on by climate change. Furthermore, the projected increase in the world's population growth rate indicates that food consumption will inevitably rise in the future, which will have a direct effect on the amount of water used in farming. In order to meet food needs and prevent excessive water usage, irrigation needs assessment is essential for water resource planning. Adopting sustainable water management techniques has become crucial in light of growing issues including population expansion, climate change, and water scarcity. Societies may protect agricultural production and ensure food supplies for future generations by placing a high priority on fair access, conservation, and effective use of water resources.
Keywords: Climate adaptation; Food security; Global; Sustainability; Water Scarcity

9. Geochemical Indicators and Hydrochemical Facies Analysis of Seawater Intrusion in the Pennar Delta, Andhra Pradesh, India

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Abstract

Indian deltas hold significant regional importance and are characterized by distinct hydro-environmental challenges. These low-lying coastal regions are particularly vulnerable to the encroachment of saline water into freshwater aquifers due to their proximity to the sea, reduced river discharges, and intensive groundwater pumping. The Pennar Delta in Andhra Pradesh, in particular, has limited potential for shallow freshwater zones suitable for drinking water supply. A systematic assessment has been undertaken using hydrogeochemical ratios and facies evaluation to determine the status of seawater intrusion in shallow and deep aquifers of the Pennar Delta. The rainfall and groundwater levels

analysis showed that rainfall variation is considered as the major cause of water level fluctuation in the Pennar delta apart from the groundwater exploitation. Analysis of groundwater levels (m, amsl) reveals that shallow wells exhibit groundwater levels ranging from 0 to -1 m, indicating conditions below mean sea level whereas, deep wells show significantly lower groundwater levels, reaching depths of up to -22 m (m, amsl) in the southern and central coastal parts of the Pennar delta. The northern and southern coastal regions **(**Vidavaluru and Muthukuru mandals**)** showing strong indications of seawater contamination, exhibited higher ratios Cl^-/Alk (>1.5) and TA/TH (<1), suggesting significant seawater contamination in the shallow and deep aquifers. To confirm this, the key salinity indicators **(**Na^+/Cl^-**,** Mg^{2+}/Ca^{2+}**,** and Ca^{2+}/HCO_3^-+ SO_4^{2-}) are calculated and further compared with the HFE diagrams. These ionic ratios revealed that shallow groundwater in Nelaturu village in Krishnapatnam suggests a potential mixing of seawater with shallow groundwater. The comparative evaluation of these three key ionic ratios indicates that Krishnapatnam village in Muthukuru mandal simultaneously satisfies all the three geochemical indicators typically associated with direct seawater intrusion and the Na–Cl facies and intrusion phase in the HFE-diagram strongly confirms direct seawater intrusion in this location. In addition, Kancharlapalem village in Vidavaluru mandal satisfies the two ratios **(**Mg^{2+}/Ca^{2+} and Ca^{2+}/HCO_3^- + SO_4^{2-}), and the sample also falls within intrusion phase in the HFE diagram, suggesting a possible influence of seawater mixing in this location. Both these locations are situated within 2 km of the coastline, supporting the likelihood of direct seawater encroachment into the deeper aquifer. Whereas samples in Nelaturu**,** Katepalli, and Mungamuru showed elevated ratios, indicative of high salinity, likely attributed to upward movement of paleosaline water from deeper geological formations rather than active seawater intrusion. To safeguard both shallow and deep groundwater resources, groundwater extraction must be carefully regulated in coastal regions**,** particularly in areas identified as vulnerable to seawater intrusion**.**

Keywords: Pennar delta, shallow wells, deep wells, seawater intrusion

10. Groundwater Flow Modeling for Seawater Intrusion Mitigation in Valsad Coastal Aquifer, Gujarat

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Abstract

Seawater intrusion into coastal aquifers is a critical issue that threatens freshwater resources, impacting water quality, agricultural productivity, and public health. This research focuses on Valsad block in Gujarat, a region severely affected by seawater intrusion due to over-extraction of groundwater, and climatic variability. The primary objective is to develop a robust groundwater model using Visual MODFLOW Flex to assess

the extent of seawater intrusion and propose effective mitigation strategies. The research methodology involved detailed data collection for the Valsad region, encompassing hydro-geological, climatic, and land-use parameters. The modelling process utilized Visual MODFLOW Flex to simulate groundwater flow and seawater intrusion, incorporating GIS data inputs, boundary conditions, and grid type selection. A conceptual model of the aquifer system is developed, followed by the assignment of observation wells and the execution of numerical simulations. Calibration and validation of the model ensured the accuracy and reliability of the simulation results. The SEAWAT predictive simulation indicated that by the end of year 2023, the seawater had intruded up to 3.2 km inland from the coastline. The study highlighted mitigating seawater intrusion through variations in recharge (hydraulic barriers) and a combination of recharge and extraction. Results indicate that these strategies effectively reduce seawater intrusion, thereby preserving groundwater quality. The combination of recharge and extraction demonstrated superior performance in combating saltwater intrusion.

Keywords: Groundwater, Visual MODFLOW, SEAWAT, Managed Aquifer Recharge, Coastal Aquifer

11.Integrated Reservoir Operation for Flood Mitigation in a Small Tropical Watershed in Kerala, India

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Abstract

Integrated reservoir operation during extreme events is one of the greatest challenges faced by reservoir operators and managers, that aroused as a consequence of climate change. The present study aims to assess the role of integrated operation of a multi-reservoir system on riverine flooding, in a tropical river basin in Kerala, India. The cascading multi- reservoir system consists of a water supply reservoir with its upstream balancing reservoir. Historic flood events were generated using the HEC-HMS hydrologic model and reservoir system operations simulated using HEC-ResSim. The hydrologic model was calibrated for the historic flood events in the basin. Flood events corresponding to different return periods were generated with the calibrated hydrologic model and the variation in peak flow observed at the downstream gauging point was examined for different combinations of initial reservoir storage and flood events of different return periods. The study provides useful insights on the safe reservoir levels to be maintained prior to forecasted extreme rainfall events.

Keywords: Extreme event; Flood management; HEC- ResSim; Reservoir simulation; Return Period.

12. Mapping Flood Escape Routes using Remote Sensing, Hydraulic Modelling, and Terrain-Informed Surveys: A Framework Study in the Gayathri River Basin, Kerala.

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Abstract

Recurring floods and droughts in Kerala have highlighted the urgent need for proactive disaster preparedness and water security planning. This paper presents an integrated framework for mapping floodwater escape routes combining remote sensing, hydrodynamic modeling, and terrain-informed surveys in the Gayathri River Basin, a flood and draught sensitive region in Kerala. Using Sentinel-derived terrain data and digital elevation models, the study identifies flood-prone areas and evaluates slope, drainage pathways, and settlement clusters. HEC-RAS 2D modelling is employed to simulate flood extents and flow characteristics under various return periods. A representative pocket within the basin is selected for detailed terrain analysis and on-ground validation, focusing on community access, existing infrastructure, and recommend potential floodwater escape corridors. The goal is to demonstrate how limited but well-targeted field inputs can complement remote sensing and modelling for practical planning. While the study is ongoing, preliminary outputs showcase the viability of this integrated method in supporting both flood resilience in monsoon and water security in summer at the local scale. The framework offers a scalable approach for basin-level planning, especially in data-scarce or partially accessible regions.

Keywords: climate resilience; water security; flood-adaptive design; local-scale adaptation; terrain-informed planning.

13. Numerical Simulation of Seawater Intrusion in Coastal Zone of Kodinar Block, Saurashtra Region, Gujarat.

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Abstract

The aim of current study was to develop suitable groundwater model to evaluate extent of seawater intrusion, its calibration, validation and suitable method for mitigation of sea water intrusion. Kodinar Taluka lies in Saurashtra coastal region and some of the villages of Kodinar taluka are on the coastal zone of the Arabian Sea. Groundwater has been the major source for drinking and irrigation purposes but the extractions without any

regulations has affected natural flow systems and caused seawater intrusion resulting in a degradation of groundwater quality. The groundwater flow model has been developed in GMS 10.6 (Groundwater Modelling System) using Finite Difference Method (FDM) to solve governing equations. The study identified seawater intrusion extent for the Kodinar taluka using the MODFLOW, MT3DMS and SEAWAT programming codes in GMS environment. The conceptual model has been developed to identify the zone of draft/recharge, zone of aquifer parameter and boundary conditions along with some observation wells to study the salt water ingress. The study based on the numerical simulations, revealed that in the year 1971 seawater intrusion were around 2 km, at present in the year 2022 it has been increased up to nearly 2.7 km and a future prediction up to 2070 suggested that seawater would be extended up to 3.5 km inland and heavily impact on agricultural activities.

Keywords: Groundwater, GMS, MODFLOW, MT3DMS, SEAWAT, Coastal Aquifer

14. Regional Flood Frequency Analysis for Catchments Located in South India

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Abstract

Estimation of design flood is essential for safe, reliable, and economical design of hydraulic structures. However, estimating design flood for ungauged catchments, where historical flow records are not available, remains a challenge. The present study is to address this issue for the catchments located in South India. 29 unregulated catchments situated across five major river basins in South India, such as the Krishna, the Cauvery, the Godavari, the East flowing river basin, and West flowing river basins were selected for performing Regional Flood Frequency Analysis. Annual maximum flood series were compiled for each gauging station. The primary objective is to estimate design flood estimates at each individual sites, with a secondary focus on enhancing flood estimates through the process of regionalisation. At-site FFA employed five probability distributions: EV-1, GEV, LN, LP3, and Weibull distributions. Hierarchical clustering using Wards method and Euclidean distance classified the clusters into three clusters. Regional homogeneity was assessed using the USGS homogeneity test, L-Moment based H-W test, and L-Moment based Discordancy measures. L-Moment Ratio Diagram guided the selection of candidate frequency distributions. The Index Flood Method was applied for the regional estimation, with growth factor curves developed for return periods ranging from 2 to 500 years. Among the candidate frequency distributions, GLO, GEV, and EV-1 showed strong performance, with the Index Flood method emerged as the most reliable approach since it yielded average NSE of 0.79, 0.78, and 0.82 for the clusters 1, 2, and 3 respectively and low RMSE values.

The design floods were estimated at three test-sites which were considered as ungauged sites.

Keywords: Design flood, Index Flood Method, Regionalisation, Hierarchical clustering, Homogeneity test

15. Scenario-Based Hydrodynamic Modeling of Glacial Lake Outburst Floods in the Sikkim Himalayas Using HEC-RAS 2D

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Abstract

In recent decades, the Himalayan region has undergone accelerated glacier recession, leading to the rapid formation and expansion of glacial lakes. The increasing number of moraine-dammed lakes has significantly elevated the risk of Glacial Lake Outburst Floods (GLOFs), posing serious threats to downstream communities, infrastructure, and ecosystems. To evaluate the potential impacts of worst-case GLOF scenarios, we employ the HEC-RAS 2D hydrodynamic model to simulate the complex flow behavior of such events, capturing multi-directional and multi-channel flood propagation. Landsat 8 imagery was utilized for the delineation of glacial lakes, while the ALOS PALSAR RTC DEM (12.5 m) provided high-resolution terrain data for hydraulic modeling. To accurately represent surface resistance, MODIS land cover data was integrated to assign spatially distributed roughness coefficients. The potential breach volume was estimated using Fujita's empirical equation, and breach dimensions such as width and depth were derived using Froehlich's relationships, forming the basis of breach hydrographs used as upstream boundary conditions. We focused on two critically vulnerable glacial lakes in North Sikkim, namely South Lhonak Lake and Gurudongmar Lake, and assessed flood hazards at the downstream settlement of Chungthang under three GLOF scenarios. Scenario 1 simulated an outburst from South Lhonak Lake, Scenario 2 from Gurudongmar Lake, and Scenario 3 represented a worst-case simultaneous failure of both lakes. The results revealed that Scenario 3 produced the most extreme flood characteristics, with a maximum flow depth of 18.4 m, velocity of 3.6 m/s, and peak discharge of 8,556 m^3/s. Scenario 2 yielded a flow depth of 16.4 m, velocity of 3.1 m/s, and discharge of 6,188 m^3/s, while Scenario 1 exhibited lower values of 9.7 m flow depth, 1.6 m/s velocity, and 1,257 m^3/s discharge. These findings highlight the significant flood risk posed by potential GLOF events in the region and underscore the urgent need for comprehensive mitigation strategies, early warning systems, and improved disaster preparedness in the Eastern Himalayas.

Keywords: Breach Hydrograph; Glacier Recession; Gurudongmar Lake; Roughness Coefficients; South Lhonak Lake.

16. The Water Infrastructure of Degrading Communities

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Abstract

Water crisis is an age-old occurrence that is having detrimental effects until date. It just does not refer to lack of water supply but also degrading the quality and declining the quantity of potable and usable water supply to all income households. The study explores the *human-induced disasters* affecting communities struggling with water access. It investigates challenges like *purchasing water,* the limitations of *piped water supply,* water theft, and *inadequate water infrastructure,* ultimately aiming to understand how these issues exacerbate societal degradation. A longitudinal community study of locality close to Asia's largest dumping ground *Deonar*, Mumbai, Maharashtra, India and the Venice of Africa '*Makoko'* with both being infamously known as *'Floating Slums'* and suffering from the tricycle of problems related to Health & Well-being, Environment and Social issues. The classic cases of *Floating Communities* are not just an issue but can be a sustainable way of living for marine and human life is Uros Islands. The use of Totora reed to manage wastewater has resulted in uplifting the *Ecological value and cultural resilience*. While systems like 'DEWATS' case study of Aravind Eye Hospital, Coimbatore highlights that the most toxic and harmful hospital wastewater can be treated to potable levels. While food, clothing, and shelter are essential for survival, water is the fundamental basis upon which these necessities depend. The combination of Uros Islands and DEWATS can serve as a benchmark to upgrade lifestyle of degrading floating communities through consistent approach.

Keywords: Human-induced disasters, Purchasing water, Inadequate water infrastructure, Floating communities, Ecological value and cultural resilience

17. Unique Specialities of Jamun (*Syzygium Cumini* (L.) Skeels) and its Potential as a Rootstock under Flood Stress Conditions

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Abstract

Increasing awareness on the consumption of protective foods has led to a search on biopotent principles available in underutilized and underexploited fruit crops. In many such cases, this has culminated in the development of innovative commercial products but on the more important side, the large genetic pool is becoming impoverished due to overexploitation. Defining ecosystems that serve as typical adaptive centres is a key component of biodiversity conservation and identifying special and unique attributes that helps in survival and establishment thus becomes a prioritized, focused area of research. Jamun (*Syzygium Cumini* (L.) Skeels) is one such fruit crop which has been identified since time immemorial due to its antioxidant, antidiabetic, anti-carcinogenic, anti-inflammatory, anthelmintic and anti-hyperlipidemic properties, finding its use in the traditional medicare systems. This paper presents a unique quality of the fruit species that is observed in Pechiparai forest reserve. The study was undertaken to access the large diversity of *Syzygium Cumini* in the humid tropics of southern Tamil Nadu during two distinct years (2023 – 2024 & 2024 – 2025). More than a hundred well-grown trees were observed growing in submerged conditions, with the top half part above the water level revealing their resilience under flooded conditions. A good lot were also observed to flourish under marshy conditions on the banks. A probe into the mechanism of its survival revealed the production of aerial roots (Stilt roots) from the main stem above water, which served multiple functions of anchorage, gas exchange and absorption of nutrients, proving that this crop can function efficiently as a component of the mangroves. Another important aspect is that seedlings from these distinct accessions can serve as an efficient rootstock to overcome flood stress. These reports are the first of their kind. Further research is required on the anatomy, physiology and biochemical basis to establish the underlying aspects that favour its establishment under excess of water.

Keywords: Jamun, Flood stress, Aerial roots, Pechiparai, Stilt roots

18. Unraveling Genomic Regions and Candidate Genes for Drought Resilience in Finger Millet

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Abstract

Finger millet (*Eleusine coracana* L.), a C_4 cereal of the Poaceae family, is a highly nutritious and climate-resilient crop widely cultivated across the semi-arid tropics of India and Africa. Despite its inherent drought tolerance, moisture stress especially during the reproductive and grain-filling stages causes significant yield losses. Drought tolerance in finger millet is a complex, quantitative trait governed by multiple physiological and

biochemical mechanisms, including osmotic adjustment, antioxidative defense, and maintenance of cellular integrity. Traditional screening methods based on morphological and physiological parameters are often inconsistent under field conditions; hence, genomic approaches are essential for precise identification of drought-tolerant genotypes. Recent advances, including the availability of a chromosome-scale reference genome (Devos *et al*., 2023), genome-wide SNP markers (Brhane *et al*., 2022), and transcriptomic resources (Parvathi *et al*., 2019; Li *et al*., 2021), provide a robust foundation for dissecting the genetic architecture of drought tolerance. The present study aims to map genetic loci and identify candidate genes associated with drought tolerance in finger millet through integrated genome-wide association studies (GWAS), quantitative trait locus (QTL) mapping, and transcriptome profiling under controlled drought stress. Candidate genes such as *DREB*, *NAC*, *bZIP*, *LEA*, and aquaporins are expected to play key roles in regulating drought responses. The integration of multi-omics data will facilitate the identification of functional alleles and development of breeder-friendly molecular markers for marker-assisted and genomic selection. This research will enhance our understanding of the molecular basis of drought tolerance in finger millet and accelerate the development of resilient cultivars, contributing to sustainable food and nutritional security in drought-prone regions.

Keywords: drought tolerance, GWAS, QTL mapping, transcriptomics, molecular breeding, climate resilience

19.2D-Flood Modelling of Vamsadhara River basin using HEC HMS and RAS

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Abstract

The Vamsadhara River basin, situated between the Mahanadi and Godavari river basins in southern India, spans a total catchment area of approximately 10,830 sq.km. The river originates near the border of Thuamul Rampur in Kalahandi District and Kalyansinghpur in Rayagada District, Odisha, and flows southeast for about 254 kilometers before discharging into the Bay of Bengal and the total basin area, 8,015 sq.km lies in Odisha, while 2,815 sq.km falls within Andhra Pradesh. The basin is geographically located between 18°15′ to 19°55′ N latitudes and 83°20′ to 84°20′ E longitudes. Being a non-perennial river, Vamsadhara relies solely on rainfall for its flow, primarily during the southwest monsoon (June–October). The region is also occasionally affected by cyclonic systems originating in the Bay of Bengal. The 2006 monsoon season witnessed the highest rainfall in the basin over a 50-year period (1971–2020), resulting in severe flooding that caused substantial economic losses and loss of life. In response, this study aims to

understand the flood inundation behavior of the basin during this extreme flood event. A hydrologic-hydrodynamic modeling approach was adopted, combining HEC-HMS (Hydrologic Modeling System) for simulating rainfall-runoff processes and HEC-RAS (River Analysis System) for simulating 2D flood propagation and inundation. Hourly rainfall data were sourced from the Center for Hydrometeorology and Remote Sensing (CHRS). The HEC-HMS model outputs, including runoff depth and excess rainfall, served as input to the 2D HEC-RAS model for simulating flash floods. Model calibration and validation were carried out using data from Gunupur and Kashinagar gauging stations. The simulated results closely matched observed data, with R^2 values of 0.766 and 0.777, respectively, indicating good model performance. The flash flood model proved effective in producing pre-flood inundation maps, which are essential tools for flood forecasting, risk assessment, and disaster management planning. These simulations offer critical support for early warning systems and decision-making by authorities in the Vamsadhara basin.

Keywords: Flash Flood, Rainfall, Model, Runoff, Simulation

Theme 5

Policy and Governance in Water Resources Management

1. Analyzing Robustness of the Water Use Efficiency Index for Higher Education Institutions (HEIs) in India: A Case Study of Sant Gadge Baba Amravati University, Maharashtra

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Abstract

The National Water Mission of the Government of India has one of its targets to achieve water use efficiency across the domestic sector, in line with Sustainable Development Goal number six, which aims to achieve water use efficiency across all sectors by 2030. One of the important stages in the development of weighted composite indexes is the assessment of the robustness of the developed index. The robustness assessment is commonly performed by undertaking uncertainty and sensitivity analysis on the index. The Water Use Efficiency Index for Higher Education Institutions in India was developed to assess water consumption patterns of Higher Education Institutions (HEIs) in the Indian Context. This study presents a sensitivity and uncertainty analysis, along with the results, for the developed index based on its application to Sant Gadge Baba Amravati University in Maharashtra. In this study, sensitivity analysis attempted to answer which of the weighting schemes and aggregation methods were more sensitive to final index value; which of the threshold values were more sensitive to the variation in the upper and lower threshold values; and how much important were the upper and lower values of the thresholds in determining the final index value. While the uncertainty analysis attempted to assess how the uncertainties of threshold values affect the respective sub-index values and final index values. The results of the uncertainty and sensitivity analysis will aid in the effective application of the developed index on different types of HEIs in the Indian context. Further, it will also aid the development of other similar indices and assessment frameworks.
Keywords: National Water Mission, Sensitivity Analysis, Sustainable Development Goal 6, Uncertainty Analysis, Water Sustainability Index.

2. Climate Change and Water Conservation: Adaptive Strategies for Sustaining Hydrology, Ecology, and Food Security

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Abstract

Global agricultural systems, ecological balances, and hydrological cycles are all significantly impacted by climate change. Extreme weather events, unpredictable rainfall,

and rising temperatures worsen water scarcity, disturb ecosystems, and endanger agricultural productivity. Adaptive solutions are required to ensure water sustainability in light of these developments. This essay explores the complex connection between water conservation and climate change, highlighting creative solutions and community-driven strategies. Indigenous water management techniques, which are based on customs and local knowledge, provide insightful information about sustainable practices. Resilience against changes in the environment and fair resource distribution are frequently given top priority in these systems. Advanced irrigation methods and digital monitoring tools are examples of technological interventions that improve productivity and reduce water waste. A comprehensive framework for resolving conflicting needs across sectors and advancing fair access to water resources is called Integrated Water Resource Management, or IWRM. The report emphasizes how urgent it is for governments, communities, and businesses to work together to address climate-related issues. Adaptive tactics that integrate contemporary technology and conventional knowledge can increase resistance to the impending climate catastrophe. Societies can lessen the negative consequences of climate change on freshwater resources, ecosystems, and food security by giving priority to sustainable water management techniques. In the face of global climate issues, this strategy not only promotes social justice and economic stability but also guarantees environmental sustainability.

3. Groundwater Pulse: Assessing Quality for Drinking and Irrigation in Puliyurnatham Firka, Oddanchatram taluk, Dindigul district, Tamil Nadu

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Abstract

Groundwater quality assessment is essential to determine its suitability for drinking and irrigation in Puliyurnatham Firka, Oddanchatram taluk, Dindigul district. Contamination from both natural and anthropogenic sources can significantly affect the groundwater chemistry. The present study assesses its suitability for drinking and irrigation purposes with 23 water samples collected and analyzed using the recommended methods. The physicochemical parameters such as EC, TDS, TH, Ca^{2+}, Na^{+}, HCO_3^{-}, NO_3^{-}, Cl^{-} and F^{-} exceed the most desirable limit. The piper plot represents the dominant type of Na-Cl. Rock dominance is more prevalent when compared to evaporation-crystallization, as most samples indicate in the Gibbs plot. Wilcox shows that water is suitable for irrigation without treatment. Doneen plot indicates that most of the samples fall in class-1 as the groundwater is suitable for irrigation. The water quality index indicates that 57% of the water is good, 34% is poor, 5% is excellent, and 4% is very poor. The irrigation indices sodium percentage and sodium adsorption ratio indicate groundwater is suitable for irrigation, but the Kelly ratio poses a significant risk. Groundwater quality must be regularly monitored to ensure

its safety for drinking, and irrigation and treatment are needed where parameters exceed permissible limits. Areas with a high Kelly Ratio require careful management for irrigation use, and promoting sustainable groundwater practices is essential for long-term use.

Keywords: Groundwater Quality, Drinking Water Suitability, Irrigation Water Assessment, Water Quality Index (WQI)

4. Hands-on Application of Graph Model for Conflict Resolution (GMCR) for Water Resource Conflict Resolution

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Abstract

This introduces participants to the Graph Model for Conflict Resolution (GMCR), focusing on its application to water resource conflicts using Parambikulam-Aliyar Project (PAP) as a case study. GMCR has proven effective in analyzing and resolving complex multi-stakeholder disputes in water management, environmental issues, and climate change impacts.

Keywords: Graph model for conflict resolution (GMCR), water resources conflict resolution, hands-on application.

5. Hijacking of Jal Jeevan Mission by Hydraulic Paradigm: The Trajectory of Water Governance in Kerala, India

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Abstract

Water governance in Kerala has evolved considerably since 1956, intertwining policy formation, legislation, institutional reforms, programmes and projects. Legislative enactments in water sector was around one percent of legislations by Kerala Legislative Assembly. Water governance was largely centralized and urban oriented, with residual focus on rural water sector. A temporal view of the sector since 1956, brings a kaleidoscope of experiences: Kerala Water Authority (KWA) replaced Public Health Engineering Department (PHED); centralized water sector investments focused on large irrigation infrastructure, including dams and canal networks, riding the hydraulic paradigm pathway;

and little focus on sustainability of investments, results and services. Community participation and management in rural water sector stems from state failures and over-stretched state treasuries. The Jalanidhi project was the largest and most noteworthy of the reform projects featuring community participation, decentralized service delivery and operational cost recovery. The Jal Jeevan Mission (JJM) was launched in 2019, aiming at universal tap water access, throwing open an opportunity to scale up the successful Jalanidhi model. However, Government of Kerala ignored the success and learnings of Jalanidhi and revived hydraulic paradigm and recentralization in implementing JJM. Kerala's water governance journey oscillated between centralized and state-led hydraulic paradigm and decentralized, participatory and community managed systems and experiences, in a spasmodic reform shifts, neglecting and ignoring rich community experiences on sustainability of investments. This paper is prepared based on review of literature, e-documents from the Legislature library, project documents and MIS on Jalanidhi and JJM, along with qualitative reflection of sectoral experience.

Keywords: community-management; decentralization; Jalanidhi; recentralization; water

6. Regulation of Groundwater in India: Benefits, Gaps, and Implementation Challenges

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Abstract

Groundwater is a vital component of water resources in India. It plays an important role in nation's economic growth sustaining the agriculture, industrial and household needs. India extracts nearly 25% of the world's groundwater, making the world's largest user of groundwater. It relies heavily on groundwater for irrigation (62%), rural water supply (85%), and urban water consumption (50%). Groundwater over-extraction in India has led to alarming depletion, necessitating stringent regulations. Central Ground Water Authority (CGWA) introduced a framework to control groundwater use across different sectors. It establishes a No Objection Certificate (NOC) system and mandates water abstraction fees improving the groundwater monitoring, discourages excessive extraction, shifting towards wastewater recycling to comply with regulations. Despites these benefits, there is an inadequacy in regulating the extraction for agriculture - the largest consumer. There is also insufficient action beyond the reports and policies due to weak enforcement mechanisms. Strengthening enforcement, introducing agricultural regulations, and leveraging technology can bridge these gaps and ensure sustainable groundwater management in India.
Keywords: Groundwater, regulation, policies, agriculture.

7. The Unspoken Pain of Water Urbanization

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Abstract

Development is a progressive approach. Often, urban development is highly regarded on a positive aspect whereas rural development is under-rated. Haphazard development and *unwavering demand and supply of infrastructure* appear with a plethora of challenges. The unspoken pain of water urbanization has significant consequences mainly the four sections social-emotional-psychological-health. The *correlational study* of Mumbai's infrastructure demands are unsustainable and have a negative impact on other areas within Maharashtra; this case been studied with three cities Parbhani, Aurangabad, and Panvel that have been experiencing ongoing *water rationing* due to water shortages. This situation has persisted without significant improvement for some time. The *water theft* through underground water market has lasting impact in metropolitan cities of Karachi, Delhi, and Bangalore. Surprisingly, the *water shortages* are a common feature in *water surplus* area of Kashmir as well. Robust reservoir catchment, Cloudburst tunnels, Sustainable water supply, Integrated green infrastructure, *Water-wise* societies have been explored in *strong water management areas* that is Micro level study Rottendam, Copenhagen, Stockholm and Macro level study Singapore as a country. Gravity led systems, wastewater treatment, community engagement are among the features of *self-sustained water areas* of Finca, Costa Rica and Findhorn, Scotland. Technical bifurcation of spaces as per *four stages of urbanization* hierarchically urbanization, suburbanization, counter-urbanization, and re-urbanization shall enable systems. The *Water-related hazard management approaches* of Singapore, Helsinki, and Cape Town can offer valuable lessons for other cities, particularly regarding water security and resilience.

Keywords: Water rationing, Water theft, Water shortage, Water surplus, Water-wise

Theme 6

Innovative and Sustainable Water Management

1. AI-Based Smart Irrigation Enhances Water Use Efficiency and Soil Biological Health

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Abstract

Effectiveness of smart irrigation systems was evaluated on the impact of soil microbes and corresponding increase in the agricultural productivity. Microbes, especially nematodes, are the functional groups at all trophic levels that play a key role in soil food webs. Their community structure allows to assign food web conditions and soil health. A field experiment was set up to investigate the effects of different irrigation regimes on the nematode fauna and the micro-food web in a garden land soil cropped with tomato with treatments *viz*., surface irrigation, sprinkler irrigation, drip irrigation and no irrigation with & without crops were investigated. Soil samples were collected during the crop and at the end and nematode community structure was determined. Faunal analysis performed resulting in: Maturity Index (MI), Plant Parasite Index (PPI), Channel Index (CI), Enrichment Index (EI), Structure Index (SI) and metabolic footprints (F). In addition, phospholipid fatty acids were determined to identify microbial community structure and biomass. The nematode fauna was investigated at plots cropped in two different depths, ridge crown (0–10 cm) and ridge base (30–40 cm). Irrigation affects the ratio of fungal to bacterial feeders, with a more active fungal decomposition pathway under drier soil conditions and stability of the micro-food web is generally low across treatments. The results also show that smart irrigation significantly increased crop productivity (34.9% higher than traditional irrigation systems) through precision watering that matches crop needs. Water savings of up to 47.8% prove that the system is able to optimize the use of water resources. Smart irrigation systems are proven to be more effective than conventional irrigation in improving crop productivity, water resource efficiency and economic returns.
Keywords: Smart irrigation, Nematode fauna, Artificial Intelligence, community analysis, crop productivity

2. Assessment of Aquifer Properties Using Pump Test Data in Select Villages of Aurangabad Tahsil, Maharashtra, India

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Abstract

Pump tests were conducted in six villages-Hatmali, Shelud, Chartha, Donwada, Adgaon, and Anjandoh-to evaluate key aquifer parameters such as transmissibility, specific yield, and discharge. Results indicate a broad range of aquifer properties, highlighting spatial variability in groundwater potential. Anjandoh exhibited the highest transmissibility (214 m^2/day), while Shelud showed the lowest (0.049 m^2/day). These variations underscore the need for localized groundwater management strategies.

3. Assessment of Nitrate Contamination in Soil and Groundwater of Palacode Region, Dharmapuri District, Tamil Nadu

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Abstract

Nitrate is one of the most common contaminants in groundwater which comes from various sources such as excessive use of nitrogen fertilizers, sewer leaks and the disposal of human and animal waste and its excessive levels pose potentially harmful risks to the environment and human health. The present study was carried out to assess the nitrate concentration in groundwater and soil at Palacode, Dharmapuri District, Tamil Nadu. Twenty-eight groundwater samples and 5 soil samples at a depth of 15 cm were collected from agricultural areas. Nitrate concentration was analysed using a UV spectrophotometer, and the results shows that the nitrate concentration in groundwater varies from 0.91 mg/l to 224.41 mg/l with an average value of 66.16 mg/l. About 43% of the samples fall below the permissible limit of 45 mg/l as per the Bureau of Indian Standards (BIS-2012), and 57% of the groundwater samples shows nitrate levels exceeding 45 mg/l, primarily due to agricultural runoff and livestock operations. High concentration of nitrate is expected due to the frequent application of nitrogen fertilizer to the mulberry crop whereas low concentration of nitrate is observed in the wells located closer to the lake. The average concentration of nitrate in soil is 15.45 mg/kg, with a range of 14 to 22.25 mg/kg. Topsoil at 15cm depth shows consistent nitrate availability across the site is mainly due to the uniform application of fertilizers, organic matter, and microbial activity in the root zone.

The presence of higher concentrations in several locations suggests a potential risk of nitrate contamination. The results indicate that better nitrogen management and regular monitoring are required in this area.

Keywords: Groundwater contamination; Fertilizer; Groundwater quality; Health risk; Agricultural practices.

4. Assessment of Nanoemulsion-Based Bio-inoculants Environmental Sustainability in Black Gram (Vigna mungo L.) under Irrigated Conditions.

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Abstract

The present investigation was conducted to evaluate the environmental sustainability and efficacy of nanoemulsion-based bio-inoculants in improving the growth, yield, and soil health of black gram (*Vigna mungo* L.) under irrigated conditions. Conventional bio-inoculants, though beneficial in enhancing crop productivity, often suffer from reduced shelf life, poor microbial stability, and inconsistent field performance due to environmental fluctuations. To overcome these limitations, nanoemulsion formulations were developed using selected beneficial microbial strains, including *Rhizobium* sp. and *Pseudomonas fluorescens*, encapsulated in biodegradable nanocarriers. The nanoemulsion system was characterized for its particle size, stability, and microbial viability during storage. Field experiments were carried out in a randomized block design with different treatment combinations of nanoemulsion-based bio-inoculants, conventional inoculants, and control plots under irrigated conditions. The application of nanoemulsion-based formulations significantly improved nodulation, plant height, dry matter accumulation, and yield attributes compared to conventional treatments. Enhanced nutrient uptake, particularly nitrogen and phosphorus, was recorded, indicating improved nutrient-use efficiency. Moreover, soil enzymatic activities such as dehydrogenase and phosphatase were elevated, reflecting a positive influence on soil microbial health.

Environmental impact assessment revealed that the nanoemulsion-based bio-inoculants were eco-friendly, exhibiting no phytotoxic or adverse effects on soil quality or microbial diversity. The use of biodegradable surfactants and carriers further minimized the risk of environmental contamination. Overall, the study demonstrated that nanoemulsion-based bio-inoculants can serve as a sustainable alternative to conventional formulations by enhancing microbial efficiency, crop productivity, and maintaining soil ecological balance under irrigated systems.

Keywords: Nanoemulsion, Bio-inoculants, *Vigna mungo*, Environmental sustainability, Irrigated conditions, Soil health, Rhizobium.

5. Biowaste-Based Solutions to Water Pollution: Dragon Fruit Peel as a Green Adsorbent

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Abstract

Water pollution has become an escalating global threat, driven by industrialization, agricultural runoff, and improper waste disposal. Contaminants such as heavy metals, synthetic dyes, and organic pollutants are increasingly polluting freshwater sources, posing serious risks to ecosystems and human health. There is an urgent need for eco-friendly and cost-effective solutions to mitigate this issue. One sustainable approach gaining attention is the valorization of agricultural waste, particularly from fruit crops like dragon fruit (*Hylocereus spp.*), to develop natural adsorbents for water purification. This review explores the potential of dragon fruit peel and other waste parts as bio-adsorbents for treating polluted water. Rich in cellulose, pectin, hemicellulose, and phenolic compounds, dragon fruit peel exhibits high surface area and active functional groups capable of binding and removing various pollutants. Studies have shown its efficiency in adsorbing heavy metals like lead (Pb^{2+}), cadmium (Cd^{2+}), and chromium (Cr^{6+}), as well as synthetic dyes such as methylene blue and malachite green, through mechanisms including ion exchange, hydrogen bonding, and surface complexation. By converting agricultural waste into a valuable resource for water remediation, dragon fruit waste offers an environmentally sustainable and low-cost solution. This approach supports circular economy practices while reducing dependency on synthetic and non-biodegradable adsorbents. In conclusion, dragon fruit waste has significant potential in reducing water pollution, and further research into optimization, scalability, and real-world applications can enhance its role in sustainable water management systems.

Keywords: Biowaste utilization, Agro-industrial waste, Sustainable wastewater treatment, Waste valorization, Eco-remediation.

6. Comparative Study on the Performance of Anion and Cation Hydrogel in Desalination Process

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Abstract

The desalination process is essential for producing high-purity water required for environmental, laboratory, and industrial uses. Since two-thirds of the world's population

is expected to experience water scarcity and over two billion people still lack access to clean drinking water, the development of efficient desalination technologies is becoming increasingly crucial. This work compares the synthesis, performance, and potential applications of cationic and anionic hydrogels for water desalination. Cation-exchange hydrogels were made with polyvinyl alcohol (PVA), sodium alginate, and sulfosuccinic acid (SSA), while anion-exchange hydrogels were made with polyethyleneimine (PEI). Chemical crosslinking and freeze-thaw techniques were applied to enhance ion-exchange and water retention capabilities. It was assessed how well the hydrogels removed ions, hardness, and chloride from model wastewater. Using a peristaltic pump and 100 g + 100 g of hydrogel, the most effective flow rate of all those assessed was 5 mL/min. Under these ideal conditions, the total dissolved solids (TDS) in the raw sample decreased from 7000 parts per million to 2000 parts per million during the first treatment cycle. After 30 to 60 minutes, it levelled off at 6.1 to 6.6 ppt. The pH increased from 4.1 to 6 during the first treatment and remained in the range of 4.3 to 4.6 throughout the trial. These findings demonstrate that pollutants can be efficiently removed with an adsorption capacity of 0.37 mg/g.

Keywords: Desalination process; polyvinyl alcohol: sulfosuccinic acid; hardness; chlorides; ion exchange beads; cross linking

7. Cracking the Groundwater Code: Unveiling Hydrogeochemical Signatures and Irrigation Suitability in Vedasandur Firka, Dindigul district, Tamil Nadu

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Abstract

Groundwater is a crucial source of freshwater, supporting drinking water supplies, agriculture, and ecosystems worldwide in Vedasandur Firka, Dindigul district. Natural processes and human activities influence groundwater quality, making its assessment vital for sustainable management. The study aimed to assess the suitability of groundwater for drinking and irrigation purposes. 27 water samples were collected, and analysed the physiochemical parameters using standard recommended methods. The total hardness, Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Nitrate and Fluoride exceeds the most desirable limit. The piper plot indicates mixed Ca-Mg-Cl and Na-Cl type as the dominant type. Gibbs indicates rock dominance is more prevalent and plays a major role in affecting groundwater chemistry. Wilcox represents groundwater as suitable for irrigation without any treatment. The doneen plot indicates that most groundwater samples fall in class-1, indicating they are suitable for irrigation with high permeability and low sodium hazard. The water quality index indicates that 59% of samples are in good water,

33% in poor water, and the remaining category is excellent. The correlation heatmap reveals strong positive relationships among major ions such as Ca^{2+}, Na^{+}, and Cl^{-}. The negative correlation of pH with most parameters suggests acidic conditions may reduce ionic concentrations. Irrigation indices like (RSC, SAR, and PI) reveal groundwater is suitable for irrigation without any treatment, but (MAR and KR) indicate that it might pose significant risks. Regular monitoring and implementing continuous assessment will detect early signs of contamination and support sustainable groundwater use for both drinking and irrigation purposes.

Keywords: Groundwater Quality, Physiochemical parameters, Hydrochemical Correlation, Water Quality Index (WQI),

8. Development of Water Supply Distribution Network System for Kopargaon City using EPANET Software

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Abstract

Water distribution systems constitute a vital part of civil infrastructure. An increasing demand for water due to population growth, industrial development and improvement of economies require management of water transfer and improve operation of distributed network systems. Design of water supply systems is one of issues that can be mapping and analyses using RS techniques. The objective of this paper is to analyze the domestic water supply distribution system of Kopargaon City using Remote Sensing and EPANET software to deliver potable water over all the areas in required quantities and under satisfactory hydraulic parameters. The image taken from goggle earth has used as raster image, which is further geo-referenced and projected according to coordinates, in which the boundaries of each zone are specified and other data and schedules of Elevated Service Reservoir ESR are plotted and the final thematic map is prepared as vector image. The required data of Kopargaon city has processed in the EPANET. Final network then run to check analyze and get the various outputs of the water distribution system.

Keywords: Civil Infrastructure; Domestic Water Supply; Hydraulic Parameters; Remote Sensing; Thematic Map

9. Enhancing Water Reuse and Profile Available Water (PAW) through Adaptive Agricultural Practices in Chittur Taluk, Kerala, India

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Abstract

Climate change has magnified water scarcity for domestic and agricultural uses, significantly impacting agricultural sustainability and rural livelihoods. Despite receiving an average rainfall of 3000 mm each year, acute water shortage and groundwater overexploitation in sensitive regions, as in the case of Chittur Taluk, still persist in peak summer. The region once known for its agrarian resilience is increasingly vulnerable to prolonged dry spells, erratic monsoons, reduced groundwater recharge and rising levels of pest infestations and diseases. This study explores adaptive agricultural strategies suited for the region with due reference to agroclimatology and primarily focuses on rootzone or profile water availability, water reuse and the integration of stress-tolerant crops such as millets, pulses and native oilseeds. Particular emphasis is also placed on greywater reuse for field crops, farm pond water budgeting and *in-situ* water harvesting measures.

Preliminary findings suggest that cultivating millets during dry spells and legumes in crop rotations improves soil moisture retention and offers higher water productivity (kg/m³) compared to water-intensive cereals traditionally cultivated. The study also suggests water quality improvement using sustainable agricultural practices. It is noteworthy that millets and fodder crop cultivation using treated greywater offers a twin advantage; Enhancing the farmers' income while addressing a pressing issue – Greywater management. By aligning traditional knowledge with emerging water reuse and management technologies, this research contributes to policy dialogues on climate-smart agriculture and decentralized water governance. The research outcomes are expected to support replicable models for other drought-prone agro-ecological regions facing similar climate challenges.

Keywords: Adaptive Agriculture, Climate Change, Greywater Recycling, Palakkad, Water-Use Efficiency.

10. Groundwater Management in Hard Rock Terrains: A Case Study from Gaya District, Bihar, India

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Abstract

Groundwater scarcity has emerged as a critical concern in Gaya district, Bihar, particularly during the pre-monsoon period, where increasing demand and unsustainable extraction practices have placed significant stress on the region's aquifer systems. The hydrogeology of Gaya is primarily characterized by marginal, weathered, and fractured hard rock aquifers with low to moderate yield potential. In addition to quantitative stress, groundwater quality is also under threat due to sporadic occurrences of contaminants such as fluoride and nitrate, which frequently exceed permissible limits of 1.5 mg/L and 45 mg/L, respectively, posing

health risks to dependent populations. The region's underlying Chhotanagpur Gneissic Complex contributes to elevated fluoride levels, while the low permeability of geological formations and poor infiltration capacity constrain aquifer recharge. These challenges are exacerbated by the absence of effective artificial recharge infrastructure, continued reliance on low-yield or contaminated sources, and limited availability of high-resolution, site-specific hydrogeological data. Moreover, excessive groundwater use in agriculture, coupled with climate variability and inadequate infrastructure, further aggravates the stress on groundwater systems. Despite these constraints, groundwater remains a vital buffer against hydrological variability due to its relatively stable recharge dynamics. This study examines the hydrogeological, geochemical, and socio-economic factors influencing groundwater use in Gaya district and advocates for a transition toward decentralized, community-based groundwater governance. By integrating local planning, quality monitoring, and sustainable abstraction practices, the research proposes a framework for resilient and equitable groundwater management in Bihar's hard rock aquifer systems.
Keywords: Groundwater management, hard rock, case study, Gaya district, Bihar

11. Groundwater Scenario in Jharkhand (2000–2025): A Critical Analysis of Trends, Causes and Sustainability Challenges

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Abstract

Jharkhand, a state in eastern India carved out of Bihar in 2000, spread over 79,714 km² and is characterized by forested plateaus, mineral-rich terrains, and hard rock aquifer systems. The state has experienced increasing stress on its groundwater resources due to rapid urbanization, industrial expansion, agricultural intensification, and climate variability. This paper examines long-term groundwater monitoring data from the Central Ground Water Board (CGWB) over past 25 years and real-time observations from Digital Water Level Recorders (DWLRs). The study analyzes changes in groundwater scenario from 2000 to 2025 and presents a comprehensive assessment of groundwater level trends across the state. The study identifies a consistent pre-monsoon water level decline in several districts, particularly in urban-industrial zones. The paper emphasizes the urgent need for aquifer mapping, regulatory enforcement, and participatory water management to ensure long-term sustainability.
Keywords: aquifer mapping, assessment, monitoring, pre-monsoon, sustainability

12. Harnessing Magnetized Water: A Growing Trend Toward Enhanced Productivity – A Review

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Abstract

The application of magnetism is already part of our everyday life and have been used in various fields effectively. Magnetized water is produced by passing regular water through a magnetic field created between two strong magnets. This process alters the physical and chemical properties of water by disrupting the liberational vibration of water molecules and dissolved substances. These changes can result in variations in pH, electrical conductivity, surface tension, viscosity, and hydration behaviour due to the weakening of hydrogen bonds and formation of smaller clusters and crystallization centres. The use of magnetized water has rapidly advanced in fields such as irrigation, civil engineering, hard water treatment, and medicine. In agriculture, it has shown promise in improving soil quality and plant productivity. Magnetized water used for irrigation has been found to reduce soil salinity, enhance moisture retention, increase field capacity, and improve the efficiency of water and fertilizer use, especially in saline or arid regions. For plant growth, it accelerates seed germination, enhances early vegetative growth, boosts nutrient uptake, and improves photosynthetic activity.

Research has demonstrated that crops irrigated with magnetized water show increased yields, plant height, root length, leaf area, and biomass. Additionally, plants irrigated with magnetized water exhibit greater tolerance to abiotic stresses such as drought and salinity. These improvements make magnetized water a sustainable and eco-friendly approach to enhancing agricultural productivity. This review highlights the potential of magnetized water to serve as an effective tool in modern agriculture and underscores the importance of further research to optimize its use based on crop type, water quality, and magnetic field conditions.

Key words: Magnetized water, salinity management, crop productivity, eco-friendly, irrigation.

13.Ion Exchange Membrane Bioreactor for Treating Groundwater Contaminated with Oxyanions

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Abstract

Oxyanions such as nitrate and perchlorate are major ground water contaminants in many locations around the globe. The major causes of nitrate contamination in ground and surface water are linked to agricultural activities, intensive livestock farming and domestic sewage. In the present study, an ion exchange membrane bioreactor (IEMB) was operated for removal of nitrate from contaminated water. The IEMB treated 1–2 m3/d of water contaminated with nitrate. IEMB was composed of an anion exchange membrane spiral module integrated with a fixed bed bioreactor (FBBR), a novel configuration for an IEMB system (Figure 1). Nitrate elimination was accomplished through Donnan dialysis using chloride as the driving ion followed by heterotrophic denitrification in an anoxic FBBR employing glycerol as electron donor and carbon source. The performance of IEMB revealed an excellent nitrate removal at the selected operating conditions, successfully eliminating a nitrate loading rate of 5.0 kg NO3- /m3/d and producing 30 ± 5 mg/L nitrate in the effluent at steady state. The anion exchange membrane also transferred a significant concentration of sulphate from the feed-side to the bio-side leading to its accumulation in FBBR. As a result, denitrification performance was affected due to the activation of sulphate reducing bacteria leading to the upset of FBBR. Batch experimental study aiming to screen the effect of nitrate to sulphate ratio on denitrification, demonstrated the possible occurrence of sulphate reduction at [nitrate]/[sulphate] < 0.2, exhibiting a highly negative oxidation reduction potential (ORP) value (- 450 mV). This signifies that a minimum [nitrate]/[sulphate] > 0.2 is required as to suppress sulphate reduction phenomenon during denitrification. IEMB calibration for denitrification using glycerol as a carbon source revealed that 100 % stoichiometric donor/acceptor (C/N) ratio was suitable for producing sufficient nitrate biodegradation and acceptable ORP value (~- 220 mV). Present work established promising application prospects of IEMB comprising nitrate selective membrane module for the treatment of high nitrate wastewater with a treatment capacity of 1.5 m3/d at optimized operating conditions. Other IEMB variations will be discussed as well. ICWRER 2025

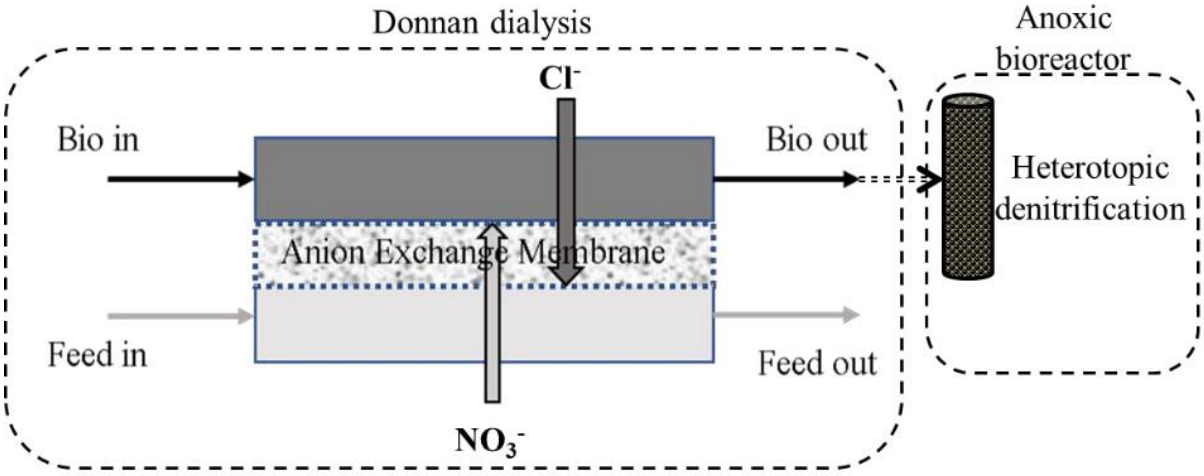

Figure 1. Schematic representation of the IEMB

Keywords: Donnan Dialysis, Ion Exchange Membranes, Oxyanions, Anoxic Bioreactor

14.Investigation of Per and Polyfluoroalkyl Substances in Wastewater Treatment Plants of Kerala - A Risk Assessment Study

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Abstract

Per and polyfluoroalkyl substances (PFAS) are extremely stable and persistent synthetic compounds. Presence of PFAS in the environment causes major problems to ecosystems and human health. Untreated wastewater from wastewater treatment plants (WWTPs) adds PFAS into freshwater systems, hence causing environmental pollution. Widespread environmental pollution, durability, and related health concerns such as liver damage, immune system disturbance, and developmental problems call for study of PFOA and PFOS. To safeguard water quality and public health, they have to be located and eliminated. The study found 1.64 ppb of PFOA in untreated STP inlets at KL4 (Alappuzha) and 7.29 ppb at KL5 (Thiruvananthapuram). Treated STP outputs showed PFOA levels ranging from 2.62 ppb at KL3 (Ernakulam) to 7.78 ppb at KL5 (Thiruvananthapuram). For untreated STP inlets, PFOS levels ranged from 0.49 ppb at KL1 (Kannur) to 2.41 ppb at KL2 (Calicut); for treated outputs, they ranged from 0.24 ppb to 5.26 ppb. The findings exceed the USEPA's recommendation of 4 ppt, hence posing a major environmental and public health concern for a developing country. Treatment effectiveness showed great variation between sites, with PFOA removal rates spanning from -83.54% to 42.29% and PFOS from -355.10% to 90.04%. Risk assessment showed notable exposure levels, especially for PFOS, with four sites' risk indices over permissible limits. With PFOA values of 764.81 mg/day/1000 people and PFOS values of 231.9 mg/day/1000 people, KL5 showed the greatest mass loading. The study draws attention to the insufficiency of traditional treatment methods in eliminating PFAS and underlines the critical need for the use of creative treatment technologies and the setting of regulatory criteria for PFAS in Indian wastewater treatment systems.

Keywords: Liquid Chromatography; Per and polyfluoroalkyl substances; Risk Assessment, Sewage treatment plants; Water Pollution

15.Indicator-Based Performance Evaluation of a Canal Distributary in North-West India

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Abstract

Ensuring equitable water distribution in irrigation canal systems is becoming increasingly critical amid fluctuating canal supplies and increasing agricultural water demands. In Punjab, water allocation to farmers through tertiary canal networks is regulated by a rotational irrigation scheme known as warabandi. Despite its implementation, variability in canal water supply continues to pose substantial challenges for equitable distribution. This study assesses the irrigation performance of canal water distribution utilizing comprehensive performance indicators, including adequacy, efficiency, dependability, reliability, and equity indices. The analysis is based on weekly volumetric data covering supply and demand from 81 canal outlets, enabling a detailed assessment of the gap between actual deliveries and crop water requirements. Using 22 years of data from Punjab's Longowal distributary, the study quantifies weekly and aggregated irrigation performance, focusing on identifying periods of critical water shortages. The findings reveal marked seasonal variability in performance metrics, particularly highlighting weeks with low reliability and equity. The proposed indicator framework supports formulating adaptive and sustainable irrigation strategies for semi-arid, canal-command regions.
Keywords: Agricultural water demands; Equitable distribution; Irrigation performance; Warabandi; Water shortages.

16.Chlorine Decay Simulation in Water Distribution Network Using WaterGEMS – A Lab Scale Study

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Abstract

A number of interrelated testing techniques, including bottle tests, intermediate pipe setups, and continuous flow experiments, were used to conduct a thorough investigation of chlorine decay in water distribution systems. Each of these techniques offered vital information about the kinetics of chlorine, iron, and manganese decay under various hydraulic and chemical conditions. Baseline bulk decay coefficients (k_b) reflecting chlorine loss in static water were established through bottle tests conducted in sealed amber glass bottles with minimal flow. The results showed that chlorine was mostly retained over 4 hours (95%) but then decayed slowly after that. Chlorine decay was accelerated by the addition of chemical species like manganese, iron, and ammonia, highlighting their impact on disinfection stability Because of pipe wall interactions, intermediate pipe tests, which replicated semi-dynamic conditions with regulated circulation and a variety of pipe materials, showed noticeably higher chlorine decay rates up to 23 times higher than static tests. High coefficients of determination from exponential decay models fitted to the iron, manganese, and chlorine data from these tests demonstrated the robustness of the model and highlighted

the importance of pipe material and chemistry. The fastest chlorine depletion, with a decay coefficient of up to 0.451 per day and a near-complete loss of chlorine within 24 hours, was demonstrated by continuous flow experiments that replicated fully dynamic distribution network flows. Iron and manganese exhibited slower but significant decay across all systems, reflecting their chemical reactivities and roles in water quality. The significance of hydraulic conditions on residual disinfectant persistence was highlighted by the significant variation in observed half-lives and decay times to regulatory chlorine minimums by system. The effectiveness of the disinfection procedures was validated by microbial investigations employing Escherichia coli assays, which showed a strong correlation between chlorine residues and microbial inactivation This thorough study adds to our knowledge of chlorine degradation under realistic circumstances and offers helpful advice for creating robust water distribution and disinfection systems.

Keywords: Chlorine Decay, WaterGEMS, Water Distribution, Water Quality

17. Evaluating the Adsorption Performance of the Bio-Composite alginate Hydrogel for Congo Red Dye removal

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Abstract

Rapid urbanization and industrial growth have led to a dramatic increase in water consumption and wastewater generation, making the provision of clean and safe water a global challenge. Traditional wastewater treatment methods, though widely used, are often costly and energy intensive. Adsorption technology, owing to its operational simplicity and high efficiency, has emerged as an attractive solution for removing dyes from contaminated water. In textile Industry after waste water treatment, the large amount of sludge is generated and these sludges are disposed into the soil and leads to Soil pollution. In the present work, the nanomaterials taken for the research are Carbon based Textile sludge Activated carbon (TSAC) that is prepared from Textile Sludge. Commercial Activated Carbon (CAC), inorganic adsorbents such as zeolite and plant based moringa seed extract (MSE). The three different combinations of sodium alginate (SA) bead formulations were synthesized with CAC, TSAC+ Zeolite and Moringa evaluated for the adsorption performance of Congo red dye of various concentration (10 ppm and 30 ppm). All the prepared Beads were impregnated with Polyethyleneimine (PEI) to enhance its strong positive charge which attracts the anionic dye molecule and the removal is more efficient. These adsorbents were selected for their ability to improve surface area, porosity, and functional group availability, non-toxic and Eco-friendly, thereby enhancing the dye uptake capacity of sodium alginate beads. The synthesized beads and treated water were characterized by microscope (outer and inner core beads analysis) and UV–Visible Spectroscopy to confirm structural integrity, surface features, and dye interaction. Batch adsorption studies were conducted under varying operational parameters such as pH, contact time, adsorbent dosage, and initial dye

concentration to determine the optimum conditions for maximum removal. The findings revealed that the modified activated carbon textile sludge incorporated beads exhibited enhanced dye adsorption compared to other adsorbents and this process is more effective than biological treatment. This study demonstrates that alginate-based composite beads offer a sustainable and eco-friendly approach for removing hazardous dyes from textile wastewater, supporting the development of low-cost and environmental sustainability goals (SD-6). The study shows that Sodium alginate impregnated with PEI beads such as sodium alginate with Activated carbon powder (Foundry-01) +PEI, sodium alginate with Activated carbon powder (Textile sludge prepared) + Zeolite granules + PEI and sodium alginate with Moringa seed powder +PEI beads removes high efficiency of Congo Red dye from 90 to 98 % of dye removal.

Keywords: Congo Red dye, Adsorption efficiency, Composite alginate beads, Low-cost adsorbents, Water purification.

18. Jackfruit Waste as a Powerful Potential Candidate for Removing Heavy Metals and Dyes from Contaminated Waste Water

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Abstract

Indiscriminate exploitation of surface, sub surface and of groundwater resources and their use, misuse and abuse both in industry and agriculture has led to environmental contamination beyond explainable dimensions. Sourcing material with high efficiency for decontaminating wastewater is one of the priority areas in the environment research particularly due to the experience faced acute shortage of portable water. Heavy metal contamination such as Copper (Cu), Lead (Pb), Mercury (Hg), Cadmium (Cd), Arsenic (As), Chromium (Cr), Nickel (Ni), Zinc (Zn), and industrial dyes contaminating water whereas large-scale use of chemical fertilizers, plant protection chemicals, and weedicides coupled with high-temperature stress are the major causes of contamination due to intensive agriculture. This review opens-out the emerging and immense potential of jackfruit waste-developed biochar and activated carbon from the peel, seed, and leaves as an efficient bio-adsorbent for the adsorption of heavy metals and dyes. The various aspects leading to removal form the crux of this paper. Besides, it serves as one of the finest examples of the promotion of circular economy as it designs the use of waste in pollution removal, keeping products and materials in use and regenerating natural systems.

Keywords: jackfruit waste; activated carbon; heavy metals; circular economy; bio-adsorbent

19.Monitoring Emerging Contaminants in the Influent and Effluent of Wastewater Treatment Plants in Kerala, India

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Abstract

Emerging contaminants in water bodies is a growing concern as they are detrimental on aquatic and terrestrial organisms. Wastewater treatment plants (WWTPs) are known to be significant sources of emerging contaminants to the environment. Emerging contaminants (EC) enter the water bodies through various sources including domestic, commercial and industrial discharges. In this study, different emerging contaminants were detected in the influent and effluent of 6 municipal wastewater treatment plants (WWTPs) in Kerala, India. Samples were collected from six treatment plants during pre-monsoon monsoon and post monsoon season of 2023-24. The water samples were pre concentrated using solid-phase extraction (SPE) prior to analysis. Gas chromatography-tandem mass spectrometry (GC-MS/MS) was used to identify a series of ECs in the sample. The methodology allowed the detection of target analytes at trace concentration. The identified ECs include pharmaceuticals, personal care products, steroids, surfactants, and phthalate. The results of this study will serve as a critical foundation for future research and policy making aimed at addressing the growing concern of emerging contaminants in the environment.
Keywords: Contaminants of Emerging Concerns, Gas chromatography–tandem mass spectrometry (GC-MS/MS), Wastewater Treatment Plants (WWTPs), Wastewater.

20.Musa Irrigation Innovations: Merging Partial Root-Zone Drying with Soil Amendment Strategies

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Abstract

Water scarcity in tropical and semi-arid banana (Musa spp.) growing regions challenges crop productivity and sustainability. Partial root-zone drying (PRD) has emerged as a water-saving irrigation strategy that alternately moistens one side of the root zone while allowing the opposite side to dry. This cyclic irrigation reduces water use by up to 50%, maintains yield, and enhances water use efficiency (WUE) through physiological mechanisms such as deeper rooting, sustained gas exchange under vapor pressure deficits, and root-to-shoot hormonal signalling promoting moderate stomatal closure. Complementing PRD, soil amendments like biochar, compost, organic bio stimulants (e.g.,

humic acids, protein hydrolysates, seaweed extracts), and microbial inoculants significantly improve soil health. They enhance nutrient retention, soil structure, microbial activity, and root development all critical under water-limited conditions. Studies in other crops demonstrate that combining PRD with amendments like biochar increases root surface area, K^+/Na^+ homeostasis, and WUE under salinity stress, while organic amendments in Musa cultivation boost chlorophyll content, root shoot biomass, and nutrient uptake. This review integrates evidence on PRD physiology and amendment-induced benefits in banana and analogous systems. We examine underlying mechanisms—hormonal signalling, osmotic adjustment, enhanced nutrient capture—and highlight how amendments may enhance PRD effectiveness by mitigating stress and optimizing root function. Key knowledge gaps are identified, including (1) interactions between amendment type and PRD scheduling; (2) long-term impacts on soil microbiome and structure; (3) optimal amendment dosages under varying edaphic and climatic conditions; and (4) economic feasibility for smallholder systems.

Keywords: Banana (Musa spp.) irrigation, Root-to-shoot signalling, Abiotic stress tolerance, Sustainable agriculture, deficit irrigation.

21.Optimization of Depth of Placement of Lateral for Sandy Loam Soil in Western Zone of Tamil Nadu, India

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Abstract

Soil moisture patterns from emitters are important for the design and management of drip irrigation systems. The soil moisture distribution pattern around a emitter depends on depth of lateral placement, emitter spacing, duration and frequency of water application, soil physical and hydraulic properties. These patterns can be obtained by direct measurements of wetting in the field, which is site specific, or by simulations using some models. Simulation of water movement in soil is very useful for optimum management of water use. Hence, the study was conducted to optimize the depth of placement of lateral in drip irrigation. Laterals were placed at 0, 15 and 30 cm below the ground level with constant lateral spacing of 1.50 m with the combination of emitter spacing of 30 and 60 cm with 2.2 and 4 LPH dripper discharge. Soil moisture distribution pattern was studied by using gravimetric method. The study revealed that wetting front in the horizontal direction started overlapping after 6 hours in lateral spaced at 15cm depth with 4 lph dripper @60 cm apart. So the layout 15 cm depth of lateral placement and60 cm @4 lph was found better than other layouts since the losses due to evaporation and percolation were minimized.

Keywords:- Drip irrigation, lateral depth, wetting front, soil moisture distribution

22.One Water, One World: Integration for a Sustainable Future

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Abstract

Integrated Water Resources Management (IWRM) is increasingly regarded as a crucial framework for achieving sustainable water governance in the 21st century. As water demand grows globally due to population increase, urbanization, industrial expansion, and agricultural intensification, the limitations of conventional, sector-based water management approaches have become evident. IWRM offers a holistic alternative by promoting the coordinated development and management of water, land, and related resources. It aims to maximize economic and social benefits while ensuring the long-term health of ecosystems.

This paper examines the theoretical foundations, guiding principles, and practical applications of IWRM in various socio-political and environmental contexts. At its core, IWRM is founded on the understanding that water is a finite and vulnerable resource, essential to life and development. Its principles stress that water should be managed at the level of natural systems, such as river basins, and with full consideration of cross-sectoral interactions. Moreover, it highlights the importance of inclusive stakeholder participation, gender equity, and the recognition of water as both a social necessity and an economic good. Despite its conceptual strength, IWRM implementation has faced significant challenges. In many regions, institutional fragmentation, inadequate legal frameworks, lack of reliable data, and insufficient stakeholder engagement have limited its effectiveness. Political resistance, unclear mandates, and limited technical capacity further hinder coordination between sectors and administrative boundaries. In addition, the impacts of climate change—including altered precipitation patterns, more frequent droughts, and water-related disasters—have added urgency and complexity to water resource management. Through a comparative analysis of case studies from both developed and developing nations, this paper identifies the conditions under which IWRM initiatives have succeeded or failed. For example, the establishment of river basin organizations in Southern Africa has demonstrated potential for cooperative water governance, while challenges persist in regions where water conflicts remain unresolved or transboundary cooperation is limited. These experiences underscore the importance of strong institutional support, adequate funding, local capacity building, and long-term political commitment.

The paper concludes that while IWRM is not a universal template, it remains a flexible and adaptable approach capable of addressing diverse water challenges when implemented thoughtfully. Its strength lies in encouraging dialogue, integrating science with policy, and building consensus across multiple sectors and stakeholders. In a world facing growing water scarcity and increasing demand, IWRM represents not only a technical necessity but a strategic imperative for sustainable development and climate resilience.

Keywords: Adaptive management; Climate adaptation; Institutional capacity; Stakeholder collaboration; Water security

23. Performance Evaluation of Carbon, Clay and Zeolite Nanocomposite Polyether Sulfone Membranes for the Removal of Evans Blue and Malachite Green using Dead-End Filtration

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Abstract

Access to clean drinking water becomes hard. Industrialization leads to water pollution and also contributes to other forms of pollution. Among many industries textile dyeing industry is the largest wastewater producer. The Hazardous Chemical Dyes are a major carcinogen. The most effective method for water treatment is Membrane technology. This research study focuses on preparing efficient nano-composite membranes that effectively remove the colour of the dyeing wastewater. The colour removal performance of the Polyether Sulfone (PES) polymer was comparatively analyzed with carbon, clay, and zeolite nanoparticles altogether. The selected nanoparticles for the nanocomposite polyether sulfone membranes were carbon based such as activated carbon AC, Carbon Nano Fiber (CNF), zeolite 4A nanoparticle, and clay, such as nano clay and kaolin. The adsorption capacity of carbon nanoparticles and the ion exchange capacity of the zeolite in the Polyether Sulfone (PES) membrane were compared. The physical properties of the membranes were evaluated by water uptake, porosity, and mean pore radius. The membrane characterizations are determined using Field Emission Scanning Microscopy (FESEM) and Energy Dispersive X-ray Spectroscopy (EDS), confirming the successful integration of nanomaterials and improvements in membrane morphology. The dead-end filtration system was used to evaluate the performance of the membranes in removing Evans blue dye (anionic) and Malachite green (cationic) dyes. It was observed that the Colour Removal Efficiency (CRE) of PES was 93 %, and PES/CNF was 99.85 %. These results confirm that CNF increases the water uptake, porosity, increases pore size, and increases colour removal efficiency than the PES control membrane.

Keywords: Dye, Dead-end Filtration, Polymer, PES, zeolite, CNF, clay

25. Phytoremediation Efficiency of *Azolla spp.* in Aquatic Environments: Removal of Heavy Metals and Nutrients from Polluted Water

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Abstract

Azolla, a genus of fast-growing, free-floating aquatic ferns, has gained increasing recognition as a sustainable and highly effective agent for the phytoremediation of municipal, industrial, and agricultural wastewater. With its symbiotic association with nitrogen-fixing cyanobacteria (*Anabaena azollae*), *Azolla* demonstrates exceptional capabilities for the uptake and assimilation of nutrients such as nitrogen and phosphorus, as well as a wide spectrum of inorganic and organic pollutants including heavy metals, dyes, and persistent organics. *Azolla*'s capacity highlights to remove over 90% of iron, chromium, and lead, and achieve reductions up to 78% for chemical oxygen demand (COD) and 66% for total nitrogen within short exposure periods. Mechanistically, *Azolla* purifies wastewater *via* rapid assimilation of dissolved nutrients and pollutants owing to its high surface-area-to-volume ratio and direct contact with the water column, outcompeting rooted macrophytes. The plant's floating mats also physically limit light availability, thus suppressing algal blooms and secondary eutrophication. *Azolla*'s rhizosphere microflora further enhances the degradation of organic contaminants, while its ability to proliferate on effluent surfaces ensures continued removal efficiency even under variable wastewater loads. *Azolla* species are effective phytoremediators capable of removing heavy metals such as lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), and zinc (Zn) from contaminated water and soil. Besides chemical and biological detoxification, *Azolla* biomass itself is renewable and finds value in downstream applications, including agriculture (biofertilizer), animal feed (when pollutant loads are negligible), and the production of bioenergy, thus contributing to resource recovery and circular economy models.

Comparative studies demonstrate *Azolla'*s superiority over many conventional and plant-based treatments such as *Lemna* and *Eichhornia* in terms of nutrient uptake rates, heavy metal tolerance, and biomass yield. Technological advances such as selective breeding and genetic engineering have recently enhanced its pollutant sequestration potential and adaptability to broader wastewater contexts, further supporting scalable implementation. Policy and practice guidelines increasingly advocate for integrating *Azolla*-based systems as a post-treatment step after conventional wastewater processes, optimizing final water quality while minimizing operational costs, carbon emissions, and sludge generation. Challenges persist, including the need for routine management and safe disposal or valorization of pollutant-laden biomass, variability in treatment efficiencies linked to fluctuating water chemistries, and potential risks of bioaccumulation if *Azolla* is used for feed. Nonetheless, research strongly supports *Azolla* as a nature-based solution aligned with global water sustainability and pollution mitigation objectives.

Keywords: Phtoremediator, Chemical Oxygen Demand, Symbiotic association, Sequestration potential, Chemical Detoxification, Biological Detoxification

24.Rehabilitation of Irrigation Tanks: Strategies and Challenges

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Abstract

In India's semi-arid regions, traditional water collection tank systems have long been essential to agriculture and means of subsistence. However, the decline of these tanks has been attributed to population pressure, poor maintenance, and the emphasis on modern irrigation systems. Tank rehabilitation has become a viable approach to revitalize these systems. It includes desilting, repairing sluices and embankments, and enhancing inlet/outlet channels. The implications of India's tank rehabilitation initiatives on water supplies, agriculture, the environment, and socio-economics are reviewed in this article, with a focus on the southern states. It talks about rehabilitation strategies, covering both conventional and cutting-edge approaches like GIS and remote sensing. It emphasizes the value of institutional approaches and community participation. Increased storage capacity, better water quality, more intense cropping, higher yields, groundwater recharge, and the resurgence of related livelihoods are all outcomes of tank rehabilitation. The paper highlights the necessity of prioritizing tanks according to their prospective advantages and implementing an integrated approach including all stakeholders for sustained repair, even as it documents the favourable achievements. In water-stressed areas, restoring these antiquated water harvesting systems can improve rural economies, food security, and climate resilience.

Keywords: Tank rehabilitation, water harvesting, semi-arid, GIS, remote sensing, community participation, water storage, agriculture, groundwater, livelihoods, food security, climate resilience.

25. Recovery of Water from Electroplating Industrial Wastewater containing Hexavalent Chromium using Electrocoagulation Treatment

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Abstract

Electroplating operations discharge wastewater that contains contaminants. Electroplating operations produce water that has hexavalent chromium [Cr(VI)] Fe Ni compounds and residual chlorine. Treating that wastewater with the step-by-step methods costs much and is hard to run. In this study we use an electrocoagulation (EC) treatment platform that uses

iron electrodes as the anodes. The electrocoagulation (EC) treatment platform removes the hexavalent chromium [Cr(VI)] the Fe, the Ni, the organics and the chlorine once. The electrocoagulation (EC) treatment platform provides removal in a step and the contaminant removal covers all the pollutants. The electrocoagulation (EC) treatment platform avoids the costs of treatment units. We ran the batch experiments. We optimized the conditions, for targeting Cr(VI) dissolved iron, nickel matter (COD) chlorides and residual chlorine at the same time. The optimized EC process remove 84 percent of Cr(VI) 68.36 percent of COD and 42 percent of chlorides. The optimized EC process also remove all iron and all residual chlorine. The optimized EC process lowered the treated water concentration of Cr(VI) to 0.133 ppm. The optimized EC process lowered the treated water concentration of COD to 159.2 ppm. The optimized EC process lowered the treated water concentration of chlorides to 262.33 mg, per liter. The optimized EC process pushed iron and nickel below detection limits. The optimized EC process eliminated chlorine, which meets the reuse criteria, for industrial makeup water applications. In this study the in-situ water recovery works inside the electroplating facilities. In-situ water recovery gives the emerging economies a path, for water management. The emerging economies must deal with regulations and freshwater scarcity.

Keywords: recovery of water, Chromium removal, electrocoagulation, iron electrodes, antigravity flow, industrial wastewater treatment

26. Removal of Heavy Metals from Electroplating Wastewater by using Biochar and Activated Carbon in Fixed Bed Column.

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Abstract

Textile sludge, the residue from wastewater treatment in textile factories, is a dual-edged sword an environmental liability as well as an under-utilized opportunity for sustainable valorization. This paper reports the preparation and detailed characterization of textile sludge biochar prepared by pyrolysis at 600 °C and activated carbon prepared at 1000°C its adsorption potential in fixed-bed column systems for wastewater remediation Thermal treatment of textile sludge in a muffle furnace produced biochar, which was then evaluated for physicochemical characteristics like pH, EC, TDS, bulk density, particle density, ash content, moisture content, specific gravity, and CEC. Magnesium (93.12 ppm), calcium (11.2 ppm), sodium (176 ppm), and potassium (21 ppm) were found by elemental analysis.When column adsorption experiments were performed with Cr-contaminated wastewater using 100 g of biochar at a controlled flow of 5 mL/min, through 300 mL of

effluent. Showed much TDS reduction from initial levels of greater than 5500 ppm to about 1300 ppm and electrical conductivity from 7.92 mS/cm to 1.84 mS/cm after 90 minutes of operation. The pH also remained relatively stable in the slightly alkaline range (7.1–8.4), showing the buffering capacity of biochar. Compared to commercial activated carbon, textile sludge biochar has bulk density of 0.89 g/cm3, particle density of 0.178 g/cm3 and moisture content of 26.5%, which exhibit different physical properties for column application. Biochar's higher ash content (20.5% than activated carbon's (71.5%) also means it retains mineral elements, which can be useful in a soil amendment. These results validate textile sludge biochar as an economical, green adsorbent with high promise for scaled flow wastewater treatment, tackling industrial waste and pollution remediation in unison.

Keywords: adsorption column, pyrolysis, wastewater management, biochar, activated carbon, textile sludge, electrical conductivity, chromium elimination, total dissolved solids, and eco-friendly adsorbent.

27. Scalable Biopolymer Production from *Synechocystis Pevaleikii*: Optimized Cultivation and PHB Recovery

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Abstract

The cyanobacterial strain *Synechocystis pevaleikii* presents a promising candidate for eco-friendly polyhydroxybutyrate (PHB) production due to its photosynthetic ability to utilize CO_2 and sunlight efficiently. This work explores the cultivation dynamics and PHB biosynthesis in *S. pevaleikii* using two different cultivation systems: a 10 L Recirculating Media Photobioreactor (RMPBR) and a 100 L open raceway pond. Both cultivation systems utilized a modified Nitrate-Phosphate-Carbonate (NPC) medium comprising sodium nitrate (1.5 g/L), dipotassium hydrogen phosphate (0.04 g/L), and sodium carbonate (0.02 g/L). To boost carbon availability and promote biomass accumulation, sodium acetate was supplemented at a concentration of 1.64 g/L as an external carbon source. Peak growth in the RMPBR was recorded on day 12 with an optical density (OD_{680}) of 0.736 ± 0.022, chlorophyll-a concentration of 7.67 µg/mL, and a dry biomass yield of 1250 mg/L. In contrast, the raceway pond reached maximum biomass on day 20, yielding an OD of 1.37 ± 0.0015, chlorophyll-a content of 12.45 ± 0.19 µg/mL, and a dry cell weight of 4950 ± 125 mg/L. Subsequent Soxhlet-based PHB extraction was optimized across varying durations (1–10 hours), with a 5-hour cycle identified as optimal—producing 13.4 % total PHAs and 2.8 % PHB by weight. FTIR spectroscopy confirmed key functional groups associated with PHB, while GC-MS analysis revealed the presence of medium to

long-chain fatty acid esters (C16–C20), predominantly methyl hexadecenoate. Differential Scanning Calorimetry (DSC) analysis indicated a semi-crystalline PHB structure, with a glass transition temperature (Tg) of 5°C and melting point (Tm) near 175°C. Collectively, these findings affirm the technical viability and scalability of *S. pevaleikii* as a renewable platform for sustainable bioplastic production.

Keywords: Microalgae; Algal photobioreactor; Soxhlet extraction; Optimization; Poly-β-hydroxybutyrate (PHB); Polyhydroxyalkanoates (PHA)

28. Smart Irrigation Scheduling for Precision Water Use in Okra

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Abstract

In India, the primary source of water for irrigation is groundwater. The overuse of this water resource in many regions of the nation necessitates the deployment of smart irrigation water management techniques. Almost in all parts of country irrigation is being done through drip irrigation system. The drip irrigation system should be operated based on soil moisture availability. Moisture presence in soil can be detected by soil moisture sensors or tensiometers. When irrigation is scheduled based on soil moisture measurement using tensiometers or soil moisture sensors, it would increase crop yield and improve water productivity. A research was conducted on okra crop to decide irrigation quantity and frequency according to the availability of soil moisture with different irrigation and fertigation treatments. The research findings indicated irrigation at the soil moisture tension of −20 kpa with 100% recommended dose of fertilizer application would bring maximum yield and water use efficiency in okra crop.

Key words: irrigation scheduling; okra yield; soil matric potential; tensiometer; water use efficiency

29.Soil Carbon: A Nature-Based Solution for Climate-Adaptive Water Management

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Abstract

Climate change has intensified the global water crisis, with rising temperatures and erratic rainfall threatening both water availability and agricultural productivity. Soils, as the largest terrestrial carbon reservoir, store approximately 2,500 Gt of carbon, which is more than three times the amount found in the atmosphere. Increasing soil organic carbon (SOC) not only mitigates atmospheric CO_2 but also significantly improves water retention, infiltration, and overall hydrological stability. Research shows that a 1% increase in SOC can enhance the soil's water-holding capacity by up to 20,000 liters per hectare. This improved water retention is especially crucial in arid and semi-arid regions, where rainfall is scarce and unpredictable. For instance, conservation agriculture practices in Sub-Saharan Africa have increased SOC levels by 0.3–0.5% annually, resulting in 15–30% improved water use efficiency and yield stability. This paper synthesizes data from multiple agro-ecological zones to evaluate the role of SOC in mitigating hydrological extremes such as floods and droughts. Techniques such as cover cropping, agroforestry, compost application, and biochar amendment have shown measurable benefits in both carbon sequestration and water regulation. For example, biochar-amended soils can retain up to 18% more water compared to control plots, while reducing nutrient leaching by up to 50%. Furthermore, integration of soil carbon metrics into hydrological models (e.g., SWAT, VIC) has enhanced forecasting accuracy of water availability under climate scenarios. Policy interventions, such as carbon credit systems and payments for ecosystem services (PES), are discussed as pathways to mainstream soil carbon strategies in water governance frameworks.

Keywords: Climate resilience**,** Soil organic carbon**,** Soil-water interaction, Sustainable water management**.**

30.Stochastic Optimization of Reservoir Operations

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Abstract

Adding to earlier versions, the recent extended forms of the objective functions of the FP optimization method of FP directly accounts for second moments of the reservoir storage and release variables in the formulation of the method. Additionally, the latest enhanced versions have accounted for the covariance terms among variables using an iterative simulation-optimization approach as it may be intractable to analytically derive expressions for the covariance terms appearing in the FP's model formulation. We quantitatively evaluate in this paper the significance of taking these two issues into account using the fast extended FP method and compare with the solution of the implicit stochastic programming

(ISP) method. The optimal solution of an implicit stochastic programming (ISP) model of a reservoir operation optimization problem not utilizing any release policies with perfect foresight on future inflows shows the best possible objective function value that can ever be achieved. Sensitivity analyses are carried out for various operational conditions.

Keywords: Implicit stochastic programming, Fletcher-Ponnambalam method, Second moments, Covariance functions.

31.Sustainable Water Management and Crop Enhancement through Hydrogel Integration in Agriculture

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Abstract

Water scarcity remains a major constraint on agricultural productivity, particularly in arid and semi-arid regions. Hydrogels, as superabsorbent polymers, offer an effective strategy to address this challenge by significantly improving soil moisture retention and regulating water availability in the root zone. This study explores the potential of hydrogel application in enhancing crop performance under limited irrigation regimes. Hydrogels absorb and retain water up to several hundred times their own weight and gradually release it to plants, thereby reducing the frequency of irrigation and improving water use efficiency (WUE). Their application through soil incorporation, seed coating, and root dipping has shown positive effects on seed germination, early seedling vigor, biomass accumulation, and final yield. Field and controlled-environment experiments have demonstrated significant yield advantages in crops like maize, rice, tomato, and groundnut, along with irrigation water savings of up to 30–50%. Furthermore, hydrogels help in minimizing nutrient leaching and improving fertilizer use efficiency. The integration of biodegradable and environmentally safe hydrogel formulations further enhances their suitability for sustainable farming practices. The findings underscore the promise of hydrogel technology as a practical and scalable solution for improving crop resilience and resource use efficiency under water-limited conditions.

Keywords: Drought mitigation, Hydrogel, Irrigation, Soil moisture retention, Sustainable agriculture, Water Use Efficiency

32.Understanding Nutrient Removal in Vermifiltration: Mechanisms and Global Trends

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Abstract

Vermifiltration is an emerging, eco-friendly, cost-effective wastewater treatment technology that relies on the symbiotic relationship between earthworms and indigenous microbes within the filter bed. While vermifiltration has been widely studied for organic pollutant removal, there is limited understanding of how system scale, hydraulic loading rate (HLR), and earthworm density collectively influence nutrient removal performance, particularly for nitrogen and phosphorus compounds. Addressing this gap is crucial for optimizing system design and ensuring consistent treatment efficiency under varying operational conditions. This study evaluated the nutrient removal performance of vermifiltration for three key factors: the scale of the treatment system, HLR, and earthworm density. Data from over fifty experimental observations were analyzed to examine the relationship between nutrient volumetric loading rate and volumetric elimination capacity for ammonium, total nitrogen, orthophosphate, and total phosphorus. A positive linear correlation was observed between the nutrient loading rate and elimination capacity across all treatment scales. However, increasing the HLR was found to have an inverse effect on removal efficiency. These findings underscore the importance of optimizing operational parameters to enhance the nutrient removal performance of vermifiltration systems and support their large-scale application in sustainable wastewater treatment.
Keywords: Earthworms; Pollution; Vermifiltration; Wastewater; Water treatment

33.Village Level Long Term Adaptation Planning – A Case Study in Community Led Groundwater Management Approaches in Marathwada Region of Maharashtra, India

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Abstract

Using groundwater management as a strategy or solution to address the agricultural and livelihood demands of the community in drought prone areas of the Deccan Plateau always faces significant challenges technological due to hard rock terrain and social challenges due to limited traditional knowledge, scientific methods, and institutional frameworks. These formations have low primary porosity and limited groundwater storage capacity, and unpredictable flow characteristics making water management difficult in semi-arid rural regions. Grass Roots Action for Social Participation (GRASP) has been working for the last five years in a cluster of villages in Block Fulambri of District Chhatrapati Sambhajinagar (Aurangabad) on community-based groundwater management as a

sustainable and participatory approach to address growing water scarcity and ensure equitable access in the light of changing climatic patterns and recurrent droughts. An attempt has been made to develop guidelines in participatory analysis of traditional knowledge, scientific methods, and institutional provisions towards collective decision-making by local communities to manage the limited groundwater resources. This paper draws upon the lessons drawn from this initiative.

For this purpose, the project emphasized on capacity building of local community on scientific practices and forming local water management committees who engaged with the development administration and Gram Panchayat for managing these initiatives, ensuring transparency and accountability. The integration of gender-sensitive practices further strengthened community resilience by involving women in water governance. This approach emphasized participatory aquifer mapping, water budgeting, runoff harvesting, and groundwater recharge to strengthen the supply side and participatory water use planning for demand-side regulation. Villages implemented water use plans based on hydrogeological assessments, aligning agricultural practices with water availability.

In conclusion, community-based groundwater management approach adopted by GRASP in the cluster opens up avenues for a holistic and adaptive solution for the water-stressed hard rock regions of the Deccan Plateau, and thereby, fosters long-term sustainability, resilience against climate variability, and equitable access to groundwater resources.

Keywords: climate variability, hydrogeology, Marathwada region, participatory planning, water budgeting.

34.Low-Tech Approaches for Removal of Nitrogen and Phosphorus from Wastewater

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Abstract

The escalating global concern of eutrophication in freshwater environments is increasing, making it extremely important to reduce the primary drivers of excessive levels of both nitrogen (N) and phosphorus (P) inputs from wastewater. The urgency of this need is related specifically to the magnitudes of the increasing occurrence of cyanobacterial blooms (cHABs), with the cHABs posing threats to human and animal health, drinking water, and recreational activities. The issues of cHABs is becoming increasingly important particularly exacerbated by climate change and increasing, intensified precipitation and altered hydrological patterns.

While large wastewater systems are being addressed, the detrimental impacts from small facilities (e.g. villages, resorts, and farm fields) are more challenging. These small facilities must be able to operate with minimal oversight, this research describes a novel procedure specifically directed to removal of N and P.This paper introduces Multi-Soil Layering (MSL) systems as a promising, low-cost, and passive decentralized technology for effective N and P removal. The fundamentals and functionality of MSLs, including the roles of soil mixture

blocks (SMBs) and permeable layers (PLs) in facilitating physical, chemical, and biological treatment processes, are detailed. Case studies, including a full-scale application at JNTUK, India, and laboratory performance evaluations, demonstrate the potential of MSLs for substantial nutrient removal in various settings and flow configurations.

Passive technologies are shown to offer a promising, low-cost, and potentially high-performing approach to mitigating nutrient loading in freshwater bodies, exemplified by the multi-soil layering (MSL) system featured in this chapter. Further assessment and refinement are necessary to ensure significant and reliable N and P removal, concisely summarizing recent scientific advancements and optimization strategies in MSL research and development. The following key findings indicate (i) SMB size minimally impacted removal, except for phosphorus; (ii) phosphorus removal was high (69-80%); (iii) nitrogen removal was substantial (75-79%), primarily occurring in the PL due to a healthy biofilm and zeolite's high cation exchange capacity; (iv) ammonia nitrification was complete (99% reduction); and (v) nitrate denitrification was complete (85-95% reduction), thus not limiting performance.

Laboratory studies have yielded significant insights, while a full-scale MSL system in China (An et al., 2016), treating restaurant wastewater and designed for small, remote communities (similar to the Kakinada, India, system constructed by University of Guelph and National Institute of Hydrology), demonstrates its potential as a full-scale land-based wastewater treatment solution. The conclusions emphasize the urgent need for continued research, refinement, and widespread adoption of passive technologies like MSLs as a crucial strategy to mitigate eutrophication, safeguard freshwater ecosystems, and address the growing challenges of water quality management in a changing climate.

Special Theme
Water, Food and Health

1. Alternate Wetting and Drying (AWD): A Sustainable Irrigation Strategy for Climate-Resilient Rice Cultivation

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Abstract

Rice (*Oryza Sativa* L.) is a staple food for more than half of the world's population, and its cultivation limits the water table level and emits methane - a greenhouse gas that leads to climate change, global warming and biodiversity loss which create a huge impact on environment. An alternative method is needed to find out the way to overcome the issues faced by traditional cultivation method (submergence). Alternate Wetting and Drying (AWD) is a promising method, in which the irrigation is applied periodically after the water dried in the field. It conserves 15 - 30 % of water, limits the anaerobic condition induced methane by 48 % and improves the health and growth of roots. By reducing the nitrogen leaching, AWD improves the nutrient efficiency and cost efficiency, also improves the yield and quality attributes of rice. Hereby, we conclude AWD is not only the profitable method, serves as an effective tool for promoting environmentally responsible and climate-resilient agriculture, especially in rice-based irrigation systems.

Keywords: Alternate Wetting and Drying (AWD), Rice, Irrigation management, Methane emission, *Oryza Sativa*

2. Comparative Evaluation of PVA Membranes and PVA- Activated Charcoal Beads for Wastewater Treatment

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Abstract

This study compares two PVA-based materials used for wastewater treatment: PVA membranes prepared without activated charcoal and PVA hydrogel beads containing activated charcoal. Both anionic and cationic forms of the materials were tested under the same experimental conditions using 50 mL of wastewater. The aim was to understand how the presence or absence of activated charcoal affects adsorption behaviour, ion-exchange ability, and overall performance during treatment. A key part of the comparison was the measurement of Ion Exchange Capacity (IEC). The PVA-CEM membrane recorded an IEC of 1.33 meq/g, while the hydrogel bead form showed 0.632 meq/g with a water uptake of 55.5%. For the anionic form, the PVA-AEM membrane had an IEC of 0.70 meq/g, compared to 0.578 meq/g for the corresponding beads, which showed a 25% water uptake. These differences point out that membranes hold a higher IEC due to their compact polymer

structure, whereas the beads absorb more water and therefore support a higher degree of swelling, which helps their adsorption process. From the overall results, the hydrogel beads performed better in adsorption because of the activated charcoal content, while the membranes provided more stable ion-exchange behaviour and better mechanical strength. The comparison highlights how each material functions differently and helps in choosing the suitable form depending on the type of contaminants present in the wastewater.

Keywords: PVA membrane; Activated Carbon; Ion Exchange Capacity; Wastewater Treatment; Adsorption Performance.

3. Evaluating Benefits of Upgrading Fenestration Systems in Single-Family Dwellings and Designing Rebate Structures

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Abstract

This paper introduces a new methodology comprising four interconnected stages to assess the
economic, environmental, and health benefits of upgrading low-energy residential windows to higher-performing alternatives in single-family homes. A modeling-based technique is developed to calculate and assign monetary values to the reductions in heating and cooling energy, greenhouse gas emissions, and premature deaths associated with the decrease in outdoor fine particulate matter. Linear regression models are used to evaluate energy prices, carbon pricing, and the value of a statistical life, quantifying these benefits in monetary terms. Aspects such as the type of upgrade, the ratio of window-to-wall in the dwelling, the decline in energy performance, geographic location, and the orientation of window placement are examined for their effects on the benefits. A case study is conducted in two areas within the province of Ontario, Canada. Findings indicate that the savings on energy bills are adequate to warrant investment in energy-efficient windows for all dwelling types in Southern Ontario. However, government rebates are essential for certain dwelling types, opting for the most energy-efficient models. Conversely, in Northern Ontario, rebates are not required for upgraded models, as significant energy bill savings are achieved. The study recommends a per-window rebate policy based on the benefits realized, taking into account various upgrade models, specific single detached dwellings, and eligibility based on geographical location.

Keywords: Ambient air pollutants; Premature mortality; GHG emissions; Energy policy; Multicriteria evaluation.

4. Fluoride Dynamics in Sedimentary and Hard Rock Aquifers of Kerala

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Abstract

This paper investigates the geogenic origin and distribution of fluoride in groundwater, in two districts of Kerala viz., Palakkad and Alappuzha, initially reported by Central Ground Water Board (CGWB, 2003). Despite contrasting geological settings, both districts exhibit high fluoride concentrations in groundwater. Palakkad, Located in the Precambrian metamorphic shield of peninsular India and part of the Palakkad-Cauvery shear zone, having the fluoride bearing minerals like fluoropargasite, fluororichterite, fluorphlogopite and fluorapatite from the rock hornblende-biotite gneiss. The weathering and leaching process of these minerals increased the concentration of Na+ and HCO3- that facilitate fluoride mobilization in groundwater. In the rain shadow region of eastern Palakkad, limited recharge enhances the fluoride concentration. In contrast, Alappuzha's groundwater is derived from a multi-layered aquifer system composed of Recent to Tertiary unconsolidated to semi-consolidated sediments, with a confining clay layer limiting direct natural recharge. The Tertiary formations of Kerala consist of four distinct units are, the Vaikom and Warkalai beds (potential freshwater aquifers), the Quilon bed (brackish water zone), and the Alleppey bed (thick carbonaceous clay). A confining clay layer separates these formations from the overlying recent alluvium, restricting direct recharge from rainfall. Long residence time, sediment-groundwater interaction, and facies changes are the main factors enhancing the fluoride concentration in groundwater. A comparative study between the aquifer systems in the two districts reveals that important hydrogeochemical changes and processes that influence the fluoride levels in groundwater.

Keywords: Archean and Tertiary formations of Kerala; Facies changes; Residence time; Sediment-Groundwater interaction; Weathering and geogenic contamination

5. Gluten-Free Frenzy: How Media Narratives and Market Dynamics Shape Consumer

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Abstract

Gluten-free food is generally more expensive, less accessible, and often less healthy for a normal person, due to the extensive processing steps and the lack of essential nutrients like vitamin B12, Iron, Zinc, Magnesium, and fiber. According to Statista Research Department (2022), over 32% of U.S. consumers have purchased gluten-free products, and by 2025, more than 10% of Americans are expected to adhere to a strict gluten-free diet daily. While fewer than 1% of Americans are diagnosed with celiac disease, and only 3–6% are estimated to experience non-celiac gluten sensitivity. The considerable gap between medical necessity and market participation suggests that demand is not being driven primarily by health-related factors, but rather by media-driven narratives framing gluten-free diets as broadly beneficial or essential for general wellness.Dietary fads, such as the widespread adoption of gluten-free diets among individuals without medical necessity, often exemplify unsustainable consumption patterns. Driven largely by compelling but frequently unsubstantiated narratives, these trends encourage consumers to purchase products that are typically more expensive, less nutritious, and environmentally taxing due to intensive processing and production methods. The resulting consumption behaviors not only compromise individual health but also strain financial resources and exacerbate ecological burdens.

6. Hydrogeochemical Evaluation, Groundwater Contamination, and Health Risks in the Mor River Basin in north Maharashtra, India

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Abstract

The purpose of this study is to establish the groundwater quality for residential appropriateness, analyze the seasonal hydrogeochemical fluctuations in the Mor River basin, and evaluate the health hazards connected with these variations. For the sustainable development of water resources, especially in water-scarce areas like Northern Maharashtra, groundwater quality testing is essential. The study fills a research vacuum by looking at how agricultural activities, seasonal fluctuations, and health hazards all affect groundwater quality in this area. During 2022's pre-monsoon (PRM) and post-monsoon (POM) seasons, 68 groundwater samples were taken. The results were compared with the World Health Organization's (WHO) 2017 drinking water regulations after major ions were examined in accordance with American Public Health Association (APHA) guidelines. Water quality is critical to human health, environmental sustainability, and economic stability. Maintaining excellent water quality guarantees access to clean drinking water,

preserves ecosystems, and benefits a variety of sectors. Poor water quality can cause widespread sickness, environmental harm, and economic losses. Electrical conductivity (EC), pH, total dissolved solids (TDS), total hardness (TH), magnesium (Mg), calcium (Ca), bicarbonate (HCO3), chloride (Cl), nitrate (NO3), and fluoride (F) were all found to be over the desired (DL) and permitted limits (PL) in both seasons. PRM had elevated TDS (average 1350 mg/L) and TH (average 320 mg/L), indicating mineral leaching and irrigation effect. Notably, 79% of the samples in PRM and 38% in POM exceeded WHO-recommended nitrate levels, indicating the influence of agricultural activities. PRM's Groundwater Quality Index (GWQI) varied from 117.38 to 188.87 (average 150.46), whereas POM's ranged from 97.08 to 181.29 (average 133.54), suggesting low water quality. This study has applications in sustainable farming, groundwater management policies, and raising public awareness of the health risks of drinking tainted water in water-scarce regions.

Keywords: Groundwater Quality, Mor River, Maharashtra, India

7. Performance Evaluation of Different Ratio of Soil Less Media Mixture for Cherry Tomato Cultivation

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Abstract

In modern agriculture, soilless media have emerged as an essential component for successful plant growth. Soilless media are the growing substrates that provide support to plants without soil. A field study was conducted with the Dutch bucket hydroponic system for cultivation of cherry tomato (*Solanum lycopersicum var. cerasiforme*) under protected conditions at the Precision Farming Development Centre, Department of Soil and Water Conservation Engineering, Agricultural Engineering College and Research Institute, TNAU, Coimbatore. This system is particularly well-suited for vegetable and fruit crops that require ample root space and individual nutrient delivery control. The polyhouse was equipped with a fogger system, exhaust fans, and environmental sensors for continuous monitoring of temperature, relative humidity, and nutrient solution pH and EC. To evaluate the effect of different soilless media combinations on crop performance, seven distinct media treatments were tested, each comprising various ratios of cocopeat, vermiculite, and perlite. Each treatment was replicated thrice to ensure data reliability and allow for statistical analysis. The combinations were designed to assess the influence of water retention, aeration, and nutrient availability properties associated with each medium and the plant growth parameters.

Keywords: micro climatic parameter; hydroponics; nutrient solution; protected cultivation; soil less media.

8. Sustainable Drought Management in Climate-Vulnerable Rainfed Regions

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Abstract

Drought is a recurrent climatic phenomenon that significantly hampers agricultural productivity, especially in rainfed farming systems, which rely entirely on natural precipitation. Considering the unpredictable nature of the climate, managing drought risk has become a critical component in ensuring food security and sustainable rural livelihoods. This review provides a comprehensive analysis of mitigation and adaptation approaches used in drought-prone, rainfed agricultural regions. The investigation assesses traditional methods, technological innovations, and policy interventions aimed at reducing vulnerability and enhancing resilience. Mitigation strategies reviewed include water harvesting techniques, conservation agriculture, soil moisture management, and the adoption of drought-resilient crop varieties. The implementation of low-cost irrigation systems and integrated watershed management shows promise in enhancing soil water retention and increasing crop productivity. Adaptation strategies focus on adjusting farming practices, such as crop diversification, shifting planting dates, and employing agroforestry systems that offer both ecological and economic benefits. The integration of indigenous knowledge with modern tools such as remote sensing, GIS-based drought forecasting, and crop simulation models is also examined to assess its role in early warning and proactive risk management. Institutional mechanisms, including crop insurance schemes, farmer cooperatives, and government-supported contingency plans, are crucial for the large-scale adoption and success of drought mitigation strategies. Policy frameworks that encourage climate-smart agriculture, facilitate the effective utilization of resources, and support capacity-building initiatives are identified as key enablers for adaptation. The traditional knowledge with scientific advancements can play a pivotal role in building climate resilience in vulnerable farming communities. In conclusion, effective drought risk management in rainfed agriculture requires a holistic and integrated framework that combines technological, agronomic, ecological, and institutional interventions.

Keywords: Agricultural productivity, Climate resilience, Conservation agriculture, Drought-resilient crops, Drought risk management, Soil moisture management

9. Water, Agriculture, and Decolonized Food Security in Ontario, Canada

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Abstract

This paper rethinks food sustainability by centering water as the foundation of food security for a regenerative food production transformation. In Ontario's (and in many other countries') farm landscapes—designed for financial benefits rather than for ecologically resilient—water management exacerbates food injustice, particularly under the expansion of corporate-controlled greenhouses with more planned for the near future. Industrial agriculture and gentrified markets prioritize profit over sustenance, alienating racialized and family farm communities from traditional knowledge and water-efficient food systems. We propose a decolonized framework that integrates sustainable water practices with grassroots governance, providing multicultural knowledge rich neighbourhoods (communities) for developing economic futures of equitable resource stabilization, longevity, and social and spiritual resilience, in the current destabilizing climate, economic, and AI based technological transitions.

Community-managed rainwater harvesting and gravity-fed systems—offer pathways to food sovereignty while resisting ultra capitalist co-optation. When paired with modern agroecology (drip irrigation, greywater reuse, drought-resistant crops, non monoculture), these approaches can reduce dependency on exploitative supply chains. However, true sustainability requires dismantling colonial water rights and redistributing control to local councils. System dynamics modeling demonstrates how water-efficient food hubs—supported by community composting and rooftop gardens—can cut waste and stabilize local economies. Yet without confronting systemic inequities, such solutions risk reinforcing gentrification. Case studies highlight grassroots successes: migrant-led farms reviving traditional water practices and Indigenous land trusts restoring watersheds. The path forward demands decentralized, community-led water governance that revives food cultures, reduces reliance on harmful imports, and anchors sustainability in justice.

10.Waterborne Zoonotic Diseases in Kerala and Tamil Nadu

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Abstract

Waterborne zoonotic diseases have become a major public health concern in Kerala and Tamil Nadu in South India, especially during the monsoon season. Zoonotic diseases are diseases that are naturally transmitted between animals and humans. Over the past 15 years, several outbreaks have been reported due to rapid urbanisation, inadequate sanitation, and close human-animal proximity. Major pathogens include *Leptospira, Campylobacter, Salmonella, Escherichia coli, Cryptosporidium* and *Giardia*. These organisms, present in animal faeces and urine, contaminate drinking water sources, particularly during floods.

Leptospirosis is associated with monsoon floods and waterlogging. The 2018 floods in Kerala resulted in over 2,000 cases and approximately 100 deaths. By mid-2025, the state had recorded 1,494 leptospirosis cases and 88 deaths. In Tamil Nadu, high leptospirosis incidence is observed in coastal and paddy-farming districts such as Chennai, Tiruvallur, and Kanyakumari. Waterborne diarrheal diseases linked to *E. coli* are also prevalent in areas with poor water infrastructure. These diseases frequently affect low-income populations in rural areas and urban slums who rely on unsafe water sources. Contributing factors include poor animal waste management on farms, inadequate sewage treatment, and open defecation. To mitigate these risks, regular water quality monitoring (including coliform testing), chlorination of public water supplies, and repair of damaged pipelines are essential. Farm-level interventions such as safe manure disposal, rodent control, and public awareness campaigns are necessary. A coordinated approach involving Health, Animal Husbandry, and Water Resource departments is needed in both states to prevent future outbreaks.

Keywords: Clean water; Leptospirosis; Livestock; Public health; Sanitation

11. Water Pollution by Sugar Factory Molasses is Obstruction for Clean Rural Water Sources

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Abstract

Indian rural areas are a clean source of air and water. Nowadays, these clean sources are contaminated by numerous parameters. In a case study of Solapur District, Maharashtra state, India, many sugar factories produce sugar cane. The factory releases a lot of wastewater during the manufacturing process of cane sugar. Numerous hazardous chemicals are present in this wastewater. This wastewater is dropped in the fields. This water is leaking through the pores in rocks. The water level in this area becomes very deep in the summer every year. The soil joints are filled with free air during that time. The water level in the soil rises after monsoon rains, and the air in the joints escapes. In this field, the water mixed with sugar mill waste is released by tankers, and the water is accumulated in the pits in this area and this accumulated water is drained into the ground. In the traditional method of sugar production, the amount of pollution is very low due to the waste produced. But the pollution caused by today's plants is much more harmful to the water and soil. The study observed that the surface water, groundwater, and soil were contaminated by the discharge of untreated effluents from sugar mills, which severely degraded the environment of the area. The release of water mixed with sugar mills in this area has to be stopped,

otherwise, well water sources bore well sources, and soil in the said area will be chemically contaminated.

Key words: Environmental Sustainability; Groundwater Contamination; Pollution of Clean Water sources; Sugar Factories molasses; Sugar factory Wastewater;

12.Water Quality, Pollution, and Mental Health: Gut–Brain Axis as the Missing Link

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Abstract

Although water is essential to life, its connection to mental health is rarely discussed in public. The majority of discussions concerning water quality focused preventing acute illnesses, which are frequently caused by microbes or overt chemical contamination. It is simpler to ignore the fact that water can have slower effects on the brain that start in the gut.

According to recent research, even minute concentrations of contaminants, such as trace levels of lead or mercury, fertiliser nitrates, pesticide residues, microplastics, or leftover medications, can alter the gut microbial balance. The gut lining may be weakened, low-level inflammation may be fuelled, and the signals that flow along the gut–brain axis may be disrupted by these subtle alterations. The brain's response to stress, mood, and memory is influenced by the same gut- brain network. However, gut microorganisms can flourish in water that has a stable pH, a balanced mineral combination, and no pro-inflammatory compounds. When they do, they frequently create metabolites like short-chain fatty acids, which have been connected to improved psychological resilience and emotional regulation. This paper makes the point that water quality should be viewed as more than just a physical health concern by combining research from the fields of environmental science, microbiology, and neuroscience. It suggests two study avenues: first, controlled in-vitro experiments to examine the effects of various water chemistries on gut microorganisms and their metabolites; second, extensive mapping of water quality and mental health trends across various geographical regions. The way that environmental and public health policies are developed may change if water is viewed as something that may actively affect the mind rather than only prevent illness.

Keywords: Water Quality, Gut Microbiome, Mental Health, Environmental Pollutants, Gut–Brain Axis, Neuroinflammation, Water Chemistry

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