



IGWC 2019

8th International Groundwater Conference
on

**Sustainable Management of
Soil-Water Resources**

October 21-24, 2019 at IIT Roorkee



Organised by:

Department of Hydrology
Indian Institute of Technology Roorkee
Roorkee - 247667 (Uttarakhand) India

In association with



Association of Global
Groundwater Scientists



International Society for
Porous Media (InterPore)

*Book of
Abstracts*



**8th International Groundwater Conference
(IGWC-2019)**



**Sustainable Management of Soil-
Water Resources**

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Gujarat Water Resources
Development Corp

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Message from Chairman



It is my pleasure to welcome you all to the prestigious 8th International Groundwater Conference-2019 (IGWC-2019) being organised by Department of Hydrology (DoH), during October 21-24, 2019 at IIT Roorkee with focus on 'Sustainable Management of Soil and Water Resources'. DoH is organising this conference in alliance with Association of Global Groundwater Scientists (AGGS) which is committed to work on the promotion of research for minimizing groundwater pollution and to advocate the effective use of groundwater for better health and sustainable livelihood through undertaking appropriate measures.

The Department of Hydrology is committed to impart quality education, undertaking research and development in all domains of hydrology since 1972. The courses offered by the Department of Hydrology are presently being sponsored by the Government of India and international organizations like WMO. Recognizing the contributions of the department in the capacity building of national and international professionals in the area of hydrology, WMO has recognized DoH as a Regional Training Centre (RTC) since 2016. Besides running regular academic programs for training engineers/ scientists from Asia, Africa and other developing countries, the department also undertakes research and consultancy projects on different hydrological aspects.

IGWC-2019, with its focus on the latest research developments taking place around the globe to preserve our soil-water resources, is building up to be a mega event with hydrologists, academicians, researchers, professionals etc. joining the conference from India and the world over. I am sure that the technical interactions among professionals and researchers would benefit all. I wish all the participants a pleasant time at IIT Roorkee and look forward to fruitful interaction with you all in the future as well.

Manoj Kumar Jain
Chair, IGWC-2019

Message from Convener



It is with the greater pleasure that I welcome you all to the Department of Hydrology, Indian Institute of Technology (IIT) Roorkee to take part in the 8th International Ground Water Conference (IGWC) 2019 with focus on ‘Sustainable Management of Soil and Water Resources’. The international conferences in IGWC series are the meeting platform for hydrogeologists working in various areas of subsurface water quantity and quality. Groundwater has emerged as a major resource in safeguarding potable, industrial and agriculture water demands in India and the world over. India is at present the largest and fastest consumer of groundwater in the world.

Conservation and effective management of groundwater resources under changing climatic conditions and its accelerated extraction will play a vital role to meet our water demands of the growing population in future. Thus the main focus of this IGWC-2019 is to provide a common platform for researchers, academicians, water managers, industrialists and technocrats to discuss and present their vision for Sustainable management of soil-water resources to face the growing challenges of the needs of the rising population and anticipated impacts of land use and climate change.

I would like to take this opportunity to express my sincere thanks to the IIT Roorkee administration and the conference committees for extending their valuable time and support. I am also thankful to all the authors, sponsors, reviewers, student volunteers and other persons who directly or indirectly contributed to the conference. Without their cooperation and full support, this conference would not have been possible. Special thanks to all my students of Groundwater Hydrology Laboratory for their day- night effort for the success of IGWC-2019. Finally, I wish all the participants a pleasant time at IIT Roorkee and look forward having an equally successful IGWC in 2021.

Brijesh Kumar Yadav
Convever, IGWC-2019

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PHYTOEXTRACTION MODELING OF HEAVY METAL (LEAD) CONTAMINATED SITES

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Abstract

Heavy metal contamination of soil-water system is a ubiquitous problem and remediation of such polluted resources is required to eliminate the risk to human and to the environment. The current practice of remediation of these polluted sites relies heavily on dig-and-dump or encapsulation methods, neither of which addresses the issue of decontamination. Cleaning these sites via immobilization or extraction by physiochemical techniques can be prohibitively expensive and is often appropriate only for small areas where rapid and complete decontamination is required. Some methods, such as soil washing, have an adverse effect on the biological activity, soil structure and fertility, moreover, some may even require significant engineering costs. Due to the limitations of these conventional methods, there is a great scientific and commercial interest in the use of alternate methods like phytoremediation for removing the heavy metals from polluted soils.

Phytoextraction is a type of phytoremediation that involves removing heavy metals from polluted sites using certain plant species called hyper-accumulators. These plants can accumulate large concentrations of targeted metal in their root-shoot system. This in-situ approach of phytoextraction is more attractive as it offers site restoration, partial decontamination, besides maintaining the biological activity and physical structure of affected land sites. Furthermore, it is visually unobtrusive and there is the possibility of bio-recovery of metals from the metal enriched plant biomass. Due to the enormous potential for its cost and environment savings, there is a significant interest in this technology. The effective implementation of phytoextraction at a target site requires a conceptual insight of the soil-plant-atmosphere continuum process that controls the removal of metal pollutants from the root zone. A mathematical model is developed here to investigate the removal of lead by maize at different stages of its growth. The model comprised of two parts; 1) soil moisture flow and plant water uptake prediction, and 2) prediction of movement of metal in root zone and its subsequent translocation from roots to shoot biomass. In the first part, the actual water uptake by plant is predicted and the hydraulic regime of the root zone for different

moisture conditions is computed using Richard's equation. Through the second part of the model, the extraction kinetics of lead is simulated using the data of water uptake and plant root biomass accumulation. The set of partial differential equations developed are solved numerically by the finite difference technique for varying boundary conditions. The integrated moisture and metal contaminant transport is simulated effectively using the present model. The accumulation of effective root dry biomass over the entire growing period is simulated from the computed shoot biomass using the shoot-root ratio. The lead accumulation rate in the plant biomass is very high in the initial growth stage of the maize due to the increase in the root biomass coupled with a high rate of metal extraction. The rate of lead uptake decreases gradually till a steady state is attained in about 100 days of crop period. Results show that a decrease of 14.2% of lead contaminant in the soil can be achieved till the end of the maize growth period. This model does not incorporate the effects of inter metal competition and the impact of soil pH and organic content in phytoextraction modeling.

Keywords: *Phytoextraction, Maize, Heavy metal, Mathematical model, Lead*

**GROUNDWATER GOVERNANCE FOR ENHANCING WATER SECURITY UNDER
GLOBAL CHANGES**

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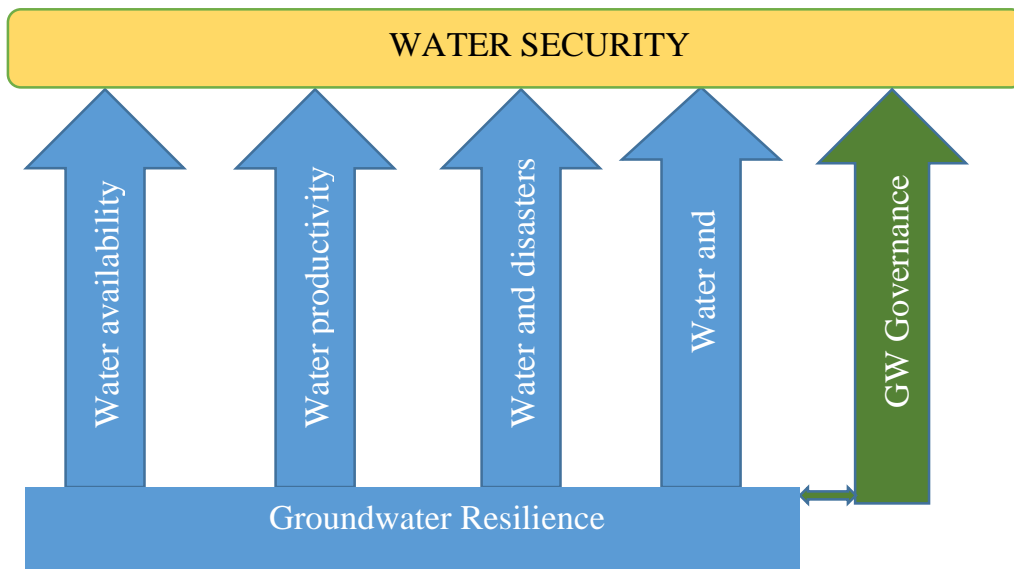
Abstract

Water crisis repeatedly appear as one of the top five risks with high impacts that the world is facing. Global changes in the form of rising population, changing land use, urbanization, climate change etc. further exacerbates this looming crisis, leaving a quarter of the world's population to live with *extremely high-water stress*. Policy makers often seek a response in development, conservation and management of the available surface water resources. Almost missing from the core of the discourse on such options is a hidden resource; the groundwater. Even in regions which are reported as water stressed, there are large reserves of freshwater available underground, which can act as buffer to the shocks induced by global changes. It, therefore, becomes important to see the ways in which groundwater can complement surface water in contributing to water security.

Water security is a prerequisite in achieving SDG 6 of ensuring availability and sustainable management of water supply and sanitation. A multi-dimensional index is established as a measure of water security, with dimensions of water availability, water productivity, water-related disasters, watershed health and water governance. Of significance is the explicit consideration of groundwater as an integral component in this index. Due to its large storage and annual recharge, groundwater is resilient against both long-term climate change and short-term climate shocks and hence contributes in improving the first four dimensions of water security.

Here, I conceptualize that the broader objective of water security can be attained by following a two-pronged approach – good governance and improved resilience. Good governance can, in fact, simultaneously foster resilience and water security. Governance of groundwater is a seemingly difficult task, by virtue of its characteristic properties of invisibility, huge storage, interconnection with surface water and transboundary nature. However, opportunities exist in the form of better policies and planning, legal and institutional framework, investing on information, knowledge and awareness creation and factoring in multiple actors.

As some pointers to a way forward, I would stress on the need to include groundwater as a part of water security assessments. Equally important is to expand our knowledge on groundwater resource base, recharge, surface-ground water interactions etc. through modeling tools. A thorough groundwater governance diagnostic analysis, aimed at identifying existing governance gaps, opportunities for improvement and actions to be taken, can lead to positive outcomes in groundwater governance and water security.



Linkage of Groundwater governance and resilience to water security

**SYNERGIC COMBINATION OF GEC NORMS AND GROUNDWATER FLOW
MODELING**

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GEC norms are routinely invoked in India for estimation of ground water resource. These norms comprise of two steps viz. setting up of lumped water balance equations aimed at estimation of the annual rainfall recharge, and subsequent estimation of the annual utilizable recharge or the resource. Whereas the first step involving estimation of recharge is quite rational (being based upon the well-known continuity equation), the second step aimed at estimating the utilizable recharge is rather arbitrary, and is thus a weak link in the norms.

The modeling approach for the resource estimation again comprises two steps. The first step involving unsaturated flow modeling is aimed at estimation of recharge. Subsequently in the second step utilizable recharge (or the resource) is estimated by invoking the saturated flow modeling (or what is usually known as ground water modeling). Whereas the saturated flow modeling is quite credible, there are large uncertainties associated with the unsaturated flow modeling. Thus recharge estimation is a weak link in the modeling approach.

It can be seen that the two approaches (i.e., GEC norms and modeling) are complimentary to each other. And as such an optimal combination of the two approaches is called for. However, the present trend in India is to invoke the two approaches in isolation. The paper presents a synergic combination of the two approaches utilizing the positive attributes of each. It is expected that this combination (which may be termed as “*Enhanced GEC Norms*”) may over the years replace the GEC norms leading to more credible estimates of the ground water resource.

**CHALLENGES AND OPPORTUNITIES FOR BIOMONITORING GROUNDWATER
DOMINATED ECOSYSTEMS**

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Abstract

The exchange of water between surface and groundwater environments is critical to the transport and fate of pollutants in the aquatic environment. Using examples from caves, springs and riverine environments this paper will examine how biomonitoring can be used to characterize and quantify ecosystem quality and health. Caves and spring represents windows into the groundwater domain and may support highly specialized biological communities. However, these ecosystems are vulnerable to anthropogenic activities occurring in the surface catchment (e.g., agriculture and industrial activities). Result of biomonitoring of the Peak- Speedwell system (Derbyshire, UK) illustrates the highly variable effects of organic pollution on both the cave and spring communities. The effects recorded were dependent on the timing, loading and flushing capacity of the system. In contrast, springs represent areas of upwelling of water that typically results in strong gradients of physical and chemical characteristics which are reflected in rapid successional changes in floral and faunal communities. These gradients can be used to characterize the zone of groundwater influence and downstream distance required for natural bioremediation processes to occur if pollution occur. In contrast, the exchange of surface and groundwater within rivers can be spatially and temporally variable and identifying where these exchanges take place in the hyporheic zone may be critical to our understanding of the biogeochemical processes. Using examples from field and laboratory mesocosm investigations the effects of variability in hydrological exchange (upwelling and downwelling) on benthic invertebrates is explored. The results of monitoring the vertical distribution of these organisms in response to sedimentation and hydrological variability illustrates how a knowledge of basic processes can be used to inform biomonitoring practices in riverine ecosystems.

Keywords: *Groundwater, hydrological exchange, biomonitoring, pollution, macroinvertebrates*

**GROUNDWATER PRECIOUSNESS AND MANAGEMENT DIFFICULTIES OF
COASTAL AQUIFERS**

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Abstract

All natural waters contain dissolved minerals from interactions with atmospheric and soil gases, mixing with other solutions, and/or interactions with the biosphere and lithosphere. In many cases, these processes result in natural waters containing solute or salinity above concentrations recommended for a specified use, which creates significant social and economic problems. Groundwater salinisation can be caused by natural phenomena and anthropogenic activities. For the former case, we can distinguish terrestrial and marine phenomena. Approximately 16% of the total area of continental earth is potentially involved in groundwater salinisation. Seawater intrusion can be considered to be the primary phenomenon for study in terms of groundwater salinisation.

Three schematic approaches to the protection of groundwater via salinisation mitigation and/or groundwater salinity improvement are described based on the classifications of the primary salinisation sources and focusing on the effect of seawater intrusion. The complexity of these approaches generally increases due to difficulties caused by groundwater quality and quantity degradation and increased demand for quality water. In order from the lowest to the highest complexity, these approaches are the engineering approach, the discharge management approach, and the water and land management approach. The engineering approach is realised on the local or detailed scale with the purpose of controlling the salinisation, optimising the well discharge with specific technical solutions and/or completing works to improve the quality and/or quantity of the discharged fresh groundwater. The discharge management approach encompasses at least an entire coastal aquifer and defines rules concerning groundwater utilisation and well discharge. The water and land management approach should be applied on the regional scale. Briefly, this approach becomes necessary when one or more need creates an overall framework of high-quality water scarcity. These conditions, sometimes combined with an awareness of negative environmental effects, force people to accept new water saving practices and land use modifications. As the natural effects of salinisation can be enhanced by a multiplicity of human actions, the discharge management approach and the water and land management approach should generally be applied by water authorities or institutional and governmental organisations that are responsible for groundwater quality and availability.

The practical study of Apulian karstic coastal aquifers is discussed in detail. Previously experienced management difficulties are described, as well as a proposed multi-methodological approach based on monitoring networks, the spatiotemporal analysis of groundwater quality changes, and multiparameter well logging. The core of this approach is the definition of the salinity threshold value between pure fresh groundwater and any fresh and saline groundwater mixture. The basic or single tools were defined to be simple, quick and cost-effective to be applicable to the widest range of situations.

Keywords: *Coastal aquifers, Seawater intrusion, Groundwater management*

**CLOUD SEEDING OPERATIONS FOR RAINFALL ENHANCEMENT- AN
EXPERIENCE OF ANDHRA PRADESH**

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Abstract

Cloud Seeding for rainfall enhancement has been carried out by Government of Andhra Pradesh, India in the Rain Shadow (<600 mm) Region of Andhra Pradesh between latitudes 12°36' to 19°08' and longitudes 76°38' to 80°55' covering an area of 1,35,680 km² in the 12 districts during 2003-2009. Mostly the cloud seeding has occurred between the altitudes of 1200-2500 m above mean sea level with an updraft velocity of 0.5-3 m/s. This conforms that these clouds are warm clouds well below the freezing level (5800 m) in the seeding area. Most of the clouds are seeded at the base by releasing hygroscopic material (mostly Calcium Chloride) with the help of pressurized aircrafts fitted with hygroscopic flares. C-Band analogue weather RADARs with TITAN (Thunder Storm Identification Tracking and Now casting) software were used to identify the clouds and to analyze the cloud growth. On an average not more than 23% of the seedable clouds are seeded with the existing infrastructure. It is observed from the RADAR data that there is an increase in Cloud Volume, Area, Reflectivity, Life and Lowering of Centroid after seeding indicating that the Clouds are responding to seeding material. It is also observed in general that, cloud seeding is more effective if we get active monsoon clouds and it is less effective if we get weak monsoon clouds. Overall about 17% of total rainfall could be attributed to cloud seeding during the years 2005-2009.

TS-1

GROUNDWATER RESOURCES CHARACTERIZATION, QUANTIFICATION, ABSTRACTION AND MONITORING

Keynote Paper

SIMULATION OF SEAWATER INTRUSION INTO THE COASTAL AQUIFER OF AN INTER BASIN AREA OF PURI DISTRICT, ODISHA, INDIA

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Abstract

About 50% of the global population resides within a distance of less than 60 kms from the coast line, where ground water is the most important source of fresh water. The quality of ground water in coastal aquifers is threatened by various human activities like irrigated agriculture, industrialization, urbanization and tourism etc. In addition, this valuable resource is susceptible to sea water encroachment which is dependent upon the level of ground water development. In the present study, a density-dependent solute transport model accounting for advection and dispersion has been developed for simulation of seawater intrusion into the coastal aquifer of an inter basin area of Puri district, Odisha. The model has been based upon SEAWAT 2000 code given by Guo and Langevin. An integrated approach involving hydrogeological and ground water quality studies followed up by a modeling exercise has been attempted. The available hydrogeological data for the study area indicates that the aquifer system comprises three units. First unit includes a sizable regional 25-30 m thick sandy aquifer of unconfined type. This is underlain by another unit composed of clay-sand alternations up to a depth of 130m below ground and mostly having saline groundwater. This unit seems to bifurcate into two layers towards west of Puri town. The third unit occurs from the depth of about 135 m to 230 m and has got fresh ground water but is often characterized by presence of intervening clay layers. The aquifer system is bounded by

Kushabhadra river on the east, and by the Daya River and the Chilika lake towards northwest and west respectively. All these water bodies seem to be hydraulically connected to the aquifer system. The Chilika lake is also hydraulically connected to the sea. The seasonal water table fluctuations are well reflected in the monitoring wells of the study area, with little notable difference between the piezometric head and water table elevation. The average premonsoon depth to the water table in the study area varies between 2.70 m to 4.50 m bgl whereas the postmonsoon water table occurs at about 0 m to 2.40 m bgl.

Due to the proximity of the study area to the sea, it is quite likely that the groundwater of the area may get affected by seawater intrusion. With this in view, the quality of groundwater in the area has been studied mainly in the context of the relevant physico-chemical parameters like total dissolved solids and the ionic ratios like Cl^-/HCO_3^- which can indicate presence of seawater intrusion into the subsurface aquifers. The study indicates the onset of seawater intrusion into the aquifer of the area up to an approximate distance of 3.5 to 4 km from the seashore. This inference matches with one of the outcomes from the modeling study. The adopted model (SEAWAT) has been adequately calibrated invoking historical data of the water table elevation and salt concentration and aquifer visualization gained through hydrogeological and water quality study.

The principal findings of the Study are as under.

- The projected long term maximum water table depth and the sea water intrusion corresponding to the prevalent cropping / pumping pattern are 4.5m and 4.1 km respectively.
- The projected long term maximum water table depth and the sea water intrusion corresponding to the optimal cropping / pumping pattern are 7m and 4.8 km respectively.
- Shift from the prevalent to the evolved cropping pattern shall enhance the net benefit from 345 million rupees to 5557 million rupees.

The study has resulted in viable conclusions regarding onset of the sea water encroachment of the subsurface aquifers in the near shore locations of the study area. The study has led to an optimal cropping pattern that ensures long term sustainability of the associated groundwater withdrawals.

**ASSESSMENT OF LEVEL OF CONTAMINATION IN GROUNDWATER AND
SURFACE WATER IN AND AROUND PERUNGUDI DUMPSITE**

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Abstract

Perungudi dumpsite in Chennai receives about 3000 tonnes of Municipal solid waste every day. This unlined dumpsite spreading over an area of 78 hectares, located in Pallikaranai marshland and receives an inflow from about 22 water streams. Perungudi and Kallukuttai lakes drain into the dumpsite and carry the leachate along, which later flows into Buckingham canal contaminating both surface and groundwater. Thus, there is a need to understand the impacts of dumpsite on the hydrogeology of the surrounding area for any remediation strategy development. In the present study, qualitative and quantitative assessment of soil and water samples collected from 9 monitoring wells in and around the dumpsite was performed. Parameters like total dissolved solids, alkalinity, acidity, chlorides, sulphates, total organic carbon, polycyclic aromatic hydrocarbons (PAH), heavy metals, emerging contaminants like pharmaceutical products and personal care products were assessed on a monthly basis. From the hydro-geological study, the subsurface of dumpsite was found to be highly permeable sandy soil and can lead to potential contamination of groundwater in the shallow water-bearing zone. Groundwater quality assessment revealed that most inorganic parameters exceeded the drinking water standards in all samples. From the GC-MS analysis, it was found that endocrine disrupting compounds like Diclofenac and Ibuprofen were present in very high concentrations. Several PAHs were also found to be present in high concentrations. These results reveal that surface water and groundwater are continuously polluted by the dumpsite and remediation strategies should be adopted.

Keywords: *Perungudi dumpsite, Leachate, hydrogeology, groundwater, organic and inorganic pollutants, pharmaceutical products, remediation*

**INTEGRATING LITHOLOGICAL AND SUB-SURFACE FEATURES WITH
HYDROGEOCHEMICAL CHARACTERISTIC OF THE AQUIFER FOR THE
PREDICTION OF ARSENIC: DEVELOPMENT OF THE ROBUST RISK PREDICTIVE
MODEL FOR THE GANGA AND THE BRAHMAPUTRA FLOODPLAINS**

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Abstract

Over-extraction of the groundwater leads to the reciprocal jump in Arsenic (As) dissolution leading to health vulnerability. High temporal groundwater fluctuations coupled with the changes in the carbonate chemistry of sub-surface system further imprecates the situation in the Gangetic (HQ_{oral} 5.6 – 57.6) and the Brahmaputra (HQ_{oral} 5.25 – 53.24) river floodplains (GBRF). This intensely resource pressurized belt (GBRF) of India witnesses one of the most intricate geological and geochemical shifts with distance and time. Therefore, an attempt has been made to develop a comprehensive scientific model for risk evaluation, so that sustainable practices may be adopted before the situation turns towards a catastrophe. The study shows that saturation indices along with parameters like redox potential and pH must be taken into consideration to evaluate the future scenario. Arsenic mobilization and enrichment processes are getting complex day by day due to the governing roles of several variables that are being affected by anthropogenic activities. One such observation was decoupling of ORP and As enrichment during the post monsoon and high undersaturation of weathering minerals in the Darbhanga. Other observations in the Buxar district, Bihar emphasizes the role of morphometry of the Ganga River over spatial pattern of Arsenic distribution. This stresses the need for *in-situ* measurements coupled with inputs from satellite imageries and physical models. REANALYSIS products derived and simulated through a network of data stations located across the globe provides a working framework for our problem.

Keywords: *Groundwater, Storage Anomalies, Arsenic, Ganga, Brahamaputra, Morphometry*

INVESTIGATING HAND PUMPED BOREHOLE FUNCTIONALITY IN SUB-SAHARAN AFRICA

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Abstract

Perceived poor performance of hand pumped boreholes (HPBs) has been a persistent problem in Sub-Saharan Africa. The UPGro Hidden Crisis project has brought together an interdisciplinary team to examine factors and identify casual pathways that explain the functionality status of boreholes equipped with hand pumps (HPs) in sub-Saharan Africa. The project developed a tiered approach to define and measure functionality of HPBs. Applying the definitions to a survey of 600 hand pumped boreholes across Ethiopia, Uganda and Malawi the results, in agreement with national surveys, show that c.80% of hand pumped boreholes produce water. However much fewer (<50%) are able to deliver HP design yield reliably for more than 11 months of the year. Fewer still provide water that meet WHO guidelines on chemical parameters and total thermo-tolerant coliforms (TTC). To understand factors which contribute to functionality outcomes, detailed hydrogeological and engineering investigations were conducted on a subset of 150 HPBs. Within this second survey a full range of HPB functionality outcomes were included. Data on aquifer properties, borehole construction and the condition of HP components were generated. Initial analysis shows that in each country there are specific contextual factors that influence functionality outcomes. For example, in Ethiopia deep water levels (>60 m) strongly influence HPB functionality classification. In some cases HPs are operating beyond lift limits (typically 45 – 80 m). Similarly, aquifer yield is an important control on functionality in Ethiopia, aquifer yield is an order of magnitude larger for fully functional HPBs than partially functional HPBs. In Uganda many HPBs operate close to the minimum aquifer yield required to sustain a HP (c.1 m²/d). Furthermore, in Uganda the use of India Mark II HPs and galvanized steel components, along with corrosive groundwater, results in high rates of corrosion. In all three countries water level, aquifer yield, borehole construction and pump cylinder placement interact to create conditions that are sub-optimal for HPs to meet design capacity (pumping head and yield). Current analysis focuses on identifying how these hydrogeological and engineering factors combine with social, institutional and economic factors to determine HPB functionality. The inter-disciplinary analysis uses different analytical approaches,

including predictive and causal statistics, systems thinking and qualitative comparative analysis. The presentation will provide an overview of the projects definition of functionality, the methods used in the forensic surveys, results from the analysis of the forensic surveys, and how these techniques can be used in functionality monitoring and asset mapping and assessment.

Keywords: *Tiered approach, Thermo tolerant coliforms, HPB*

**QUANTIFYING GROUNDWATER RECHARGE IN UPPER YAMUNA BASIN, INDIA,
USING WETSPASS MODEL**

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Abstract

The appropriate management of groundwater draws paramount significance in the backdrop of the ever increasing water demands and depleting groundwater levels. Over exploitation of aquifers during the past decade makes it essential to quantify groundwater recharge so as to estimate replenishable groundwater and form effective management policies. Hydrological models are important tools for estimation of groundwater recharge and simulate the effects of various natural and anthropogenic changes, such as climate and land cover changes on groundwater recharge. Integration of the data obtained from satellite remote sensing, such as land cover, enhances the utility of these models to simulate groundwater recharge at high spatial and temporal scales. In this study, a GIS-based distributed water balance model, named WetSpass, is used to estimate groundwater recharge in upper Yamuna basin, India. Spatial variations in land cover, such as area under forest, urban settlements, agriculture, etc., are considered using a land use land cover map derived from Landsat image. The estimated recharge shows that the spatial distribution of recharge is considerably affected by variations in precipitation, soil type and land cover. The lowest recharge is observed in urban areas due to presence of impervious surfaces to a large extent as compared to forest, cultivated and bare soil areas. Results of this study provide an understanding about the spatial distribution of groundwater recharge in the upper Yamuna basin. The estimated recharge could also be utilized in future studies for groundwater flow and solute transport modeling.

Keywords: *Groundwater recharge, Upper Yamuna Basin, WetSpass, Quantification*

GEOPHYSICAL MAPPING OF PALEO-CHANNELS AND LATE QUATERNARY DEPOSITS IN THE PERIYAR-CHALAKUDY RIVER BASINS OF KERALA

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Abstract

Late Quaternary period has witnessed several climatic oscillations which is recorded in the alluvial and coastal sediments. The study is an attempt to delineate the paleo-river courses in the midland and coastal plain region of the Periyar and Chalakudy River basins of Central Kerala. Periyar is the longest river in Kerala (244 km in length) drains an area of 5,398 km² and Chalakudi River originate in the Anamalai hills of Western Ghats has a length of 130 km and drainage area of 1704 km². Both of these rivers have extensive delta plains, paleo-drainages and flood plains. Geomorphological mapping revealed the presence of several paleo-channels in the northern side of present channel of Periyar and Chalakudy Rivers. Presence of a paleodelta and shifted river mouth is also noted in the coastal plain region of Periyar river. The river course changes of Chalakudy river is evident in the IRS P6 imagery. Vertical Electrical Sounding was carried out at thirty two locations applying schlumberger electrode configuration in the paleo-channels. Apparent resistivity values were plotted against half current electrode separation in ZondIP software. The resistivity parameters (ρ , h & z) shows good resistivity contrast from twenty eight locations with mainly 3-4 resistivity layers of H-type, KH-Type and HK-Type curves. H-Type curves are seen from paleo-channel areas and apparent resistivity (ρ) values ranges from 1-92 Ω m. The resistivity values indicate the presence of highly saturated fluvial sand and clayey sand deposits. and also peat layer (peaty clay/peaty sand) in the paleo-channel deposits.

Keywords: *Paleo-channels, electrical resistivity sounding, Periyar and Chalakudy River basins, Kerala*

**GEOPHYSICAL SIGNATURES FOR DETECTION WATER-BEARING ZONES IN A
MICRO-WATERSHED OF DRY LAND ENVIRON FROM SOUTHERN INDIA**

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Abstract

Geophysical signatures play a vital role to decipher subsurface geometry which leads to detect water-bearing zones in dry land environ. A micro-watershed is situated in granite terrain under dry land environment in Southern India where the variation of basement depth and location of water-bearing zones are identified using the Dar-Zarrouk (D-Z) parameters achieved from the geo-electrical layer parameters. Pumping wells were recommended for the drilling and the high yielded wells are confirmed in the water-bearing zones. The observed litho-logs are correlated very closely with the interpreted geoelectric layer parameters. It indicates that water-bearing zones exist in highly weathered (resistivity range: 50-100 Ω -m) and fractured granites (resistivity range: 100-300 Ω -m) at 12 to 22 m depths. Further, the estimated S-values (range: 0.12-0.44 Siemens) and T-values (range: 1523-7897 Ω -m²) are found for the suspected zones along with the high hydraulic conductivity (K), which indicate to confirming the presence of possible shear zone in this watershed.

Keywords: *Groundwater potential zone, shear zone, dry land environ, Southern India.*

**IMPACT ASSESSMENT OF VIADUCT CONSTRUCTION ON GROUNDWATER
RECHARGE IN NCT DELHI**

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Abstract

NCT Delhi has massive networks of elevated metro rail corridors/viaducts constructed either on the natural soil surfaces or paved road surfaces/built-up areas. Whether or not these elevated metro rail corridors/viaducts have any influence on the natural rainfall recharge is one of the concerns. If yes, how much is the quantity and what is its impact on groundwater recharge! To answer these questions of apprehension and to ascertain the quantity and impact, DMRC has referred the task to the National Institute of Hydrology, Roorkee for a comprehensive study. The average annual rainfall recharge of the areas through which major part of the elevated metro line corridors have routed, has been estimated as 67.32 mm; of which 54.53 mm occurs during monsoon period. The quantity of annual rainfall recharge, which is expected not joining the groundwater because of the obstructed surface area of the elevated metro corridors and elevated stations of 2.43 km², if full area is considered to be an impervious strata on the natural soil surfaces, has been estimated 0.1635 MCM (million cubic meter), which is about 0.157% of the annual rainfall recharge of NCT Delhi and in case of elevated metro rail corridors located on natural soil surfaces, recharge has been estimated 0.05065 MCM, which is 0.0487 % of the annual groundwater recharge of NCT Delhi and is extremely an insignificant quantity or we can say that elevated metro rail corridors and stations in NCT Delhi have very insignificant influence and impact on natural rainfall recharge to groundwater.

Keywords: *natural soil surfaces, groundwater recharge*

**HARD ROCK COMPLEXITY AND DELINEATION OF POTENTIAL
GROUNDWATER ZONES AND ITS CHARACTERISTICS IN A VARIED
GEOLOGICAL SETTING FROM FULL WAVEFORM ELECTRICAL RESISTIVITY
TOMOGRAPHY DATA**

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Abstract

Two diverse hydrogeological regions - one in plateau area of Chhotanagpur gneissic complex, Jharkhand and the other in limestone-quartzite-shale drought prone region of Anantapur district, Andhra Pradesh in a varied geological setting were studied for groundwater. Detailed geophysical exploration was conducted for hydrogeological assessment followed by groundwater prospecting, exploitation and development of the resources. The study mainly focuses on aquifer characteristics as well as borehole sustainability for a longer time period in these varied hard rock regions. Based on the significant geophysical results in these two different hydrological regions 8 boreholes were drilled with depths ranging from 81 m to 215 m, which confirmed the geophysical anomalies and validated the high resolution resistivity models encountering various distinguished lithology of hydrogeological significance. The yield of the boreholes varies from 5,632 to 63,769 litres/hr in Chhotanagpur gneissic complex and is rated the good aquifers while it yielded 300 to ~5,000 liters/hr in limestone-quartzite-shale region. The high resolution resistivity models of this region revealed clear picture of the subsurface geological rock strata and structure with a large variation in resistivity ranging from ~20 Ohm×m to 275 kOhm×m and delineated a major fault, which separated the low resistivity 100-200 Ohm×m formation and the high resistivity >17 kOhm×m geological formation. The depth of top of the aquifer zone lies between 24 m to 124 m mainly at the contact zones of shale and quartzite rocks as well as in the weathered shale. The fault, which is extended up to 230 m depth, is the potential target for groundwater prospecting and the long term development of the resources due to its hydrogeological importance. The 2D resistivity models, lithology of the boreholes and the conceptual geological models together has helped in detailed understanding of the aquifer and the hydrogeology of the limestone-quartzite-shale formation. Nevertheless, the geophysical inversion of the high resolution dataset of Chhotanagpur gneissic complex revealed the groundwater prospect scenario at 6 sites based on the substantial resistivity

contrast between the highly weathered/fractured & the saturated rocks with respect to the massive rocks. These prospect zones mostly lies at deeper depths ≥ 100 m. The low resistivity inferred as the prospect groundwater zone(s) signifies favourable hydrogeological scenario lies below the hard rock formation and also between two high resistivity rocks is situated under confined condition, which are the potential target(s) for groundwater exploration and development. The interpretation of 2D models clearly shows the average resistivity of the aquifer zone lies in the range of ~ 50 to around $500 \text{ Ohm}\times\text{m}$, which corroborated with the drilling results. However, the broad resistivity range between $10 \text{ Ohm}\times\text{m}$ to $1000 \text{ Ohm}\times\text{m}$ inferred from the model results represented the saturated weathered/fractured granite-gneiss rocks. It is confirmed from the study that the main aquifer(s) is trapped within the hard rock system at a shallower between 50 m to 70 m depths as well as between 100 m to $\geq 150 \text{ m}$ at a deeper depths, which is under confined condition with a large pressure within the aquifer system. Nevertheless, the shallow static water table, which vary from 5.25 m to 8.05 m below ground level as well as the different yields of the boreholes guided that there is substantial rainfall recharge to the aquifer system in this granite-gneissic region. The conceptual geological models aided in detailed understanding of the geological scenario, hydrogeological variation, groundwater availability and the status of the aquifer in the present hard rock aquifer system in the complex geological setting of Chhotanagpur Gneissic Complex of Jharkhand region.

Keywords: *High Resolution Resistivity & IP Tomography, Chhotanagpur gneissic complex, quartzite, shale-limestone formations, water scarcity areas, groundwater*

CHARACTERISATION AND WELL FIELD DESIGN OF MIOCENE AQUIFER FOR SALINE WATER REQUIREMENT OF OIL AND GAS FIELDS OF RAJATHAN, INDIA

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Abstract

The crude in Rajasthan oil field has high viscosity and it requires water flooding to support the reservoir pressure. There was need to find a large aquifer to meet the current and future water demand for oil field development. The objective of the study was aimed to Abstract saline water that has no practical use for domestic or irrigation purposes with minimum cost of construction and operating the well field on long term basis without any adverse effect on fresh water system. A detailed hydrogeological investigation using seismic, geophysical logs supported by drilling data has been carried out and extensive sandstone aquifer in Miocene formation was identified. The oil exploration data are especially comprehensive and valuable in defining the aquifer geometry. Four distinct groups of permeable granular zones separated by impermeable zones have been identified. The spatial extent of the aquifer has also been mapped with help of seismic reflection data. Finally, geometry and thickness of the aquifer has been defined of each layer with reasonable accuracy. The salinity in quaternary aquifer increases with depth. Brackish (2000 μ S/cm) groundwater occurs at the top and become highly saline (~10,000 μ S/cm) at the bottom. An extensive deep confined saline aquifer has been identified in Jagadia (Miocene) formation. The aquifer test indicate that hydraulic conductivity is in range of 20-25 m/day and salinity to be ~20,000 μ S/cm in the Jagadia formation.. The aquifer is shallower in the north and gradually deepens southwards where aquifer top is ~ 1500 mbgl. The gross thickness of sand in Jagadia formation varies from 25 m to a maximum of 600m (south-east). The total gross calculated volume of the aquifer is ~ 2.6 X 10⁹ m³. The aquifer contains unconsolidated to poorly-consolidated, medium to coarse grained, moderately to well sorted, sub-rounded sands. Grain-size analyses indicate a mostly uniform formation with the majority of samples having a uniformity coefficient of 4 or less. The effective porosity has also been derived from petrophysical logs and it is ~20% in the northeast, increase to ~30% in the southeastern-boundary. It has been found that it is possible to get the required volume of saline water by tapping only 36m of the upper portion of the Miocene aquifer, with screens of 6.5/8” diameter continuous slot wire wrapped 1mm slot aperture. It was found that 304L metallurgy for

well casing, screen and tubing was appropriate to meet the possible corrosion threat. The low value of uniformity co-efficient of the aquifer material has helped in deciding the artificial gravel packing across the screen. Efficient saline water well field developed has been achieved due to integration of oil field data, aquifer testing and numerical as well as analytical modeling, minimizing the risk related to availability of resources, impact on the environment and conflict with other stockholder.

**SCIENTIFIC APPROACH FOR GROUNDWATER MEASUREMENT IN BASALTIC
TERRAIN**

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Abstract

Due to heterogeneity of hydrogeological characters of basalt flows, the figures published in the groundwater assessment report do not match with the actual scenario in a watershed area comprising 20/25 villages. Groundwater estimation varies from one location to other in a watershed area. The main object of the research work is to be established location specific methodology for groundwater measurement in basaltic terrain with proper scientific approach. The basaltic terrain is more challenging than any other hard rock terrain due to variation in their hydrogeological characters from one flow to another or even within the same flow of considerable thickness about 10 m. or more. From the methodology adopted in the present work, hydrogeological maps of every village in Jalna block of Maharashtra State, India has been prepared in which different basalt flows showing variation in hydrogeological characters have been demarcated. From the well inventory data the vertical thickness of the flow at the subsurface has been measured by plotting litholog. Thus the area and volume of different basalt flows exposed in the village has been calculated and finally groundwater potential and estimation of every village in the block have been determined. After calculating exact groundwater potential and estimation of each village the different location specific measures have been suggested from this research project

Keywords: Basaltic terrain, Groundwater potential, Hydrogeological characters

**EFFICACY OF ELECTRICAL RESISTIVITY TOMOGRAPHY IN DELINEATION,
DEVELOPMENT AND MANAGEMENT OF GROUNDWATER RESOURCES –CASE
STUDIES FROM HARD ROCK TERRAINS**

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Abstract

Approximately two third surface area of India is occupied by different types of hard rock which include volcanic rocks, granites, gneisses, charnockites, khondalites, quartzites, schists etc.. Almost eighty percent surface area of Maharashtra state alone is covered by volcanic basaltic rocks popularly known as Deccan traps. In hard rock terrains such as in the state of Maharashtra, groundwater occurs in fractures, faults, joints and intertrapean sedimentary formations. Scarcity of water supply in these areas is because of finite dimensions and sporadically distribution of groundwater resources in these areas. Hence, delineation of their exact locations is a challenging task. The other reason for the shortage of water supply is the faulty design of bore wells adopted in this region. In order to explore the groundwater potential zones Electrical Resistivity Tomography (ERT) has been carried out in two river basins, namely Chandrabhaga and Tawaja basins falling under drought prone Vidarbha and Marathwada regions of Maharashtra and at some locations in granitic terrains of Hyderabad. This paper present an overview of the efficacy of ERT in delineation and sustainable development of groundwater resources with the help of case studies from Deccan traps and granitic terrain in order to achieve the preset objectives of management.

GROUND WATER POTENTIAL ASSESSMENT AND SUSTAINABLE MANAGEMENT

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Abstract

Ethiopia has 12 river basins with an annual runoff volume of 122 billion m³ of water, estimated ground water potential of 2.6 - 6.5 billion m³. Groundwater offers a major life support to humankind in terms of meeting the domestic, irrigation and industrial demands. Groundwater plays a crucial role in Ethiopia in providing drinking water, increasing food and agricultural production, and facilitating industrial developments. It is the most preferred source of water in all climatic zones for its convenient availability, drought dependability, excellent quality and low cost of development. The rural areas which account more than 85% of the country's population are encountered with shortage of potable water supply which can be solved by proper groundwater utilization. The management of a groundwater basin implies a program of development and utilization of subsurface water for some stated purpose, usually of a social or economic nature. In general, the desired goal is to obtain the maximum quantity of water to meet predetermined quality requirements with the least cost. Generally, the current groundwater management practices in the aforementioned area are poor. Despite the existence of evident challenges which are pervasive and devastating in nature, immediate and proper responses have not yet been given to the problem. Thus, such frustrating threats and challenges have initiated the researcher to work in the project area.

Keywords: *Ground Water Potential, Ground Water Management, South Gondar Watershed, Ethiopia*

EVALUATION OF GROUNDWATER POTENTIAL AND AQUIFER PROTECTIVE CAPACITY OF THE OVERBURDEN UNITS IN DHULE DISTRICT, MAHARASHTRA

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Abstract

This paper illustrates the determination of the overburden protective capacity using vertical electrical resistivity sounding (VES) in the drought-prone Dhule district of Maharashtra. A total of 54 VES were carried out using Schlumberger configuration with maximum electrode separation of 200m. The objective of this study was to locate groundwater potential zones and to evaluate the protective capacity of aquifers. The results reveal that the longitudinal unit conductance values obtained from the analysis of data, ranges from 0.07 to 13 mhos. The overburden protective capacity of the aquifers reveals a good to moderate rating at 92% of the VES sites. While 2% each represent weak and poor rating, 4% fall in the excellent category. Vulnerability map of the study area derived from the longitudinal unit conductance suggests that the northern and eastern parts are less vulnerable than the western side. Electrical anisotropy shows a large variation ranging from 1.028 to 6.55. This implies the heterogeneous and anisotropic nature of the subsurface in the study area. A positive correlation is observed between the fracture porosity and electrical anisotropy, indicating the porous zones in the study area. Further, stations with low reflection coefficient revealed higher electrical anisotropy, suggesting an inverse correlation between these two parameters. These results provide reliable information about the protective capacity of the materials overlying the aquiferous unit and the fracture geometry using various geophysical indices. This is vital for planning and development of prospective water resource programs and is vital to understand groundwater pollution control in hard-rock, semi-arid regions.

Keywords: *Electrical resistivity, anisotropy, protective capacity, Dhule,*

**GROUNDWATER POTENTIAL MODELING IN HARD ROCK TERRAIN THROUGH
REMOTE SENSING AND GIS: A CASE STUDY OF TIKAMGARH DISTRICT,
BUNDELKHAND REGION, MADHYA PRADESH, INDIA**

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Abstract

Ground Water, which is in aquifers below the earth's surface, is one of the most precious natural resources and invaluable gift of nature to mankind. Groundwater constitutes an important source of water for various purposes such as domestic, industrial, drinking water supply and agriculture needs. Groundwater flows very slowly in the subsurface toward points of discharge, including wells, springs, rivers, lakes. The importance of groundwater for the existence of human society cannot be overemphasized. Despite the valuable nature of the resource, 29% of groundwater blocks are semi-critical, critical, or overexploited, and the situation is deteriorating rapidly. Moreover, aquifers are depleting in the most populated and economically productive areas. Climate change will further strain groundwater resources. In this study various thematic maps such as geology, geomorphology, land use land cover, soil, lineament density, and drainage density etc. were prepared, covering an area of about 5,048 sq. km. Based on the hydrogeomorphological mapping the study area has qualitatively been categorized into four groundwater potential zones, viz. very good, good, moderate, poor and very poor.

Keywords: *Ground water aquifers, Surface water, hydrogeomorphological mapping*

**MONITORING OF URANIUM AND FLUORIDE ALONG WITH ASSOCIATED
PHYSICO-CHEMICAL PARAMETERS IN DRINKING WATER OF BHARUCH
DISTRICT OF GUJARAT**

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Abstract

Bharuch district is located in the southeastern part of Gujarat (21.7051° N, 72.9959° E). Geographical area of district is 6527 km² with varied landscape viz; hilly, plain and coastal areas with average annual rainfall of 707 mm. The objective of this study was to assess the spatial distribution of uranium as well as associated water quality parameters in drinking water of Bharuch district. Uranium is a naturally occurring radioactive element present in all compartment of the environment with wide variation. Recently elevated level of uranium has been reported in some part the country [1]. Uranium and associated water quality parameters were monitored in drinking water samples collected from Bharuch district of, Gujarat under National Uranium Project (NUP) of Bhabha Atomic Research Centre (BARC). In this study, 144 samples were collected and analyzed for uranium, fluoride and other water quality parameters using BARC standard protocol and APHA standard method. Fluoride levels were found to be in the range from 0.05-2.07 ppm and 0.15-1.98 ppm in pre- and post-monsoon, respectively. Uranium concentration in drinking water samples was observed in the range of <0.2 – 58.9 ppb and <0.2 – 18.4 ppb in pre- and post-monsoon, respectively. The uranium level in all the drinking water samples was observed to be below the Atomic Energy Regulatory Board drinking limit of 60 ppb.

Keywords: *Uranium, Fluoride, Drinking water*

EVALUATION OF WATER LEVEL FLUCTUATION BEHAVIOR AND QUALITATIVE ASSESSMENT OF GROUNDWATER NEAR COAL-MINING AREAS

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Abstract

Industrial activities in India started decades back, since then the groundwater is getting affected. Coal mining and its related industries disturb the underground water table in terms of its level, quantity as well as quality. The present paper discusses, in brief, the status of the quantitative and qualitative assessment in the coal mining and its nearby township areas of the Jharkhand State. In Jharkhand the major mining area is located in Bokaro and Dhanbad district. In the adjacent township areas of coal mining region like Bokaro district and Dhanbad district, the average value of water level fluctuations is 6.29 mbgl and 5.21 mbgl respectively, during the pre-monsoon season and the average value of water level fluctuations is 6.29 mbgl and 3.40 mbgl respectively during the post-monsoon season. The water quality parameters Bokaro district is slightly acidic to slightly alkaline in nature and is dominated by Ca^{2+} and Na^+ and HCO_3^- and Cl^- concentration in both the seasons, respectively. The groundwater quality of Dhanbad district is slightly acidic to alkaline in nature and is dominated by anionic (HCO_3^- and SO_4^{2-}) and cationic (Ca^{2+} and Na^+) concentrations. The concentrations of 'Fe' has been found more than the desirable limit of Indian drinking water standard (BIS 2012) and WHO (2006) at many places. Therefore, it has been found that the groundwater management is urgently needed in these areas.

Keywords: *Coal Mining, Groundwater, Water level fluctuations, Qualitative Assessment, Groundwater management.*

GROUND WATER SCENARIO OF JAMMU AND KASHMIR

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Abstract

The valid concern for continued depletion, degradation and pollution of the ground water makes it essential to study the ground water prospects of Jammu and Kashmir State. It requires both, the hydrological and the geospatial approach to study the ground water prospectus, its conservation and the management viz-a-viz to the State of Jammu and Kashmir. The present study is an attempt to ascertain the ground water Scenario of the State of Jammu and Kashmir, so that the concerned agencies can formulate a strategy for a judicious use of ground water and to prevent it from further depletion and the pollution.

Keywords: *Ground Water; hydrological, Geospatial, Conservation and Management*

WATER ARSENIC EXPOSURE IN POPULATION OF BIHAR, INDIA AND CANCER INCIDENCES: PRESENT PERSPECTIVES AND FUTURE DIRECTIONS

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Abstract

In the entire world, about 300 million populations are exposed to arsenic poisoning in groundwater. In Bihar, India about 50 million people are drinking arsenic contaminated water. According to the provisional guideline value of WHO, arsenic in drinking water up to the level of 10 µg/l is decided as safe. This has caused various health related problems in the population like skin diseases, anaemia, bronchitis, gastrointestinal problems, hormonal imbalance and cancer. According to recent study, cancer risk is associated with daily consumption of 2 litres of water with inorganic arsenic 50 µg/L has been estimated to be 1/100 denotes that elevated blood arsenic levels in population can lead to cause various diseases including cancer to them. Skin and several types of internal cancers, including, bladder, kidney, liver, gall bladder, lung, uterus and prostate have been found associated with arsenic ingestion. Study on 1500 cancer patients was carried out to know the correlation between cancer and arsenic contamination. The study showed significant correlation between arsenic toxicity and cancer incidences in the exposed population. High blood arsenic concentration was observed in the samples of cancer patients. Moreover, the numbers of incidences are very high in the Gangetic zone in comparison to non-Gangetic zone. The state government strategy to control the present situation is at very infancy state. Hence, concrete strategy and proper implementation of the policy is urgently required to combat the present problem as the disease burden is increasing day by day.

Keywords: *Arsenic exposure, Cancer incidences, Arsenicosis, Gangetic basin, Bihar*

GROUNDWATER MODIFICATIONS IN SHIMLA, HIMACHAL PRADESH, INDIA

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Abstract

Shimla district is located at the south-east of Himachal Pradesh and have geographical area of 5131 sq km. Groundwater is not uniformly distributed all over and is limited in hard rock terrains. In hilly and mountainous parts, the most common issues relate to scarcity of water, particularly in low precipitation year during non-monsoon period when depleting water levels and dwindling spring discharges are a common factor. Besides this, two dug wells were also found in the area at village Sandhu and Chambi. These wells were constructed by the local folk to explore the availability of ground water during summer season. These dug wells were reported to have very low yield and dried out during summers. Now these wells are abandoned. To know the aquifer system of the hard rock area, Central Ground Water Board, NHR, Dharamshala, under exploration programme has constructed one deep tube well of 302 m depth at Ashwani Khad. The well has a discharge of about 1173 lpm with transmissivity of 70.39 m² /day. Recently, the State Department has drilled shallow bore wells fitted with handpumps to provide domestic water. The average depth of these hand pumps is 50 - 60 m, having low discharges up to 1 lps. Urban areas are highly prone and vulnerable to surface and ground water pollution thus water quality monitoring at close network is essential. Proper waste/effluent disposal measures are required to be adopted by stat authorities to check the pollution.

Keywords: *Groundwater, Dwindling, Rain water, Precipitation*

**AGRICULTURAL SUITABILITY OF GROUNDWATER IN SILISERH REGION,
ALWAR, RAJASTHAN**

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Abstract

India is an agrarian economy which is geographically very diverse with six major agricultural belts. The wheat belt located in Northern India is one among the highest producers of cereals. Since the advent of intensive agriculture, groundwater table in many of the regions is receding, and issues related to water quality have also come up particularly in water scarce regions. The present study is the first attempt to determine the agricultural suitability of groundwater in Siliserh region, Alwar of Rajasthan state. Since the land-use around the lake is primarily agricultural, twenty-three samples from five villages located around Siliserh lake were collected from open wells, submersibles, and tube-wells during the month of March 2018 to determine the quality of groundwater for agricultural use. The suitability for irrigation was determined by calculating ion-based ratios and comparing the observed values with prescribed standards. The parameters used for assessing the suitability for irrigation were electrical conductivity (EC), percentage sodium (%Na), residual sodium carbonate (RSC), soluble sodium percentage (SSP), sodium absorption ratio (SAR), magnesium hazard, and permeability index (PI). The groundwater was found suitable for irrigation in long term use, with the only problem of magnesium hazard. Based on EC, 78% of the samples were found suitable for irrigation. Based on %Na, SSP, SAR, RSC, and Kelly's ratio (KR) all the samples were classified as good for irrigation. Based on PI all the samples were categorized in class I type which indicates the ground water quality is fit for irrigation option here.

Keywords: *Siliserh lake, Irrigation, Percentage Sodium, Sodium Absorption Ratio, Suitability*

UNDERSTANDING GROUNDWATER SCENARIO AND SUGGESTING SUITABLE METHODS OF RECHARGE FOR VADODARA CITY

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Abstract

Groundwater exploration faces the twin hazards of de-saturation of aquifer zones and consequent deterioration of ground water quality. Vadodara, the third most populated city in Gujarat is selected as the study area is no exception. Ground water plays an important role along with the surface water to be supplied as a source of water for the Vadodara city. Due to population growth, urbanization & industrialization there is stress on a ground water resulting in depletion of levels and deterioration of the quality of ground water. Vadodara has a highly complicated hydro geological condition. The areas have great variations in aquifer thickness. To tackle the twin hazards of de-saturation of aquifer zones and consequent deterioration of ground water quality, there is an urgent need to augment the ground water resources through suitable management interventions. However, it is important to understand the suitable method for recharge in order to attain better efficiency. This study divides the city into different zones as per hydrogeology, studies the quality of groundwater and attempts to prepare guide map for the city for groundwater exploration and recharge.

Keywords: *Groundwater quality, recharge, aquifer, TDS*

**HYDROGEOCHEMICAL PARAMETERS FOR ASSESSMENT OF GROUNDWATER
QUALITY IN TRIBAL POCKETS OF NAVAPUR TAHSIL, DISTRICT NANDURBAR,
MAHARASHTRA, INDIA**

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Abstract

In order to know the quality and suitability of groundwater for drinking and irrigation in tribal pockets of Navapur tahsil of Nandurbar district, twenty five groundwater samples were collected from bore wells and dug wells and analyzed for pH, EC, TDS, Total Hardness, Ca^{2+} , Mg^{2+} , Na^+ , K^+ , HCO_3^- , CO_3^- , Cl^- and SO_4^{2-} , NO_3^- in order to assess its suitability for drinking as well as irrigation water purpose. The determination of Physico-chemical parameters of groundwater samples were carried out by adopting standard method given by APHA (2002) and Trivedi and Goel (1984). A comparison of groundwater quality in relation to drinking water quality standards proves that the parameter like Chloride, Sulphate, Nitrate NO_3^- and Total Hardness at same places are exceeding permissible limit given by BIS (2012) and these water samples are not suitable for drinking purpose due to agricultural and domestic activities. The suitability of groundwater for irrigation was determined by analyzing sodium adsorption ratio (SAR), Kelly's ratio (KR), soluble sodium percentage (SSP), Residual sodium carbonate (RSC), and Residual sodium bicarbonate (RSBC) and the study reveals that the most of the samples of the study area is below the permissible limit, which indicates that groundwater is suitable for irrigation purpose. Various classification methods such as Piper diagram, Gibbs diagram are employed to critically study the geochemical characteristics of groundwater.

Keywords: *Groundwater quality, Tribal pockets, Navapur, Drinking purpose, Maharashtra*

GROUNDWATER QUALITY ASSESSMENT FOR DRINKING IN DELHI-NCR, INDIA

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Abstract

Inland salinity of groundwater, having a TDS of 1500–3000 mg/L, has been found in substantial volumes (over 1.90 lakh km²) throughout the majority of India. As per the report of Central Ground Water Board (CGWB), New Delhi, the concentration of total dissolved solids in the ground water of Delhi has been found to vary generally between 202 mg/l to 9967 mg/l. TDS of 39% of analyzed water samples falls in the category of fresh water, while 61% samples have TDS in the range of 1000 - 10,000 mg/l and fall in the brackish water category. Groundwater quality assessment should be done periodically to provide the necessary treatment of water for drinking. This study aims to evaluate the quality of groundwater in Delhi--NCR for drinking purposes. Various samples were collected from the study area and parameters like pH, Electrical Conductivity, Total Dissolved Solids (TDS), total hardness, total alkalinity, Calcium (Ca⁺²) magnesium (Mg⁺²), sodium (Na⁺), potassium (K⁺), chloride (Cl⁻), Fluoride (F⁻), sulphates (SO₄⁻²), phosphates (PO₄⁻³) and Nitrates (NO₃⁻) were determined. TDS of certain samples reached as high as 8000 mg/L, which is highly significant when compared with permissible limits of drinking water standards. The data obtained from the assessment of the samples would be helpful in determining the suitable treatment on a large scale for drinking purposes.

Keywords: *Groundwater, Water Quality, Delhi-NCR, Water Characterization, Total Dissolved Solids*

APPLICATION OF GALDIT INDEX MODEL TO ASSESS TO SEA WATER INTRUSION IN TUTICORIN COASTAL REGION

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Abstract

Groundwater in coastal areas is relatively vulnerable to contamination by sea water. The study area identified for the present study is Thoothukudi coastal region. It is positioned in the East–West International sea routes on the South–East coast of India. In the present study, the vulnerability of the coastal aquifers in Thoothukudi coastal region was assessed for seawater intrusion using the GALDIT model with the six significant parameters of seawater intrusion. The results shows that the vulnerability classes of low, moderate and high are classified based on the GALDIT index range values. The percentage distribution of the study area within low, moderate and high vulnerability zones are 79.53, 19.5 and 0.97%, respectively. The groundwater recharge potential zones were assessed in the study area to improve the groundwater quality in the saline water intrusion areas. The groundwater recharge potential zone map was prepared and it was classified into three categories. The categories are high, moderate and low occupying the areas of 10%, 65% and 25% respectively. The low effective recharge potential zones falls in the Northwest portion. The suitable artificial recharge structures can be constructed in the moderate and high recharge potential areas to mitigate the saline water intrusion.

Keywords: *GALDIT index, recharge, seawater intrusion, vulnerable*

**PERFORMANCE EVALUATION OF A RECHARGE SHAFT IN TANK COMMAND
THROUGH TRACER TECHNIQUES – A CASE STUDY IN KANCHEEPURAM
DISTRICT OF TAMIL NADU, INDIA**

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Abstract

It is observed by the Central Ground Water Board, India that as much as 77% of the groundwater in Tamil Nadu has been extracted and one of the remedial measures are artificial recharge structures. Recharge shafts that are simpler and cost effective structures are one among them to recharge the impervious layer directly. A number of such structures are constructed by various organizations and it is important to study its impact. A recharge shaft constructed in the water spread area of an irrigation tank, Odanthangal in Kancheepuram District of Tamil Nadu was chosen for the study. Fluorescein dye was injected into the recharge shaft. The dye concentration, EC, TDS were monitored in the recharge shaft and 11 pumping wells in the command area along with water levels and pumping hours. Ranking the wells on the basis of their ability to get recharged through the recharge shaft is an indication of the effectiveness of the recharge shaft. This was done based on the concentration gradient, number of days the tracer was detected, EC, TDS, water level, pumping hours. Scores were given for all the factors and based on the total scores, the wells were ranked. It is concluded that the wells PW7, PW9a, PW9, PW5, PW3, PW4a, PW1, PW8, PW2, PW6 and PW4 performed better in the order. This methodology can be extended to any artificial recharging structure to assess its performance periodically and over different seasons which would help the implementing agency for its better maintenance and management.

Keywords: *Artificial recharge, Recharge Shaft, Tracer techniques*

GEOSPATIAL INTERPOLATION OF HYDRAULIC HEAD DISTRIBUTION IN KAREWA AQUIFERS OF NORTHWESTERN HIMALAYAS, INDIA

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Abstract

Fresh water resources in the water-rich Jhelum basin located in the north-western Himalayas of India are unevenly distributed in space, with the Karewas (fluvio-lacustrine/fluvio-glacial sedimentary deposits) being highly deprived of this resource. Lack of sufficient surface water together with erratic distribution of precipitation over the last few decades has led to the exploration of groundwater resource in these formations. Though groundwater development is at a preliminary stage, proper exploitation of this resource presses for the need of understanding the spatio-temporal distribution of groundwater levels. The simplest way to decipher spatial distribution of groundwater heads is to interpolate the observed groundwater levels. In this study, different Geostatistical and deterministic interpolation methods have been applied and their performance compared in mapping the spatial hydraulic head distribution in phreatic and confined aquifers in the Karewa formations. For phreatic aquifer, depth to water table was interpolated whereas in case of confined aquifer, absolute piezometric levels were interpolated. Effects of trend removal and various transformations were also evaluated. Based on ME and RMSE values, it was concluded that Ordinary Kriging of untransformed data with first order trend removal is the best interpolation model for phreatic water levels of this region; whereas that for piezometric heads is third order Local Polynomial Interpolation.

Keywords: *Karewa aquifers, Groundwater level, Geospatial data interpolation, Jhelum basin, Northwestern Himalayas*

ENVIRONMENTAL MONITORING OF ANTIBIOTICS FROM DIFFERENT GROUNDWATER SOURCES IN CHENNAI

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Abstract

Antibiotic resistance will become one of the leading causes of death (an estimate of 10 million people a year) by 2050 as per a report commissioned by UK government. India is now the world's largest consumer of antibiotics with 62% increase in consumption reported over the last decade. Rampant use of antibiotics in hospitals, livestock, poultry and aquaculture farms, indiscriminate disposal of waste and wastewater from municipalities, animal farms and pharmaceutical industries into rivers, lakes and other water bodies have contributed to the development of the mammoth problem of antibiotic resistance. The primary source of antibiotics is municipal wastewater contaminated via excretion, flushing of unused medications, and our daily use of personal care products. Climatic changes like pre-monsoon, post-monsoon, low and high temperatures, storm water can greatly affect the fate and transport of antibiotics. Chennai being the fourth largest metropolitan city, is among the worst affected city for water quality as it has suffered long spells of water shortages and flooding due to rapid and haphazard urbanization of its ever-expanding suburbs. In this study, groundwater from different sources were sampled and analyzed for the presence of antibiotics using liquid chromatography-mass spectrometry (LC-MS/MS) and heavy metals have been analysed using Inductively coupled plasma mass spectrometry (ICP-MS). Samples analysed from a pharmaceutical industrial estate in Chennai showed significant levels of ciprofloxacin and trace levels of ampicillin and trimethoprim. Thus there is an immediate and urgent need for antibiotic surveillance from various groundwater sources in Chennai.

Keywords: *Antibiotic resistance, surveillance, groundwater, Chennai, Ciprofloxacin*

GROUND AND SURFACE WATER QUALITY ASSESSMENT IN AND AROUND AN URBANIZED LAKE SYSTEM IN CHENNAI

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Abstract

Intense human interventions by natural and uncontrolled settlements in and around the water bodies have induced fragmentation of landscape and left the water bodies disconnected and encroached. Sembakkam is one such urbanized lake in Chennai and is an integral part of the cascading system of lakes draining into the Pallikaranai marsh with a total tank area of 39 hectares. Adding to its woes is the lack of civic amenities, untreated discharge of sewage from 22 inlets and dumpsite on its southern boundary which has marked negative impacts on oxygen levels in the lake and profuse growth of water hyacinth, an invasive species due to excessive nutrient loading. Assessment of satellite imagery confirms the presence of 62% built-up area in the catchment and 40 to 50% invasive species cover in the lake. Quarterly monitoring of lake water analyzed for one year during various seasons was found to have high concentrations of organic content in the range of 27-185 mg/L of BOD and 2 – 5 mg/L of ammoniacal nitrogen and 2–8 mg/L of phosphates. Hotspots of pollution were found near the major inlets and dumpsite confirming the contamination by leachate. The groundwater in the immediate vicinity were found to have high organic content nitrogen and heavy metals indicating pollution from solid waste dumped on the lake bank and in the upstream lakes.

Keywords: *Sembakkam, urban lake, waste water, contamination, dumpsite, organic pollutants, groundwater*

**ASSESSMENT OF HEAVY METAL CONTAMINATION IN GROUNDWATER
SOURCES IN PARTS OF BRAHMAPUTRA FLOODPLAIN ASSAM, NORTH-EAST
INDIA**

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Abstract

Heavy metal contamination of the groundwater of parts of Brahmaputra floodplain in and around Nalbari district of Assam was assessed. About 30 groundwater samples were analyzed for heavy metals (As, Fe, Cd, Cu, Zn, Pd and Mn) using Atomic Absorption Spectrophotometer. From the study it was found that the metal As, Fe, Mn and Cd were present beyond WHO permissible limits. Arsenic which is carcinogenic in nature is detected in 83% of the samples. The samples were also seen to be loaded with Fe which is detected in 93% of the sample followed by Mn. Cadmium which has various adverse effect on human health is also detected in 50% of the samples. Pd, Cu and Zn was found to be within the WHO permissible limit. The metal concentrations showed a dominance in the order of Fe>As>Mn>Cd. The results obtained from this study suggest a significant risk to the local rural population who use tube wells as a dominant source of drinking water.

Keywords: Heavy metals, groundwater, Health effects, Brahmaputra Floodplains

ASSESSMENT OF WATER QUALITY OF RIVER AND GROUNDWATER OF THE DELTAIC REGION OF CAUVERY RIVER

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Abstract

Water quality is an important factor to determine the usage of drinking and irrigational practices. The present study is carried out to evaluate the river water and groundwater suitability for drinking and irrigation from the Cauvery delta region. The water samples were collected from 2013 to 2018 once in four months and samples were analyzed for physicochemical parameters such as EC, pH, major, minor ions and trace elements. Sodium and bicarbonate were the dominant cation and anion in both river and groundwater. The total dissolved solids were found to exceed the permissible limits in most of the groundwater samples and it was below the permissible limits in river water samples which located away from the coastal region. The major ions values were compared with limits recommended by the Bureau of Indian Standards for drinking purposes which indicated that most of the river water samples were found to be suitable, but most of the groundwater samples were unsuitable. Irrigation water quality was also assessed based on magnesium hazard, residual sodium carbonate, sodium percentage, sodium adsorption ratio which indicate that the most of the river water and groundwater samples are unsuitable were collected from the coastal region. The concentration of minor elements such as lead, zinc, copper, cadmium, iron, fluoride and uranium were found to be within the permissible limits. Therefore, this preliminary data set will help to predict and monitor the Atmosphere- Land- Water interactions in the delta region.

Keywords: *River water, Groundwater, Physico-Chemical, Minor elements, Cauvery delta.*

VARIABILITY OF SOIL MOISTURE UNDER TWO DIFFERENT LAND COVERS

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Abstract

Soil moisture variability is important to characterize the linkage between the hydrology and ecology of a region. Dominant influencing factors controlling the soil moisture are depth of the soil, land use land cover and rainfall. With the changing land cover, the soil moisture patterns are also changing that ultimately affects the groundwater recharge of a region. The main objective of this study is to analyze the spatial and temporal variation of soil moisture under two different land covers. For the purpose of our study, two experimental plots are selected in which one is covered with grass and other one is bare. Soil moisture sensors are installed in the two plots for monitoring the soil moisture at different depths. Soil potentials are measured at those locations at daily intervals during the period 22 September, 2018, to 29 February, 2019. Soil moisture at shallow depths presented a moderate variability in the two plots at the sampling times. The variability was relatively higher in dry season with lower mean soil moisture, but lower in rainy season with higher mean soil moisture after heavy rain event. It shows higher variability in the deeper depth of the soil. In the grass cover plot, soil water flows quickly to the subsurface zone compared to the bare land plot. The overall results of the study gives an idea about the spatial as well as temporal variations of soil moisture content with the different land covers. This study provides an insight into the groundwater recharge processes and is helpful for groundwater management.

Keywords: *Soil Moisture, Land cover, Silt loam soil, Field experiment*

SEASONAL INDEXING OF GROUNDWATER QUALITY IN ENVIRONS OF SHALLOW AQUIFERS OF GHAZIABAD DISTRICT, UTTAR PRADESH, INDIA

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Abstract

The present study intended to perform a comprehensive evaluation of groundwater quality that has been monitored in three distinct seasons in shallow aquifers levels in Ghaziabad district of Uttar Pradesh, India. A total no. of 21 parameters as general parameters (pH, EC, TDS, TH, Ca, Mg, Na, K, HCO₃, Cl, F, SO₄, NO₃), and heavy metals (Fe, Mn, Zn, Cu, Cd, Cr, Ni, and Pb) were integrated. The application of the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) modeling was integrated in order to categorize the groundwater quality based upon five categories of CCME WQI as; Excellent (95-100), Good (80-94), Fair (65-79), Marginal (45-64) and Poor (0-44). The criteria limits of the parameters of the quality index were in accordance with Bureau of Indian Standards ascribed for the suitability for drinking water purposes. The seasonal distribution of groundwater quality inferred that majority of the samples in all the respective seasons were falling under marginal (45-64) category with 46.1% of the samples in summer; 65.3% in post-monsoon and 92.3% in the winter season. The results elucidated that groundwater conditions often deviate from desirable levels and groundwater quality with respect to drinking water purposes was critically impaired. As one of the effective tools, CCME WQI has widely facilitated in registering the health of the water quality and ensures sustainable management of the water resources in relation to exceeding parameters as per their specified limits.

Keywords: *Groundwater quality, drinking suitability, CCME WQI, BIS, Ghaziabad district.*

INVESTIGATING GROUNDWATER CONDITION AND SEAWATER INTRUSION STATUS IN COASTAL AQUIFER SYSTEMS

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Abstract

Providing sustainable water supply for domestic needs and irrigated agriculture is one of the greatest challenges for the 21st century. This challenge is more daunting in coastal regions. Groundwater plays a pivotal role in addressing this challenge and hence, it is under growing stress in several parts of the world. To address this challenge, proper understanding of groundwater characteristics in an area is essential. In the present study, spatio-temporal analyses of pre-monsoon and post-monsoon groundwater levels of two aquifer systems (leaky confined and confined) were carried out. Trend analysis of seasonal groundwater levels of the two aquifers systems was also performed using Mann-Kendall test, Linear Regression test and Innovative Trend test. Finally, the status of seawater intrusion in the two aquifers was evaluated using available groundwater-quality data. Considerable spatial and temporal variability were found in the seasonal groundwater levels of the two aquifers. Further, decreasing trends were spotted in the pre-monsoon and post-monsoon groundwater-level-time series of the leaky confined and confined aquifers, except pre-monsoon groundwater levels in Contai-I, Deshpran and Ramnagar-I blocks, and the post-monsoon groundwater level in Ramnagar-I block for the leaky confined aquifer. The leaky confined aquifer in Contai-I, Contai-III and Deshpran blocks, and the confined aquifer in Nandigram-I and Nandigram-II blocks are very vulnerable to seawater intrusion. There is an urgent need for regular monitoring of groundwater levels and groundwater-quality in both the aquifer systems, which can ensure efficient management of groundwater reserves.

Keywords: *Time series analysis, Trend detection, Dynamic groundwater reserve, Seawater intrusion, Coastal aquifer*

FLOW THROUGH FRACTURED ROCKS

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Abstract

Generally, groundwater flow rate varies spatially through the volume of fractured rock. This is attributed to their fundamental characteristic of spatial variation in hydraulic conductivity. Therefore, number of traditional methods is used for characterization of porous-media, which holds limited significance in case of fractured rock aquifer systems. Hydraulic conductivity is proportional to the cube of aperture according to parallel plate model and it can be applicable for smaller flow rates. In this study, series of laboratory experiments have been conducted for unconfined groundwater flow in a single fracture, which is non-Darcian turbulent flow. Scale dependency of hydraulic conductivity for fully developed turbulent flow in a single fracture for different fracture apertures, surface roughness and hydraulic gradients have been analysed.

Keywords: *fractured rock, hydraulic conductivity, experimental study, non-Darcian flow, aperture variation*

NEXUS BETWEEN DROUGHT IMPACT AND STRESSED GROUNDWATER RESOURCE IN BARIND TRACT, BANGLADESH: AN ANALYTICAL EXPLORATION

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Abstract

In present study, multi-step methodology is adopted to identify impact of drought along with variable hydro-climatic factors and to find out the mechanism for stressing conditions of depleting groundwater resource in the Barind Tract, NW Bangladesh. The area receives almost 39% less rainfall than national average (2,456 mm) with declining trends in long run. Rainfall deficit along with frequent dry spells start in October-November and continue till May requiring irrigation for this lengthy period. During 1980-2017 the area experienced twelve moderate-extreme (Class-**B**) agricultural droughts. Increasing depleting trend of groundwater-level (GWL) during rainy season indicates unsustainable groundwater withdrawal triggering drought, since regaining water-level depth corresponds with rising *SPI* values and vice-versa. Moreover, statistically significant increasing groundwater Abstraction trend influences rapid depletion of groundwater resource. Influence of land-cover patterns on groundwater drought shows that evapotranspiration and rainfall deficits determine meteorological drought showing direct relation with groundwater recharge deficits. Land-cover change has small effect on groundwater recharge and may not be the main cause of GWL depletion. Groundwater depth and GWL deficit (drought) are continuously increasing correlating with meteorological drought or recharge anomalies. Finally, efficient irrigation management is essential to reduce the growing pressure on groundwater resources and ensure sustainable water management.

Keywords: *Drought impact, SPI, Stressed groundwater resource, Barind Tract, Bangladesh*

SUBSURFACE CHARACTERIZATION USING ELECTRICAL RESISTIVITY TOMOGRAPHY

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Abstract

Most traditional method is generally used for obtaining the subsurface information data by drilling observation wells but this method is expensive and therefore inefficient. The use of electrical resistivity tomography (ERT) is relatively inexpensive geophysical method and groundwater survey cost can be improved by reducing bore holes. Now days, ERT is more popular because of its relationship between electrical resistivity or conductivity and aquifer properties (i.e., types of soil, water content, Mineralization in the groundwater, etc.). This method is non-invasive and also sensitive towards the heterogeneity of the aquifer. In this study, an attempt has been made to conduct field experiments at different sites near Roorkee region. Different electrode array configurations (Schlumberger, Wenner and dipole-dipole etc.) were used for data collection. Results obtained from ERT were compared with borehole data regarding aquifer characterization at different depth. This study demonstrates the usefulness of electrode (efficiency and less time consuming).

Keywords: *Electrical resistivity tomography; Groundwater; Electrical conductivity; Aquifer characterization*

HYDRO-GEOCHEMISTRY AND APPLICATION OF WATER QUALITY INDEX (WQI) FOR GROUNDWATER QUALITY ASSESSMENT OF BIJNOR DISTRICT, INDIA

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Abstract

In the present study, the geochemical characteristics of groundwater have been studied based on water quality indices, piper trilinear diagram. The groundwater samples were also assessed to check the suitability for drinking water as per BIS standards. Twenty-five groundwater samples were collected from the Bijnor district, Uttar Pradesh, India during the month of April, 2018. These samples were analyzed for pH, electrical conductivity, total dissolved solids, carbonate, bicarbonate, chloride, sulfate, nitrate, nitrite, phosphate, calcium, magnesium, sodium, potassium, total hardness, and fluoride and trace metals. The results revealed that most of the water quality parameters are within the permissible limits except iron and manganese. The Piper trilinear diagram shows that groundwater is Ca-Mg-HCO₃ type. Ca⁺⁺ and HCO₃⁻ are the dominant ions among cations and anions, respectively. The Water Quality Index (WQI) is found in the range of 71 to 86, which indicates that the samples fall under the fair to good category. Water needs some treatment for the locations where the WQI is found below 75.

Keywords: *Groundwater, Water quality index, Piper diagram, Bijnor*

**CONTROLLING FACTORS AND MECHANISM OF GROUNDWATER QUALITY
VARIATION IN SEMI-ARID REGION OF SOUTH INDIA: A WATER QUALITY
INDEX (WQI) AND HEALTH RISK ASSESSMENT (HRA) APPROACH**

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Abstract

Groundwater is the primary source for drinking and household needs. Its quality is a big issue in the three aquifers, which are mostly of human health concern. Many developing regions suffer from lack of safe drinking water, thereby health problems arise in many parts of the regions, and Telangana state is one of them. For this reason, 194 groundwater samples were collected and analyzed for fluoride, nitrate, chloride, and other physicochemical parameters. The concentrations of fluoride (F^-), nitrate (NO_3^-), magnesium (Mg^{2+}), total dissolved solids (TDS) and total hardness (TH) are above the acceptable limits for drinking purposes, prescribed by the World Health Organisation (WHO). The higher concentrations of fluoride and nitrate in drinking water cause health hazards, and above 50% of the groundwater samples are not suitable for drinking purposes with respect to fluoride and nitrate. Weathering of rocks and dissolution of fluoride-bearing minerals can be a cause for higher fluoride concentrations, while anthropogenic sources are one of the major reasons for higher nitrate concentrations in the study area. Groundwater suitability for irrigation suggests that more than 90% of the groundwater sampling locations are suitable for irrigation. In addition, health risk assessments were evaluated by using the United States Environmental Protection Agency (US EPA) model, to determine the non-carcinogenic risk of fluoride and nitrate in drinking water for adults (females and males) and children. The ranges of hazard index in all sampling locations are varied from 0.133 to 8.870 for males, 0.146 to 10.293 for females, and 0.419 to 29.487 for children, respectively.

Keywords: *Hydrochemistry, groundwater quality, drinking usages, health risk assessment*

ASSESSMENT OF DECADAL VARIABILITY AND TREND ANALYSIS OF GROUNDWATER FOR KOYNA RIVER BASIN, MAHARASHTRA, INDIA

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Abstract

Water is a precious element of life for society. The growing population increases overstress on available resources of water. Water resources management is very important for the sustainable growth of developing society as it is becoming a crucial resource in the present day. Earlier, the use of groundwater was not significant, the occurrence of frequent droughts, limitations of the availability of surface water, very low institutional finance for surface water irrigation lead toward exploration of groundwater for domestic, agricultural and industrial use. The over-Abstraction of groundwater threatened the long term effect on its availability. The availability of groundwater is uneven in space, time and depth due to heterogeneous lithology and variability of rainfall. Therefore, understanding the availability of groundwater, its spatiotemporal variation in the region is important for estimation of extraction of groundwater in relation to rainfall trend, population growth, and multi-use. In present work, the groundwater level trend at different observatory well has been assessed within the Koyna River catchment for two decades. The rainfall variation in the Koyna river basin was analyzed and compared with the groundwater level. The statistical parameters have been estimated for long term groundwater levels and a relationship between rainfall and groundwater level was developed. The groundwater level assessment is very useful for planners, policymakers, farmers, and other stakeholders for categorizing watershed, preparation, implementation water extraction policy, and mitigation measures. Also, the installation and fixing new bore well and its depth, future water availability and cropping pattern such study plays a key role.

Keywords: *Koyna River, Water level Fluctuation Method, Groundwater Trend, Decadal Assessment*

DOMINANT PROCESSES CONTROLLING MIGRATION OF POLLUTANTS FROM SURFACE WATER TO GROUNDWATER

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Abstract

Understanding the factors controlling contaminant transport across surface water - groundwater (SW-GW) is needed to construct predictive models of elemental cycling, contaminant fate and transport under future environmental scenarios. Spatial and temporal variation of SW-GW mixing chemistry is a key component of biogeochemical functions in these systems. The present study attempted to delineate dominant processes controlling contaminant migration from SW to GW in the vicinity of Hindon River. SW, GW and drain samples were collected from vicinity of Hindon River during pre-monsoon and post-monsoon season. The trace elemental chemistry (As, Cu, Ni, Cd, Pb, Hg, Zn) and BOD, Cl⁻, were analysed. Presence of As (0.16 mg/l), Hg (0.05 mg/l), Cd (0.01 mg/l) and Pb (0.01-0.05 mg/l) denote unnatural input of elements in SW and GW. Since, study area is highly populated with industries and agricultural activities which contribute to altitudinous levels of contaminants to SW and GW irrespective of seasons. Parallel increase in concentration of Pb, Ni, Cu, Zn and Cd in SW and GW at elevated GW-extraction areas shows migration of contaminants from SW to GW. Principal Component Analysis adumbrates contaminant variation are pollution load from tributaries, redox condition and microbial activity. Dominant processes of pre-monsoon are enhanced microbial activities and over exploitation of GW while post-monsoon are confluence of tributaries and redox environment. Comprehensively, study reveals dodgy situation of GW due to interaction / mixing of extremely polluted SW (Hindon River) and over exploitation of GW.

Keywords: *Surfacewater-Groundwater interaction, trace elemental chemistry, geochemical processes, contaminant transport.*

A PILOT POINT BASED TRANSIENT HYDRAULIC TOMOGRAPHIC INVERSION- SYNTHETIC STUDY

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Abstract

To understand and study the flow and availability of groundwater, the mapping of subsurface heterogeneity is an essential, albeit challenging task. Hydraulic Tomography (HT) has proven to be highly successful in accomplishing the said task. HT attempts to solve the inverse problem of determining the hydraulic conductivity (K) and specific storage (S_s) distributions from the drawdown data obtained from multiple cross-hole pumping tests. This inverse problem is highly parameterized and underdetermined. To reduce this indeterminacy pilot points are used in conjunction with geo-statistical interpolation. In this study, a two-dimensional multi-layered granitic aquifer typically found in the Deccan region of India is synthetically created using HydroGeoSphere (HGS). Cross-hole pumping tests are simulated, and the resulting data from the wells are inverted simultaneously to obtain the hydraulic parameters at the locations of pilot points and geostatistical interpolated to obtain K and S_s tomograms of the aquifer. The inversion is done by the Parameter Estimation (PEST) code. The number of pilot points is varied to understand the effect of this number on the solution. The optimal number corresponding to the least validation error is used to determine the K and S_s distribution of the aquifer. The results are compared with the direct inversion of data without using pilot points to check the efficiency inversion schemes.

Keywords: *Hydraulic tomography, Pilot points*

IMPACT OF MUNICIPAL SOLID DUMPSITE ON GROUNDWATER QUALITY NEAR THE DINDIGUL CITY USING GIS APPROACH

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Abstract

Sanitary land filling is the most significant part of waste management. The direct disposal of solid waste is one of the major urban environmental problems in the developing countries as it is difficult to find space for landfill/dumpsites. However, improper management and operation of landfill is creating a severe environmental impact. Uncontrolled disposal of MSW causes considerable environmental pollution, besides being directly harmful to public health. In the present study, leachate percolation impacts on groundwater quality were estimated from an landfill site Dindigul, Tamil Nadu. Eighteen parameters consisting of pH, EC, TDS, TA, TAL, TH, Cl, NO₃⁻, PO₄³⁻, Mg, Na, K, Zn, Mn, Fe, Cd, Ag and Pb were found to be the main indicators of groundwater pollution caused by landfill leachate percolation. There is no serious heavy metal contamination in this area. The WQIs indicated that 26% of the water samples were unsuitable for consumption, while other samples were in the good, very good and excellent categories. The results show that the landfill leachate has a minimal impact on the groundwater resource. Pollution source will be less vulnerable when the depth and distance of the well is increases from the dumpsite.

Keywords: *MSW, landfill, groundwater resource*

GROUND WATER MANAGEMENT PROSPECTS FOR LAKSHADWEEP ARCHIPELAGO, INDIA

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Abstract

Ground water is the only available natural source of fresh water for all uses Lakshadweep, which comprises of 10 inhabited small islands having fragile eco-system. It occurs as thin floating lenses in the coral sands within top few meters from the surface and getting replenished every year during rains and are being tapped by shallow open wells fitted with electric pumps. Due to sandy surface, the entire water during the rains gets percolated immediately without generating run-off. The stage of ground water development for the group of islands 66 % (as on 2017) and the majority of the islands are in “Safe” category. Due to fast-growing developmental activities, particularly, building constructions has resulted boundless stress on ground water aquifers. Excessive pumping through electric pumps has brought alarming situation in some of the islands. including deterioration of water quality due to up-coning. Ground water contamination by pathogens has been recorded in almost all the islands. Integrated water management approach involving rainwater harvesting, desalination of brackish water (Low Temperature Thermal Desalination), judicious use of water for construction activity (temporary dug ponds with polythene laying) will help to sustain the limited fresh water resources stored in the aquifers.

Keywords: *Ground water, open wells, rainwater harvesting,*

DEVELOPMENT OF GROUND WATER QUALITY INDEX FOR THE STATE OF UTTAR PRADESH, INDIA

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Abstract

Water quality of various ground water systems has been affected because of anthropogenic sources directly or indirectly. Many a times this water is contaminated because of presence of several quality parameters. In such situations, interpretation of large sets of data makes it difficult for the policy makers to classify the water quality in a single term (e.g. very good, good, fair, poor, etc.). A water quality index is a tool for summarizing large amount of water quality data into a single term for reporting to the policy makers and public in a comprehensive manner. It makes information more easily interpretable than numeric values. In this study, a ground water quality index has been developed for the state of Uttar Pradesh, India. The data of ground water quality of nine parameters was obtained for 751 locations spread across all districts of the state of Uttar Pradesh from secondary source, for a four year period i.e. from 2013 to 2017. These parameters were pH, total dissolved solids, Ca, Mg, Cl, NO₃, SO₄, total hardness and fluoride. The methodology comprised of 4 steps: a) parameter selection, b) development of rating curves to transform the concentrations of water quality variables into quality scores, c) use of Principal Component Analysis to extract the parameters into three components and d) use of aggregation technique to produce a final score. The implementation of these indices will help the water resource agencies in India to develop sustainable strategy for development of ground water resources.

Keywords: *anthropogenic sources, comprehensive manner, water quality*

INFLUENCE OF RAINFALL ANOMALIES ON THE GROUNDWATER STORAGE IN CAUVERY RIVER BASIN, INDIA

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Abstract

Cauvery being one of the largest river basins in southern India with very high surface and groundwater potential is shared predominantly by the states of Karnataka and Tamil Nadu. The River Cauvery is the major source for meeting the drinking water supply of many of cities in the above-mentioned states as well as supplying water to irrigation and industrial activities. Irrigated agriculture and associated sectors provide employment to 2.3 million people living in the basin. This paper aimed at understating the trends in groundwater storage in the basin by performing the statistical Theil Sen non-robust linear regression and non- parametric Mann Kendall test on the observation well data maintained by the Central Groundwater Board (CGWB). The presence of non-stationarity in the groundwater storage anomalies has been analysed for classifying the basin into mild to severely affected region of groundwater storage decline. Further analyses on the trends in rainfall considering both spatial and temporal scales for determining the linkage to groundwater storage was explored. Based on our analysis, a clear decline was found in the mean rainfall and groundwater storage, especially in the downstream region of the basin. These results reinforce the need for effective groundwater management practices in the basin.

Keywords: *River basins, groundwater storage*

STATISTICAL APPROACHES TO DETERMINE THE GEOCHEMICAL ORIGIN OF GROUNDWATER OF VISHWAMITRI RIVER BASIN, GUJARAT, INDIA

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Abstract

Detailed geochemical investigation of groundwater of Vishwamitri river basin have been carried out to understand the overall quality of groundwater and to determine different mechanisms involved in its evolution. In present study, 60 groundwater samples are analysed for 25 parameters; pH, EC, TDS, total hardness, total alkalinity, Na^+ , K^+ , Ca^{2+} , Mg^{2+} , NO_3^- , SO_4^{2-} , Cl^- , HCO_3^- , PO_4^{2-} , F^- , Fe, Zn, Mn, No, Li, Sr, As, Se, Th and V. Hydro-chemical facies analysis reveals that there are 3 types of hydro-chemical facies (i) HCO_3^- -rich mixed facies, (ii) Cl-rich mixed facies and (iii) Saline water facies and major part of study area is covered by saline water facies. Gibbs diagrams reveal that the chemical composition of groundwater is dominantly controlled by evaporation process. X-Y plotting of (Na^+) vs (Cl^-) also supports this statement. Principal Component Analysis indicates that parameters like Cl, SO_4 , Ca, Mg, Na, Sr and TDS are the most significant parameters which control the groundwater chemistry of the area and mechanisms such as natural mineralization, rock-water interaction due to long residence time and anthropogenic activities, mostly agricultural activities are the main mechanism that determines the groundwater chemistry. Hierarchical Cluster Analysis indicates that groundwater is clustered into three different categories, indicating mechanisms like dissolution of carbonate minerals, rock-water interaction and ion-exchange processes are responsible for evolution of groundwater.

Keywords: *Groundwater; Geochemical origin; Hydro-chemical facies; Principal Component Analysis; Hierarchical Cluster Analysis*

GREEN SYNTHESIS OF IRON NANO PARTICLE USING TREATMENT OF WASTEWATER BY MARINGA OLEIFERA LEAFS

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Abstract

Biologically dependable processes for the green synthesis of moringa Fe nanoparticles (Fe NPs) were developed in Nano science and nanotechnology. The results obtained in the present study showed that green synthesis Fe GAC Moringa can efficiently remove methylene blue 98% in the aqueous solution. In this present paper, green synthesis of Fe NPs was performed from aqueous ferric chloride using the fresh moringa leaves extract. The formation of Fe NPs as observed by the change of colour from colourless to dark brown by the addition of ferric chloride in to leaves extract. The synthesized Fe NPs were characterized by UV.

Keywords: *nanoparticles, green synthesis, ferric chloride*

GROUNDWATER FLOW MODELLING OF A MICRO-WATERSHED IN THE UPLAND AREA OF EAST GODAVARI DISTRICT, ANDHRA PRADESH, INDIA

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Abstract

In view of the progressive decline of groundwater levels in the majority of non-command upland area in the East Godavari district, Andhra Pradesh state, India, there is an urgency to augment groundwater in the non-command upland areas. Groundwater flow model is constructed for a micro-watershed of 50 km² namely 'Konda Kalava watershed' of 'Suddeggedda river basin' located in the non-command upland area of East Godavari district. The steady state groundwater flow model simulated to seven observation wells and calibrated for the month of April, 2018. The objective of the model is to assess input and output stresses and to identify the over-stressed areas within the basin. The water budget analysis has revealed that the total groundwater extraction by pumping wells is 83.3% and evapotranspiration loss is 5.7% of the total groundwater recharge in the basin. The groundwater flow following the topography and is towards the mainstream with a maximum velocity of 0.4 m/day. The results revealed that the southern part of the basin is experiencing huge aquifer stress due to over-dependence on deep bore wells. It is recommended that, for at least one season, the most affected dry areas which are under paddy cultivation are to be promoted Irrigated Dry crops such as maize and jowar. It is also suggested that, due to local high salinity in and around Vannepudi village at the central part of the basin, the horticulture cultivation is to be promoted by increasing the artificial recharge structures at suitable areas in and around Vannepudi village in order to improve the groundwater quality in terms of high salinity and also to rise the groundwater table in the southern part of the basin.

Keywords: *Groundwater, flow modeling, micro watershed, East Godavari*

ASSESSMENT OF AQUIFER CHARACTERISTICS IN A TYPICAL KHONDALITIC AQUIFER IN THE NORTHERN PARTS OF EASTERN GHATS OF INDIA

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Abstract

Estimation and analysis of aquifer properties have been carried out in Kandivalasa river sub basin comprising of a typical Khondalitic terrain in the Vizianagaram district of Andhra Pradesh, India by conducting fourteen pumping tests in the basin. The Transmissivity values are obtained in the range of 26–304 m²/day and the Storativity values are in the range of 0.00029–0.0091. Lower Transmissivity and Storativity values are observed where the kaolinisation (highly weathered material) is more predominant at the main Kandivalasa river and vice-versa. Groundwater potential areas are identified with less fluctuation of water table. Two-Dimensional resistivity imaging has also revealed that the kaolinisation is increasing towards the stream which is responsible for well failures and reduction of Storativity all along the main stream. Based on Transmissivity distribution, eastern part of the study area is identified as high groundwater potential zone while most of the western side of the basin is having less groundwater potential zone. To delineate the litho-units of the formation and the hydraulic properties of the khondalitic aquifer, a bore well is drilled in the basin. The well logging studies are carried out in the drilled bore well. All the well logging results are well correlated with the drilling results. The fractured zones having the resistivity value of 30 Ohm-m are identified with the lateral resistivity logging and the boundaries between layers are obtained from the SP logging. The well logging investigations have revealed that the aquifer porosity is of the order of 28% in the region.

Keywords: *Well logging, resistivity imaging, SP logging*

**SITE SELECTION FOR BOREHOLE DRILLING IN FRACTURED ROCK TERRANE:
A STRUCTURAL AND MULTI ELECTRODE RESISTIVITY IMAGING (MERI)
STUDY**

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Abstract

In northern Gujarat, local communities depend on fractured Precambrian basement rocks as the primary source of water supply. The hydrogeology of these aquifers is poorly understood and the boreholes are frequently placed with little appreciation of the local fracture systems. Increasing demand for water puts stress to explore groundwater from less reliable sources of basement rocks and hence, makes it vital to identify high yielding hydrogeological zones. The present study comprising of structural data featuring fractures/joints and geoelectrical survey (Multi-electrode resistivity imaging) has been done by fieldwork. The field area comprises gabbro norite basic granulite series, granite, cataclasite and mylonitic type of rocks and due to late stage brittle fracturing, these rocks have been fractured. These fractures are mainly reactivated fractures which are controlled by pre-existing fractures in the shear zone and control the groundwater circulation. The fractures in the study area are oriented mainly in NW-SE, NE-SW, and E-W directions. Based on structural study, electrical resistivity tomography (ERT) has been carried out along and across the lineaments to delineate the subsurface fracture geometry. This helps to pinpoint subsurface fracture system and hence potential borehole site. For the present study, ERT were carried out at 27 diverse locations and among nine (09) prominent deeper fracture zones has been identified which are correlated with surface fracture data for pinpointing potential borehole site for long term use.

Keywords: *multi-electrode resistivity imaging, resistivity tomography, hydrogeological*

CHARACTERISATION AND EVALUATION OF GROUNDWATER RESOURCES OF KHETRI COPPER MINING REGION, INDIA

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Abstract

Groundwater resources in the semi-arid region of Khetri copper mines are characterized and evaluated for irrigation and hydrogeochemical processes. Groundwater samples were analysed for major cations (Ca^{2+} , Mg^{2+} , Na^+ and K^+) and anions (HCO_3^- , Cl^- , SO_4^{2-} and NO_3^-) and also for heavy metals. For heavy metals, samples were divided in two categories: *first* acidification followed by filtration (AF) and *second* filtration followed by acidification (FA) methods. Significant variation in concentration of Fe and Zn is observed among AF and FA indicating the dissolution of solids (precipitates or nodules) or minerals due to anthropogenic disturbances in the region. Mn, Cu, Co, Ni and Pb do not show variation in concentration of AF and FA. The dominance of hydrogeochemical facies such as Ca-Mg-Cl, Ca-HCO₃ and Na-Cl in the region is attributed to weathering and anthropogenic activities. The observed permanent hardness and salinity in groundwater of the region is due to the dominance of Ca-Mg-Cl and Na-Cl respectively. Higher magnesium hazards (MH) and permeability index (PI) suggest its unsuitability for irrigation. Thus, the deteriorated water quality of the study area warrants an urgent need for proper planning and systematic management of mining waste.

Keywords: *Anthropogenic, hydrogeochemical*

GROUNDWATER RESOURCE ASSESSMENT IN METRO AREAS

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Abstract

As per the guidelines of GEC 1997, the watershed is a unit for groundwater assessment in hard rock terrain, for alluvium resource assessment is based on block wise. The geographical area of the watershed for resource assessment is divided into groundwater non-worthy area (hilly region having slope percentage more than 20%) and groundwater-worthy area. The groundwater worthy area (area suitable for groundwater recharge) is further divided into saline groundwater, canal command and canal non-command area and a separate resource assessment is made for each area. Out of the groundwater-worthy area in some of the watersheds in metros, some area is covered with over-urbanization, extension of rural habitation, industrialization and a large area covered with old water bodies. Further, some area is occupied with the National Highway, Expressway, State Highway and other major roads are in a long strips / linear structure in a few meters in width and a few Kms to tens of Kms in length. Although all these tiny manmade structures cover small areas with impervious surface tar roads, cement roads and metal roads, which hinders the percolation of water, reduces some recharge to ground water and favour for fast runoff with a great speed. This would decreased in recharge to groundwater up to some extend and increase in draft due to large number of drilling of deep borewells / tubewells in new habitations, new constructions are used for drinking, domestic constructions and other purposes in which non available or in adequate during summer or in scarcity area. Ultimately it results in some change in stage of groundwater development and change in categorization of watersheds. Impervious surface of the watershed should be deleted from the areas of suitable for groundwater resources. Considering all these parameters, it is suggested that groundwater resources assessment it should be made separately on the GEC 1997 guidelines in metros areas based on mini, micro watershed/ward wise. Irrespective of geological formations. An attempt has been made for groundwater assessment in metro areas.

Keywords: *GEC 1997, Groundwater Assessment, metro, urban area recharge, draft groundwater worthy areas, man-made structures, developments*

EVALUATION OF PHYSIO-CHEMICAL CHARACTERISTICS OF SOIL AND ESTIMATION OF DEVELOPMENT STAGE OF GROUNDWATER UTILIZATION IN THE DHORA CANAL COMMAND

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Abstract

The present study was conducted to investigate the physico-chemical characteristics of soil and status of water resources of the Dhora Canal system. Study area lies in the Dhora canal command located in Rudrapur Block of Udham Singh Nagar district of Uttarakhand and Baheri Block of Bareilly district of Uttar Pradesh. The soil samples were collected from 15 locations, in the command of three minors *i.e.* Bhanga, Shahdaura and Sirsa, in the Dhora Canal Command at a depths of 0-20 cm, 20-40 cm and 40-60 cm. The Physico-chemical properties of the soils in the command, *i.e.* texture, pH, EC, available Ammonia nitrogen, potassium and micro-nutrients viz Zinc, Copper and Manganese, were determined. The textural analysis was done using Bouyocos hydrometer method, as given by Black (1965). The nutrients analysis was done using Lamotte smart 2 colorimeter. The soils were Loamy Sand except three places where it was Sandy Loamy for 0-20 cm depth in the command. Soils were found Loamy Sand at 20-60 cm depth at all places in the command and the soils in all depth were found is acidic in nature. Different groundwater recharge components viz. recharge due to rainfall, recharge due to return flow of irrigation water, recharge due to seepage from canals, and recharge due to seepage from tanks and ponds were calculated. Similarly, groundwater discharge components viz. groundwater draft for irrigation, domestic use, industrial use and livestock use were also calculated. The block wise as well as for total command, stages of development of groundwater utilization were evaluated, for 21 years, by calculating the net recharge and net discharge in the study area. Rudrapur block remained under safe category of development stage of groundwater utilization with 40.55% in 1995 to 60.16% in 2015 while Baheri block was in safe category in the year 1995 and over-exploited category in the year 2015. The Dhora Canal Command as a whole, the development stage of groundwater utilization was found to be under safe category during the year 1995 while in the year 2015; it was found to be under semi-critical category of groundwater utilization stage. Therefore, in the Dhora canal command area the groundwater is being pumped more than the recharge. Considering the changing groundwater scenario, re-evaluation of resources need to be carried out periodically.

Keywords: *Canal Command, Groundwater utilization, Physio - chemical properties, Resources*

ANALYZING THE IMPORTANCE OF GROUNDWATER ENERGIES IN WELL CAPTURE ZONES

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Abstract

Groundwater capture zone analysis has become necessary with the unsustainable levels of exploitation and pollution. However, there has been fewer advancements and research towards the application of energy concepts to groundwater flow, which in contrast as any other physical process in nature directly governs the very motion of groundwater. Karney and Seneviratne (1991) developed a one-dimensional energy equation to study the dynamic behavior of confined aquifers. The equation summarizes the total energy into frictional dissipation and change in the internal energy, thereby characterized the response of an aquifer to given excitations. This paper model a two-dimensional homogeneous isotropic confined aquifer with the application of the energy equation. The frictional dissipation was found dominant over the rate of change of internal energy and thus highlighted the quasi-steady state behavior of the aquifer, despite the adopted pumping pattern that changes with time. The energy approach, along with the capture zone delineation facilitated insights into sub-regions having pronounced transient behavior, though very trivial, compared to the entire region within the capture zone and model domain.

Keywords: *Energy equation, confined aquifer, model*

**ESTIMATION OF GROUNDWATER AND ITS POTENTIAL IN BASALTIC TERRAIN,
CASE STUDY OF SONDEV AND PAHEGAO VILLAGES OF JALNA DISTRICT,
MAHARASHTRA**

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Abstract

The surface water available in dams, Storage Tanks, Percolation tanks etc. can be measured by particular method that has been developed long back. Immediately after rainfall volume of the water stored can be determined, but the technique for Estimation of water occupying joints, cavities, and porespace of subsurface formations is not yet available. Groundwater estimation depends on the type and hydro geological characters of the subsurface rocks. The main aim of this research work is to establish appropriate methodology for measurement of groundwater in our challenging basaltic terrain for accurate estimation of groundwater. The study area lies in villages around Jalna city in Maharashtra. The Jalna watershed has semi-arid climate and is characterized by low precipitation and high evaporation. When different hydrological conditions from the study area are analyzed to solve various affecting factors in occurrence of ground water, then it was observed that the study area mostly consists of low permeability zone of partially weathered and broadly spaced jointed Compact Basalts. The basalts at few places are having high permeability zone due to occurrence of highly weathered sheet jointed amygdaloidal basalt. The quantity of occurrence of groundwater depends on thickness and extent of sheet jointed portion. As groundwater plays very important role in most of the development activity it has become need of the hour to conserve the groundwater in that region only where it is received by means of rainfall. Most of the rainwater runs away in the form of rivers and streams which is called as runoff. The maximum quantity of water return back to the atmosphere by process of evaporation and very small quantity of water percolates below the surface if geological conditions are favorable and become groundwater. This paper is result of hydro geological survey carried out in the villages Sondev and Pahegao of Jalna District in Maharashtra for estimation and potential of Groundwater in Basaltic Terrain by establishing proper methodology.

Keywords: *Groundwater, Estimation, Methodology, Research work, Basaltic Terrain, Dams, Percolation Tanks*

TS - 2

(SOIL-WATER POLLUTION, ISOTOPE HYDROLOGY)

Keynote Paper

IDENTIFYING CURRENT KNOWLEDGE GAPS IN UNDERSTANDING INTERACTION OF MIXTURE OF ENGINEERED NANOMATERIALS TO SOIL SYSTEMS

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Abstract

The aim of this work is to improve understanding on long-term interactions of nanomaterial with natural and undisturbed soil during land application of nanomaterial-contaminated sludge. A review of published reports indicated that currently, information about fate of mixture of metal oxide nanoparticles in soil is not available. It is important to study co-transport of engineered nanomaterials (ENMs) in porous medium as environmental media is expected to contain more than one type of ENMs which might lead to different fate and transport of different ENMs, their associated ions through porous medium. Although some studies have focused on this aspect, none of these studies have focused on understanding effect of co-transport of ENMs in porous medium on their retention and breakthrough profiles. Further it is also important to know how this condition influences column operating parameters. This study emphasized the need for obtaining this information as it can be useful in improving understanding on effect of sludge on soil after land application with regards to mixture of nanomaterials and to know its potential of groundwater contamination. Finally, it will help in deciding whether the practice of land application of contaminated sludge as soil-amendment materials is safe to soil environment and to groundwater.

Keywords: *Engineered nanomaterials; Impact on soil; Groundwater; Leaching.*

**SOURCE IDENTIFICATION OF SULPHATE CONTAMINATION USING
HYDROGEOCHEMICAL INVESTIGATION: A CASE STUDY OF DISTRICT
BEMETARA, CHHATTISGARH, INDIA**

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Abstract

Ground water situation in different parts of India is diversified because of variation in geological, climatological and topographic set-up. Geo-environmental conditions have a marked influence on the groundwater quality. Hydrogeochemical studies relevant to the water quality explain the relationship of water chemistry to aquifer lithology. Such relationship would help not only to explain the origin and distribution of dissolved constituents but also to elucidate the factors controlling the groundwater chemistry. The groundwater of Bemetara district is affected by sulphate contamination reported by Public Health Engineering Department, Durg. Therefore, Bemetara district is selected for the study of sulphate contamination in ground water. Fifty-three ground water samples during pre-monsoon (May 2018) were collected from the study area and analyzed for hydro-chemical parameters. Hydro-chemical data processed to understand the geochemical processes controlling the chemical composition of groundwater using Scatter Plots and Gibbs Plot and indicate that the relatively high contribution of (Ca+Mg) to the total cations (TZ⁺) and high (Ca+Mg)/(Na+K) ratio indicate that carbonate weathering is a major source of dissolved ions in the groundwater of the study area. The plot of (Ca+Mg) vs HCO₃ for most of the samples indicates that the excess of Ca+Mg over HCO₃ indicate an extra source of Ca and Mg. This requires that a portion of the (Ca+Mg) has to be balanced by other anions like SO₄ and/or Cl. Plot of (Ca+Mg) vs HCO₃+SO₄ shows the reverse ion exchange process controls the chemistry of groundwater of the region, which may be due to the excess of Ca+Mg. The plot of Na vs Cl indicates contribution of silicate weathering through the release of Na. Further, plot of Ca, Mg, Na and K v/s SO₄ indicates high relationship between Ca and Mg with SO₄ ($R^2 \geq 0.7$). It can be inferred from this discussion that the main sources of high concentration of sulphate in the ground water of district Bemetara may be due to dissolution of gypsum veins present within Maniyari shale formation existing in the study area.

Keywords: *Groundwater, Hydrogeochemical process, Bemetara, Scatter Plot*

THE POSSIBILITY OF ENGINEERED NANOPARTICLE OF BECOMING AS EMERGING CONTAMINANTS

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Abstract

The application of various engineered nanoparticles (ENPs) has increased significantly given that the small size of nanoparticles (NPs) leads to very large specific surface area (SSA) of NPs. The increase in the application of nanotechnology has resulted in an increase in the production of ENPs. Excessive production of different ENPs will eventually result in the release of those ENPs into the environment. Thus, there is a chance that these ENPs may act as a potential source of emerging contaminants when released into the environment. The potential risk due to exposure of ENPs through the groundwater is likely to depend on the fate and transport behavior of ENPs in the natural porous media. In the environmental condition, it is expected that one or more ENPs are likely to mix together before and/ after it enters in the porous media. Thus, it is very important to understand the co-transport behavior of ENPs through porous media under varying solution chemistry relevant to real groundwater condition. Considering these facts, the objective of this study, are to evaluate the cotransport behavior of nZnO along with iron oxide (nFexOy) nanoparticles through the saturated porous media in the presence and absence of humic acid (HA) under varying pH. Furthermore, long term fate of those ENP-mix in the porous media under constant head condition is also assessed. To achieve this objective a series of column experiments are performed where the nZnO-nFexOy-mix is injected in the porous media in the presence and/ absence of HA and under varying pH (8 to 6.5). Furthermore, fir the the long-term co-transport study the water is passed through a sand packed porous media containing nZnO-ENP mix under a constant head condition for a longer duration (i.e., 100 PVs). The samples are collect at the outlet and analyzed for total zinc and iron concentration. The result shows that at pH 8, the nZnO particles elutedthrough porous media when injected as a single entity ($C/C_0 = 0.65$) and/ as a mixed suspension of nZnO-nFexOy ($C/C_0 = 0.57$) in the presence of HA and for the shorter duration. Slight decrease in transport of nZnO is observed in the presence of nFexOy, which is probably attributed by hetero-aggregation between nZnO-nFexOy and formation of bigger aggregates. With decrease in pH (i.e., 8 to 6.5) the co-transport efficiency of nZnO decreases drastically from $C/C_0 = 0.57$ to $C/C_0 = 0$, even though suspended in HA. This is likely due to decrease in the surface charge of particles from -43.9 mV to -22 mV at pH 8 and pH 6.5, respectively. It is important to

note that when the experiment is conducted for longer run, though at the initial stage no release of nZnO or nFe₃O₄ is observed, however at the later stage at around 40 PVs, those ENPs are observed to be release at the outlet. Overall, the results suggest (i) there is a high chance of groundwater contamination by nZnO-ENP mix at higher pH and in the presence of organic matter. (ii) Though at the lower pH (pH-6) not much nZnO is observed to be released in the water phase in short duration, however in the longer run there might have some chance of groundwater contamination by nZnO in lower pH condition as well. Furthermore, there is also a chance of dissolution of Zn²⁺ in the long run with the background water having a lower pH.

Keywords: *Nanoparticles, Emerging Contaminants, Colloid Filtration, Porous Media, Fate and Transport*

APPLICATION OF ENVIRONMENTAL ISOTOPES IN GROUNDWATER SALINITY STUDIES

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Abstract

Groundwater salinity – either coastal or of inland origin is a serious threat to mankind by causing health problems, diminishing agricultural yields and profits by destroying soils and its fertility, affecting livelihoods. In general, it is believed that the parts of the subsurface influenced by ‘meteoric water’ often young have fresh groundwater. In some cases, shallow water tables also cause salinity due to high evaporation in arid and semi-arid regions. Thus saline groundwater is found in stagnant/unused conditions. Salinity is also found at greater depths where groundwater has long residence times and under favourable conditions, there is a continuous dissolution of minerals over the time. It has also been found that the geographic distribution of saline groundwater is not fixed in time and there may be migration and/or mixing of these with fresh groundwater due to certain processes such as geological, meteorological, climatic- tsunamis, earth quakes, consolidation of compressible sediments; or factors like drainage, irrigation, groundwater pumping, etc. Due to these processes and factors saline water flows to the zones where the extraction of fresh water is at higher rate. As a result, groundwater salinity tends to expand in the fresh water zones. For monitoring of the saline water intrusion and assessing salinity there is a need of advanced hydrological research. Use of isotopes can play an important role in this aspect due to advantage of their wider applications in providing critical information for the improved management of water resources. In the present study, grid wise groundwater samples were collected from hand pumps and tube wells in south west Punjab and are being analysed for environmental stable isotopes ($\delta^{18}\text{O}$ and δD) to find out the probable saline water intrusion in the fresh groundwater of central Punjab.

Keywords: *Groundwater Salinity, Intrusion, Isotopes, Punjab*

STATUS OF EMERGING CONTAMINANTS IN GROUNDWATER: SOURCES AND EFFECTS

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Abstract

India is one of the major users of Groundwater with more than 65 % irrigated agriculture and 85% of the drinking water supplied through Groundwater resources. Groundwater pollution due to Emerging contaminants (ECs) is a major cause of concern. The study reviews the status of contamination of groundwater with ECs in India from various sources. Municipal wastewater spillage, overuse of Pesticides and Insecticides in agriculture fields, application of digested wastewater sludge as manure for soil conditioning, and seepage of excreta of farm animals treated with veterinary medicines are the major causes of introduction of ECs in the subsurface. Compounds with low Log K_{ow} value are more likely to be present in the groundwater. Based on the study on tracers, the presence of ECs in deep aquifers suggests input of younger water to deep aquifer. The residence time of various ECs can be significantly high which can have chronic effects on human health and negatively affect crop yield of the field irrigated with contaminated water. This underlines the need for monitoring ECs in Groundwater and find suitable ways to avoid the introduction of ECs in the subsurface in the first case.

Keywords: *Emerging Contaminants, Groundwater, Risk assessment*

NATURAL LEACHING PROCESS OF ARSENIC FROM SEDIMENTARY ROCKS IN BARAK VALLEY (ASSAM), NORTHEASTERN INDIA

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Abstract

High arsenic (As) concentration in groundwater is an emerging as in new occurrences problem in the recent past in Barak Valley, Assam, north-eastern India. Elevated concentrations of As in water, rock and sediments pose both a human health risk and an environmental hazard on a global scale. Arsenic concentration in groundwater from the Barak valley (Assam) is usually at levels above the maximum permissible limit of WHO guidelines. Distribution of As between solid and water phases during the low temperature water rock interaction is predominantly dependent on pH- Eh of the reacting solution, bulk geochemistry of sediments and/or bedrock etc. Release of As in a natural system is intensely controlled by pH during water-rock interaction. An effort has been made, likely for the first time, to elucidate As leaching experiments which were conducted for widely distributed rocks in Barak valley area of South Assam. The fraction of leached As has been calculated for lithostratigraphic units for examining the water-rock interaction in different conditions. A studied of water-rock interaction experiments shows valuable information on the mobilization of As from the source and their processes. Arsenic mobilization is controlled by interdependent physico-chemical processes (dissolution/precipitation, pyrite oxidation and adsorption/desorption). Experimental results show that high range of As had leached (95-274 mg/kg) at near neutral (pH=7) condition which could be the prime source for high As concentration in the groundwater regime of the study area.

Keywords: *Water-rock interaction, pH- arsenic leaching, Barak Valley*

ASSESSMENT AND PREDICTION OF POLLUTION IN A STRETCH OF PAMPA RIVER, KERALA FOR ITS SUSTAINABLE MANAGEMENT

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Abstract

Pampa River, venerated as southern Ganga, is the third longest river in the state of Kerala, India. Pollution of the Pampa River is associated mainly with human interventions such as the Sabarimala pilgrimage, one of the largest pilgrim center in the world as well as the agricultural practices. Pampa River is contaminated by bacteria, a huge amount of nutrients and oxygen demanding wastes discharged during the pilgrim season. It is highly imperative to have point source specific quantitative estimates of these impacts in order to improve the pollution database and to propose management strategies. Water samples were collected from 14 stations of the river during non-pilgrim season (Oct-Nov 2017) and peak pilgrim season (Jan 2018) to assess the impacts on water quality. Moreover, the study region is segmented in such a way that the hydrological parameters are uniform in those stretches for assessing the dispersion of pollutant load. The changes in the water quality in the upper stretch of the river is predicted using conventional water quality model and HEC-RAS model for worst pollution load scenario. The study found that pollution occurred mainly during the pilgrim season in a stretch of the stream which carries the treated effluent and discharges from commercial establishments nearby. The models effectively predicted the reduction in pollution load at a point about 35.0 km from the bathing ghats of Pampa.

Keywords: *Pamba River Pollution, Water quality Model*

**GROUNDWATER QUALITY ASSESSMENT AND ITS IMPACT ON HUMAN HEALTH
USING AHP AND CLUSTER ANALYSIS IN NORTH KASHMIR, WESTERN
HIMALAYAS INDIA**

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Abstract

Groundwater is an important natural resource. Worldwide, more than 2 billion people depend on groundwater for their daily supply (Kemper 2004). Groundwater is important for human water supply and in Asia alone about 1 billion people are directly dependent upon this resource (Foster 1995). Hydro geochemical examinations have been carried out to study the chemical quality and sources of dissolved ions in groundwater in rural and urban areas of Bandipora district, Kashmir Valley. The physico-chemical parameters of the groundwater of the study area showed a remarkably wide range. For identification of areas of marked impact, techniques like Kernel density would be applied to visualize the point data of groundwater quality, occurrence and distribution of diseases complimented with density and hotspot mapping. The kernel density method would be calculating the density of groundwater problems and the density of the occurrence of diseases using a kernel function by taking into account the surrounding neighborhood in the analysis. To make the study more diversified and applied, AHP (Analytical Hierchal Process) would be used to have the suitability and levels of groundwater quality. To cater to these processes, different data- computing devices would be adopted like MATLAB, Fuzzy statistics and Delphi method etc. The results suggest that the chemistry of groundwater is mostly controlled by rock-water interaction and bear the imprints of lithological control. However, the groundwater at some places is obliterated by anthropogenic inputs as well.

Keywords: *Spatial, Hotspot mapping, AHP, Anthropogenic, Fuzzy Statistics*

**ANALYSIS OF FLUORIDE CONCENTRATION IN GROUND WATER OF MINING
REGION AND MANAGEMENT STRATEGIES IN CHHOTA UDEPUR BLOCK,
GUJARAT**

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Abstract

Chhota Udepur block of Gujarat state is one of the big mining region which involves in supplying granite, dolomite, fluorspar, sand and few other building stone in and around the region. This analysis focus on concentration of fluoride in local ground water due to anthropogenic as well as geogenic activities. The primary data of ground water samples from shallow and deep tube wells are tested in environmental laboratory of civil engineering department, the M S University of Baroda. The result states excess fluoride concentration above permissible limit along with pH, TH, Mg^{+2} and Na^{+} have also been found above permissible limit prescribed by BIS 10500:2012. Ground truth study reveals dental fluorosis along with kidney stone have been found in the local population remarkably. Present study emphasis on management strategies to reduce fluoride concentration of local ground water by adsorption, ion-exchange in addition to impose legislation regarding disposal of mining waste. The need of the hour is application of economically viable advanced technology of defluorination.

Keywords: *Fluoride, Ground water, Mining region, Adsorption, Defluorination.*

A CRITICAL PERSPECTIVE ON THE UTILISATION OF RED MUD-WATER/SOIL POLLUTANT FOR ALTERNATIVE ENGINEERING APPLICATIONS

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Abstract

One of the major areas of concern in the current environmental situation is the rampant pollution of ground and surface water. Red mud, a by-product produced during the extraction of Aluminium from Bauxite by Bayer's Process, causes serious hazards for the human and ecological system. Red mud consists of composition including oxides of Fe, Ti, Al and Si and is extremely toxic due to its high alkalinity (pH 10-13). More than 90 million tons of red mud is produced globally in a year and its disposal without disturbing the water bodies and ecosystem is essential. However, there are no efficient methods of disposal due to its tiny particle size (~10-15µm) and incessant production rates. Traditional disposal of red mud is through the construction of dams wherein a clay lining is filled with the red mud slurry and allowed to dry naturally. Many industries use pressurized pumping techniques followed by filtration to improve the red mud's consistency of around 72-75% solids and dumped into red mud ponds. These methods cause various detrimental effects on surface water bodies as well as groundwater affecting the flora and the fauna. Current trends in the utilization of red mud are in the manufacture of composites, fabrication of tinted glasses, bricks, as catalytic adsorbents, water purifiers and for Rare Earth Element extraction. This paper provides a critical perspective into the harmful effects of red mud as a pollutant to water bodies and emphasizes on the need for its futuristic application in the engineering innovations.

Keywords: *Red mud, Soil-water pollution, Disposal, Application*

INVESTIGATION OF CONTAMINATION SOURCES IN GROUNDWATER OF THE ALLUVIAL TRACT BETWEEN MAHI AND NARMADA RIVERS OF GUJARAT, INDIA

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Abstract

Ground water contamination and their sources detection is a challenge for local pollution control boards and other environment controlling authority in the central industrialized districts such as Vadodara, Bharuch, Panchmahal, Chhota Udepur, etc. of Gujarat state of India. Various industries are established in and around the current study area like, Reliance Petrochemicals & Oil Refinery, GSFC, industrial estates and small scale industries. Mahi and Narmada are the main perennial rivers flowing through the study area while Vishwamitry, Mini and Dhadhar are other rivers. The study carried out focusing the analysis of pollution parameters of ground water in the alluvial tract of central region of state. The study analysis is carried out for various physico-chemical parameters such as pH, EC, TDS, NO_3^- , F^- , Ca^{2+} , Mg^{2+} , Cl^- , SO_4^{2-} , K^+ and Na^+ by monitoring open wells, tube wells and piezometer of agencies like Gujarat Water Resources Development Corporation (GWRDC) and Gujarat Pollution Control Board (GPCB). The groundwater quality, in various clusters reveals the anthropogenic sources, combined natural + anthropogenic sources and non-polluted pockets by multivariate geostatistical analysis. Results of identified type of sources of contamination have been verified by collecting primary data of 51 well locations and also analyzed using Fuzzy Overlay method.

Keywords: *Groundwater, Contamination, Multivariate Geo-Statistical Analysis, Source Identification, Fuzzy Overlay.*

ASSESSMENT OF GROUND WATER QUALITY PARAMETERS TO EVALUATE THE STATUS OF CONTAMINATION OF GROUND WATER IN VILLAGES AROUND AHMEDABAD DISTRICT, GUJARAT

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Abstract

Water scarcity is a giant problem that is affecting human population of the present world. Very limited amount of water is available for the humans to survive. In addition to it the amount of water which is available is polluted. Therefore, it is a double blow for the human race especially in India. Majority of the daily water needs is being fulfilled by the ground water sources in rural areas. Leach pits system of black water discharge in village households can lead to the ground water contamination. Hence, present study deals with the assessment of ground water quality parameters of villages nearby Ahmedabad district. Eleven villages have been considered as the case. Ground water samples from considered villages are acquired. Water Parameters such as pH, Electrical Conductivity, Turbidity, Acidity, Alkalinity, Total Hardness, Chlorides, Chemical oxygen demand, Biochemical oxygen demand, Total dissolved solids, suspended solids and Settle able solids has been tested. The presence of Fecal E-Coli bacteria is also being checked. Tested water quality parameters are compared with standards of IS 10500:2012 and WHO Guidelines. The drinking water of most of the villages found fit for drinking according to IS standards but not fit according to WHO guidelines (4th edition). Fecal bacteria were found to be absent during analysis.

Keywords: *Ground water quality parameters, Fecal E-Coli bacteria, IS 10500:2012 & WHO standards.*

**GROUNDWATER CHEMISTRY AND ARSENIC MOBILIZATION IN THE
BRAHMAPUTRA RIVER BASIN AQUIFERS: IMPLICATIONS FROM
GEOCHEMICAL MODELING, GEOLOGICAL PROCESSES AND AQUIFER
CHARACTERIZATION**

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Abstract

Groundwater is a critical resource as drinking water, especially for rural and urban populations of South Asia. However, the elevated concentration of groundwater arsenic (As) higher than the World Health Organization (WHO) guideline value for drinking water of 10 µg/L, across this densely populated region, along with more than 20 geographic provinces across the world, have threatened the health of >100 million people. Arsenic distribution and its potential health impact in drinking water supply systems in the Brahmaputra river basin (BRB), upstream of the Bengal basin, located in mostly in the Indian state of Assam, has only recently availed some attention. The present study interprets the influence of geogenic processes and geochemical reaction on solute chemistry and As mobilization mechanism in the aquifers of two distinct tectono-morphic regions, i.e., northern (N) region, located along the Eastern Himalayas, and southern (S) region (near the Indo-Burmese Range) of the BRB. The S-region is highly enriched in groundwater As (bdl to 415 µg/L), compared to N-region (bdl to 134 µg/L). Chemical leaching data shows that sorbed phase As only consists a small part of the total extracted As in N aquifers sediments; however, S-aquifers contain the significant amount of labile As (surface exchangeable or reactive As). Surface complexation modeling suggests that competitive adsorption/desorption reactions in aquifer sediments also can influence As mobilization mechanism. The present study proposes that the water-sediment interaction (geochemical weathering) and sorption reactions might be a dominant mechanism of As liberation in the groundwater system of the BRB.

Keywords: *Groundwater, Arsenic, solute chemistry, Brahmaputra river basin, Weathering*

ATTRIBUTING CONTRIBUTIONS OF METAL BASED SOURCES IN METAL-BASED LEACHATE FOR PROTECTING SUB-SURFACE ENVIRONMENT

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Abstract

The aim of this study is developing a framework to attribute contribution of metal based sources in metal-based leachate for protecting subsurface environment (i.e. soil and groundwater) which becomes contaminated after unplanned disposal of such wastes on dumps and/or landfills in India. Scientific reports and papers were reviewed and information about sources contributing to metal-based leachate were documented. Metals posing carcinogenic risks were screened and then their possible sources were hypothesized and characterized by linking metal occurrence and source characteristics. Preliminary analysis indicates difficulty in characterizing changes in soil surface morphology and metal content (form as well) and then linking that with primary metal and co-occurring constituents. A case study of occurrence of Pb on soil and its attribution with possible sources was linked and discussed. There is a need of developing a structural approach to properly link different sources of metals to their contributors in leachate pollution indexes and also towards potential public health.

Keywords: *Leachate pollution index, Carcinogenic metals, Source contribution*

ONE-DIMENSIONAL SOLUTE DISPERSION WITH TIME-VARYING INPUT CONCENTRATION

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Abstract:

The mathematical simulation of solute transport for non-reactive contaminant is often required in the evaluation of potential risk from consumption of groundwater near the impacted areas. To observe the movement of contaminant in groundwater flow, a One-dimensional solute transport model is developed in a semi-infinite aquifer. Initially the aquifer is not solute free, therefore, the initial concentration in the aquifer is taken as exponential decreasing function of space dependent term. The source of contaminant works periodically i.e. it is active for certain period of time and then removed. The input boundary condition at the origin is of Robin type linear pulse time-dependent boundary condition in the form of shifted Heaviside function. The analytical solution is obtained using Laplace transform technique and it is validated numerically by Finite difference method. The graph of the model is plotted using MATLAB.

Keywords: *Solute Transport, Contaminant, Aquifer, Analytical/ Numerical Solution.*

ASSESSMENT OF THE RADIOLOGICAL TOXICITY FROM THE ANALYSIS OF NATURAL RADIOACTIVITY IN SOIL AND GROUNDWATER SAMPLES

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Abstract

The present study emphasizes the estimation of natural radioactivity level in soil samples to evaluate the gamma radiation dose received by the population living in the study area. Activity concentration of natural radionuclides (^{226}Ra , ^{232}Th , and ^{40}K) in thirty soil samples collected from the Nawanshahar district of Punjab, were analyzed using NaI (TI) gamma-ray spectrometer. The determined activity concentrations ranged from 18.95 to 33.12Bq kg⁻¹ for ^{226}Ra , 136.02 to 54.21Bq kg⁻¹ for ^{232}Th and 333.23 to 472.01Bq kg⁻¹ for ^{40}K . Radium equivalent varied from 107.46Bq kg⁻¹ to 137.48 Bq kg⁻¹ with a mean of 123.45Bq kg⁻¹. The internal and external hazard index varied from 0.36 to 0.47 Bq kg⁻¹ and 0.30 to 0.38 Bq kg⁻¹ respectively. Gamma hazard index was well below the prescribed threshold of unity (UNSCEAR, 2000). Measured activity concentrations were further used for calculating gonadal, annual effective and absorbed dose. In addition, uranium content in groundwater sample, collected from the same location of the study area, has also been analyzed using LED Fluorimeter. Uranium concentration for all water samples has been found below the advocated level of 60 μgL^{-1} recommended by AERB 2004. However, water samples of 3 locations exceeds the contamination level of 30 μgL^{-1} recommended by WHO, 2011. Excess cancer risk values for all groundwater samples were found less than unity but for two location hazard quotient were higher than unity. The high values of uranium than permissible limit may lead to high radiological and chemical risks.

Keywords: *NaI (TI) Gamma-ray spectrometer, Radium equivalent, Hazard indices, Activity concentration index, Gonadal dose, LED fluorimeter, Excess Cancer Risk, Hazard Quotient, Lifetime Average Daily Dose, Annual effective dose*

GROUNDWATER CONTAMINATION DUE TO UNTREATED SEWAGE IRRIGATION AND WASTE DISPOSAL IN SALIYAR AREA DELINEATED USING 3D JOINT INVERSION OF RMT AND DCR DATA-A CASE STUDY

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Abstract

The Impact of untreated sewage irrigation and waste disposal practice in Saliyar area near Roorkee, India on groundwater is studied by 3D joint inversion of Radio Magnetotelluric (RMT) and Direct Current Resistivity (DCR) data. Field measurements were carried out earlier in the vicinity of a waste disposal site, which was extensively irrigated with untreated sewage water. The measured data sets were inverted, using a 2D joint inversion by Yogeshwar et al. (2011). We have performed 3D joint inversion of recorded 8 RMT and 5 DCR profiles independently and jointly using our own MATLAB based inversion code, *AP3DMT-DC*. Inverted 3D model is generally consistent with the earlier model and also giving some fine details of the subsurface geometries and groundwater flow. The inversion results indicate a decrease of resistivity up to 75 percent in comparison with the reference site. The decrease in resistivity values in shallow unconfined aquifer indicates the influence of contamination. The increase in the resistivity of the shallow unconfined aquifer is detected as we move away from the waste disposal site indicating movement of contaminated water in the nearby region. The advantages of both, the DCR and RMT methods, are quantitatively integrated by the 3D joint inversion of both data sets resulting in an inverse model, which explains both data sets. Thus, a well-resolved subsurface resistivity model obtained from the joint inversion is used to define the extent of groundwater contamination due to untreated sewage water irrigation and waste disposal practice in the area.

Keywords: *AP3DMT-DC, Sewage water, Radio Magnetotelluric, Direct Current Resistivity*

AN ASSESSMENT OF GROUNDWATER QUALITY OF MEWAT DISTRICT, INDIA

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Abstract

A quality assessment of groundwater was conducted in an underdeveloped district called Mewat in Haryana, India over a period of one-year, comprising of a collection of groundwater samples and physico-chemical analysis for pre and post-monsoon seasons. A total of 30 groundwater samples were collected from three blocks namely, Nuh, Nagina and Ferozpur Jhirka residing in the foothills of the Aravali range and were analyzed for various chemical and biological parameters such as, pH, Electrical Conductivity, Total Dissolved Solids, Total Hardness, Calcium, Magnesium, Total Alkalinity, Chloride, Sulphate, Sodium, and Potassium. The results were analyzed further for drinking and agricultural parameters referring to the Indian and international standards (IS 10500, WHO 2011, APHA 1992, and USSSL 1954). For agricultural usage, the parameters used for assessment are Residual Sodium Carbonate (RSC), Sodium Adsorption Ratio (SAR), Kelly's Index (KI), Magnesium Ratio (MR), and Sodium Percentage (SP). Approximately 70% of the groundwater samples were found unfit for the irrigation purpose and 80% for the drinking purpose. The values of total dissolved solids (TDS) is recorded up to 15 times the maximum permissible limits which are making life difficult in the area. The extreme values of dissolved solids in the groundwater and absence of any freshwater canals in the area may lead to a complete drought situation. A better approach towards the usage of saline water and a regular supply of fresh water to villagers in the area is necessary for a sustainable life.

Keywords: *Mewat, Soil Salinity, Water Quality, Total Dissolved Solids, Sodium Adsorption Ratio, Residual Sodium Carbonate*

EFFECT OF SOIL-SALT WATER INTERACTION ON GRAVITY DRAINAGE IN SOILS

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Abstract

Soil water retention characteristics (SWRCs) are widely used in the constitutive relationships for unsaturated moisture flow problems. Pressure plate experiments with saline water of varying concentrations of NaCl were conducted to analyze the effect of salinity on water retention curves. For this, disturbed soil samples from two contrast soils viz., silt loam (A) and sandy loam (B) were collected. From the obtained water retention curves it is seen water retention capacity of soils reduces as the concentration of salts increases. Soil A, with a major fraction of fines, was observed to be affected more by this soil and salt water interaction as compared to that of soil B, with a minor fraction of fines. Obtained water retention curves were used to fit the van Genuchten water retention equation and parameters α and n were obtained. The changes in water retention curves were evaluated as changes in water retention parameters. As salinity increased from 0.5 dS/m to 50 dS/m for sample A, parameter α was observed to increase from 0.00120 to 0.00157 and for sample B, no significant trend in the changes of α could be observed. The parameter n was observed to increase from 2.278 to 2.645 for sample A and from 1.481 to 1.693 for sample B. These results are used to simulate gravity drainage and effects of salinity in terms of changes in parameters are analyzed. This study is helpful in salinity affected agricultural fields by, where frequent irrigation is necessary to maintain the required soil water content.

Keywords: *Hydrometer analysis, soil texture, soil water retention curves, gravity drainage*

**LYSIMETRIC STUDY TO ASSESS THE LEACHING BEHAVIOR OF DI-2-ETHYL
HEXYL PHTHALATE (DEHP) IN SOIL AND RISK ASSESSMENT OF
GROUNDWATER CONTAMINATION**

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Abstract

Phthalates are group of synthetic compounds that are broadly used in several applications such as PVC, Building and construction, Wire cable, Automotive, Medical, Outdoor products, Food Wrap, Packaging, Children's toys. Di-2-Ethylhexyl phthalate (DEHP) is one of the most common plasticizers used to make plastic flexible. Soil serves as an important environmental channel for accumulation and migration of phthalates. Furthermore, phthalates can remain on the soil for a long time and can move to crops and enter food chain causing risk to the environment and human health. Lysimeters are designed for scientific studies to understand the fate and movement of water, pesticides, salts/nutrients, trace elements, heavy metals and various other. Study of phthalate leaching has been carried out to understand the fate and mobility of contaminants. It has been observed that continuous phthalate leaching can cause groundwater contamination as it is detected in both leachate and soil samples. The results presented in this paper consist of a lysimeter experiment set up to evaluate the risk assessment of soil and groundwater contamination by phthalates. The experiments are repeated to understand the reproducibility of the data and most of the lysimeter results agreed with previous experiments. The integrated approach allows us to understand the behaviour of phthalate leaching in various soil conditions, which is essential to define strategies for the prevention of groundwater contamination. Recommendations are made for further optimizing the design of future leaching studies and to promote this method in regulatory decision making for the protection of groundwater description here.

Keywords: *Lysimeteric study, Leaching, Phthalates, Xenobiotics,*

PRELIMINARY STUDY ON SEAWATER INTRUSION AT A COASTAL LOCATION OF VISAKHAPATNAM USING CHEMICAL INDICATORS

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Abstract

In coastal areas, freshwater aquifers are in direct contact with the ocean. Under natural conditions, fresh groundwater flows towards the ocean as the flow of freshwater is predominantly driven by topography. Seawater intrusion (SWI), i.e., the ingress of seawater is generally caused by prolonged changes in coastal groundwater levels due to over pumping, land-use change, climate variations or sea-level fluctuations. Monitoring groundwater quality may indicate migration of the freshwater-saltwater interface and provide information on sea water intrusion. The chemical characteristics of the groundwater samples collected from a coastal site at Visakhapatnam were analyzed to ascertain on the basis of chemical indicators if there is sea water intrusion in the aquifer of this area. Eighteen groundwater samples were collected from the site in May 2017 and analyzed for physical and chemical parameters. Chemical indicators viz. the Na/Cl ratio, Ca/Mg ratio and the Base Exchange (BEX) index were estimated for all the samples. The chemical indicator values suggested no sea water intrusion in the groundwater of the study area.

Keywords: *Sea water intrusion, groundwater quality, aquifers.*

SOIL WATER POLLUTION DUE TO AUTOMOBILE EMISSION: A CRITICAL REVIEW

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Abstract

Rapid development of society results into more automobile growth. Automobile emit various types of gases from tail, they not only pollute air only but soil is also polluted by the emission, which affects the groundwater table thereby affecting the herbs, human and animals as well. Due to the chemical constituent in the gases among the hydrocarbon, polycyclic aromatic are the main concern about pollution. Some of the compound shows the carcinogenic properties. Incomplete combustion of fossil fuel mainly diesel is the main contributor of polycyclic hydrocarbon to the environment. Vehicle tail gas not only produces inorganic but Pb, NO_x, CO, SO₂ also. Sometimes pollution due to heavy metal from the traffic is Cd, Cu, Cr, Ni, and Zn. If we consider our country, economy is mainly based on agriculture, so we strongly need to focus on soil pollution. Mainly soil pollution divided into two categories: -Inorganic and Organic. Heavy metal is most persistent and complex kind of pollutants in nature. When pollutant enters into the soil they undergo physical, physiochemical, microbiological and biochemical process that reduce or degrade them. These pollutants affect the mineralogical composition and soil texture like change in organic matter, Ph, moisture content and temperature. Soil pollution coming from automobile engine is measured by Geofina Hydrocarbon Meter. Soil pollution due to vehicular emission affects human, animal, plants and ecosystem. So organic contaminants by emission of car tail cannot be neglected.

Keywords: *Soil, Water, Pollution, Car tail gas*

COMPARISON OF LEACHATE POLLUTION POTENTIAL OF LANDFILLS OF DELHI AND THEIR IMPACT ON ENVIRONMENTAL MATRIXES

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Abstract

Okhla, Bhalswa, Ghazipur and Narela-Bawana, four functioning MSW dumping sites/landfills of Delhi, India were reviewed for their leachate pollution potential (2004 to present). Out of these, Okhla, Ghazipur and Bhalswa are the non-engineered landfills, devoid of liner system, leachate collection and treatment facility. The leachate with high heavy metals can percolate from these sites and can potentially impact nearby environmental matrixes (groundwater and soil). In present study, data on various leachate parameters of stated landfills were compiled from available literature. The data on 18 parameters index (i.e. pH, BOD, TDS, COD, TKN, TCB, ammonical nitrogen, lead, arsenic, chromium, chlorides, cyanide, nickel, iron, zinc, mercury, arsenic, Phenol) were compiled and subsequently, leachate pollution index (LPI) was calculated for respective sampling. The trend in variation of these parameters and calculated LPI was calculated year-wise and location-wise. Further, a preliminary assessment of groundwater contamination correlation with LPI and associated risk has been done. The present study suggests that LPI of Okhla and Ghazipur landfill decreases from 2004 to 2014 and increases afterwards whereas opposite trend was observed for Bhalswa landfill. As per preliminary assessment, it is difficult to link LPI with groundwater and soil contamination due to limited available data at present. Further, limitations in the available literature and framework for future research actions has been compiled.

Keywords: *Leachate Pollution Index, Metal contamination, Landfill, Human health risk assessment*

GROUND WATER QUALITY IN ANANTNAG DISTRICT OF KASHMIR VALLEY

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Abstract

The importance of ground water for the existence of human society cannot be overemphasized. Ground water is the major source of drinking water in both urban and rural areas. It is the major source of drinking water in India. Even in advanced countries such as Germany and Netherlands about 70 percent of drinking water comes from ground water. Kashmir valley has rich deposits of ground water in both confined and unconfined aquifer system, but its occurrence is highly uneven due to diverse geological formations. Although ground water development in Kashmir valley is at its early stage, but its demand is expected to increase over in future due to population pressure and urban sprawl. Ground water crisis is not the result of natural factors, but it has been caused by human actions. During the past two decades, the water level has been falling rapidly due to an increase in extraction and dry weather conditions especially during autumn, giving rise to drought like situation. This has decreased not only the level of surface waters but also reduced the discharge from many perennial springs and in some areas springs and wells have even dried completely. Despite its vastness and significance in Kashmir the available information about ground water resources is scanty. The ground water quality may yield information about the environments through which the water has circulated and the physico_chemical features of water are important indicators that provide information about the water quality. The present study revealed that ground water in the aquifers of Anantnag District are fresh and alkaline in nature. The results revealed that varied lithology and anthropogenic activities play an important role in influencing chemistry of the studied ground water sources. Ground water chemistry differs depending on the source of water, the types of rocks, topography, climate, the degree to which it has been evaporated and mineral it has, encountered.

Keywords: *District Anantnag, Physicochemical analysis, SAR*

EXPERIMENTAL INVESTIGATION OF LEACHING OF METALS DUE TO CONTINUOUS RAINFALL FROM BORAGAON (GUWAHATI) LANDFILL REFUSE

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Abstract

In developing countries like India, most of the waste are unscientifically dumped in open fields. This cause toxic and heavy metal contamination of groundwater. This experimental study is focused to find the concentration of metals that leach into the subsurface water due to continuous rainfall. The study area selected for study is Boragaon waste landfill refuse which is one of largest waste landfill in north-east India. The arrangement for experimental study is done by heaping of landfill refuse soil to a certain height in landfill leaching model trapezoidal apparatus. Experiment is conducted for different height 10 cm, 20 cm and 30cm of landfill soil. Specific gravity of soil solids, porosity, and saturated hydraulic conductivity of soil, etc. are some other properties of soil which are kept constant for every case. Inflow rates during experiment are maintained constant. Infiltration of water takes places through the soil heap and leaches the toxic metal like Fe, Co, Mg and Cu, etc. by percolating the pores present in the soil. The effluvium from the apparatus is collected at interval of 5 minutes for initially 120 minutes and 10 minutes for last 120 minutes after reaching a pseudo-steady state. AAS (Atomic Absorption Spectroscopy) instrument is used to measure the concentrations of Fe, Co, Mg and Cu in the effluvium leachate. The variation of concentration of these metals with respect to time are plotted. The plotted result shows that concentration of magnesium is highest among four metals. The outcome likewise demonstrates that convergence of every one of the four metals is in abundance than permissible limit. The concentration follows order as $Mg > Fe > Co > Cu$.

Keywords: *Continuous Rainfall; Trapezoidal Apparatus; AAS (Atomic Absorption Spectroscopy); Landfill Refuse.*

SOIL - WATER POLLUTION BY INDUSTRIAL EFFLUENTS

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Abstract

Throughout the world, the disposal of industrial effluents is a problem of increasing day by day. In India, a huge amount of wastewater generated from industries discharged into the running water and on the land. For the sustainability of agriculture and environment conservation of soil and water resources is important. Due to ever increasing population thereby ensuing growing demand for fiber, food, and shelters the Water- soil resources are under immense pressure. Due to different natural and anthropogenic factors Soil- water resources are being deteriorated. Industries Effluents contributes a huge amount of acidic effluent containing high biological oxygen demand (BOD), Chemical oxygen demand, nitrogenous pollutant, and other pollutants. The discharged water contains high levels of contaminants considered hazardous to the ecosystem. Most of the heavy metals like Cu, Fe Cr, Ni, and Cd were found to be much higher than the maximum permissible limits. These heavy metals have created a threat to the aquatic life and through biomagnification may enter the food chain thereby affecting the human beings as well. Industrial effluents to control water pollution, greater efforts are required to reduce the risk to public health as toxic pollutants which are mainly colorless and odorless are released into the ecosystems. The mineral constituents present in trace amounts in the discharged effluent favor the growth of some algal, fungal and bacterial colonies which in turn change the texture of the soil. The organic matter and nutrient content in the majority of the soil samples from the study area recorded low values and therefore soils in the surroundings of TTP industry are of low fertility. The soil heavy metal analysis showed that the concentration of Cd, Pb, and Cr was high in the station near the effluent discharge site compared to that in the other stations of the study area. Effluents reduce the porosity of the soil resulting in poor yields due to the discharged of micronutrients into the soil through effluents. Organic effluent with a high concentration of biodegradable organic matter discharged into the soil attract the saprophytic soil and air microflora and thus could proliferate resulting in poor yields or fungal diseases in many cases. Thus there is a need to monitor the soils where wastewater is applied for irrigation/plantation purposes. To protect the soil resources against erosion different control measures are adopted. The concept of soil conservation cannot be materialized without conserving and efficient use of water resources. It is, therefore, pre-requisite that soil conservation practices should be adopted. Soil conservation practice includes crop management, soil management, engineering, forestry operation, and range management. The study also provides evidence that local

communities are suffering from a variety of health problems including diarrhea, skin, dysentery, respiratory illnesses, anemia and complications in childbirth. Cholera, Yellow fever, dengue, malaria and other epidemic diseases are also available in the area. Furthermore, the people are suffering by the odor pollution and respiratory problems.

Keywords: *Sustainability, Pressure, Hazardous, Bio Magnification, Deteriorated, Porosity, Low Fertility, Materialized, Soil Conservation.*

**IMPACT ASSESSMENT OF MODERN AGRICULTURAL AND
URBANIZATION/INDUSTRIALIZATION PRACTICES ON GROUNDWATER
DYNAMICS AND HYDROCHEMISTRY**

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Abstract

Groundwater samples were collected from 124 marked locations four intensive agricultural prone districts of Punjab as well as from four intensively urbanized districts of the adjoining state Haryana for more than a decade to identify the Impacts of modern agricultural and Urbanization/Industrialization practices on Groundwater dynamics and hydrochemistry. Sampling points were mostly hand pumps and bore wells which were fully or partially (at few locations) in use. Chemical analysis was carried out for groundwater samples as per APHA (18th Edition) handbook and obtained results were compared with the Indian standard (BIS) quality parameters prescribed specifically for safe drinking, industrial and agricultural uses. The water flow parameters were determined from geological logs and well pumping tests. Numerical models were used to describe the transport of dissolved and separate phase pollutants in heterogeneous multiphase subsurface environment in their entire complexity. It was estimated that much of the pollutant transport occurs in unconfined aquifers (sand layers). The water flow in these layers was measured to be towards south-western direction with an average gradient of 0.6% and 0.5% respectively. These estimates were used in modelling of the contaminants transport in the aquifers. This study revealed that modern Agricultural and Urbanization/Industrialization practices critically affected Groundwater dynamics and hydrochemistry in Gurugram, Palwal and Faridabad (Haryana) and Jalandhar, Kapurthala regions (Punjab) respectively mainly due to leakage from sewer lines, unlined MSW and Industrial waste dump sites, chemical storage/spreading areas (urbanization practices) and chemical fertilizers - pesticides storage – use sites, irrigation sites (poorly constructed irrigation wells and improperly abandoned wells) and injection wells (agricultural practices).

Keywords: *Urbanization, Industrialization, Geological Logs, Heterogeneous, Multiphase, Aquifer, Hydrochemistry, Contaminant Transport Modelling, Groundwater Flow Dynamics*

HYDRO-CHEMICAL CHARACTERISTICS OF UPPER GANGA BASIN, INDIA

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Abstract

The study of major ions chemistry of snow and glacier meltwater from the Himalaya has a special significance, as the dilute snow/ice melt water streams feed the north Indian rivers and play significant role in regulating the concentration of pollutants in these rivers. Hence any change in the quality and quantity of the Himalayan tributaries of River Ganga under the climate change regime will impact the quality parameters of River Ganga. Understanding of low temperature solute acquisition processes is therefore very important for assessing the solute acquisition and pollutant loading further downstream. Total fifteen sampling sites have been selected (4 sites on River Bhagirathi, 8 sites on River Alaknanda and 4 sites on River Ganga) for water quality assessment in Upper Ganga Basin and monitoring is carried out on monthly basis from September 2016 to May 2018. All the samples were stored in sampling kits maintained at 4°C and brought to the laboratory for detailed physico-chemical analysis. The various water quality parameters monitored include pH, EC, TSS, Alkalinity, Hardness, Major Cations (Na, K, Ca, Mg), Major Anions (HCO₃, Cl, SO₄, NO₃) and Demand Parameters (DO, BOD, COD). Analysis of various water quality parameters reveals that all parameters are well within permissible limits of river water quality, except COD and TSS. The present investigations reveal that DO varies from 7.0 mg/L to 12.9 mg/L with lowest value in River Bhagirathi at Uttarkashi and highest value in River Alaknanda at Devprayag. BOD ranged from 0.3 to 3.4 mg/L. Upon comparison of COD values with prescribed limits for river water quality by CPCB, it was found that COD values are above the prescribed limit at 11 locations, while TSS values are above the limit at all the locations. Further, it has also been noticed that COD is high at lower reaches of River Ganga (below 1200 m), which is indicative of the fact that anthropogenic pollution is responsible for high concentration of COD. Moreover, high concentration of COD at Haridwar (257 m) is due to the effluent discharge from various industries located in the area. Contrary to COD values, TSS has shown opposite trend. TSS appears to be decreasing from higher elevation to lower elevation, besides being unexpectedly high at all the locations. High TSS is due to unstable and young Himalayan geology, from where silt and rocks are easily carried off. Deforestation in the catchment area of the river and rapid urbanization in river flood plains also enhances TSS. These sediments get deposited during the course of the river flow and thereby low TSS at lower elevation.

Keywords: *Upper Ganga Basin, Physico-chemical parameters, COD, TSS*

ECOLOGICAL AND BIODIVERSITY STUDY OF UPPER GANGA BASIN, INDIA

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Changing climate is altering the temporal and spatial distribution of different components of hydrologic cycle. Altered flows in the rivers may change the habitat (depth, velocity, temperature, pH, DO, BOD and sediment concentration) required for survival of various aquatic species. As these species are very important considering the fact that they are responsible for the self-purification capacity of the rivers. Aquatic biodiversity of the River Ganga being very rich in nature is very susceptible to these changes. Hence, it becomes imperative to study the impact of climate change on the river ecology. Eight sampling zones are selected for ecology and biodiversity study of Upper Ganga Basin viz; Zone 1 - Upper Alaknanda River; Zone 2 - Upper Bhagirathi River; Zone 3 - Upper Bhilangana River; Zone 4 - Lower Bhagirathi River; Zone 5 - Alaknanda – Bhagirathi Confluence Zone; Zone 6 - Upper Ganga River Stretches; Zone 7 - Middle Ganga River Stretches; Zone 8 - Lower Ganga River Stretches. Monitoring of temporal abundance of different aquatic species (Phytoplankton, Zooplankton, Macro-Benthos and Piscine fauna) at selected zones is carried out along with the aquatic habitat parameters (Temperature, Depth, Velocity, Slope, Gradient, pH, EC, TDS, Turbidity, DO and BOD). Assessment of aquatic biodiversity and relative abundance of phytoplankton, zooplankton, benthos and piscine fauna (distribution, species richness and abundance as per their habitat) is carried out at selected zones. As a general trend, phytoplanktons are decreasing towards lower altitudes, while zooplanktons and macro-benthos are on the rise. Highest phytoplanktonic density is reported in the month of January to March in all the 8 zones, while lowest density is found in the months of July to September. Highest zooplanktonic density is reported in the month of April while lowest density is reported in the months of September and June. Similarly, in case of macro-benthos, highest density is reported during April and lowest during the months of September and July across all the 8 zones under the study. In case of piscine fauna, maximum density recorded in the month of October to December whereas the minimum fauna are recorded in the month of July. The investigation reveals that piscine fauna decreases in the monsoon season, which may be attributed to the fast flowing current and total discharge, that affects the habitat population. All other biotic species viz; phytoplankton, zooplankton, and macro-benthos decreases in monsoon season due to high velocity and turbidity of aquatic ecosystem.

Keywords: *Upper Ganga Basin, Ecology, Biodiversity, Phytoplankton, Zooplankton, Benthos, Piscine fauna*

COASTAL GROUND WATER RESOURCES IN EAST MEDINIPUR DISTRICT, WEST BENGAL – CONTRIBUTION OF NEAR-SURFACE AQUIFERS OF SAND DUNES

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Abstract

The coastal plain of East Medinipur district of West Bengal is spread over an area of 2625 sq km extending from the Subarnarekha river in the west to Hugli-Rupnarayan river in the east. This coastal plain lies in the active delta of Hugli-Bhagirathi river system. The area is underlain by a thick pile of unconsolidated Quaternary and Neogene sediments. The lithologic sequence of the area indicates that at least three group of aquifers occur – the uppermost one, unconfined nature (Sand Dunes) with 20-meter depth, Confined the middle one (40-170 meter) comprising alternate layers of clay and sand and the deeper one occurring between 170-260 meter with intercalations of clay bed. The sand Dunes comprising the upper most aquifer are aligned in linear disposition almost parallel to the present day shore line. Aquifer parameters of the three groups of aquifers have been computed obtaining the pumping tests data. Hydrochemistry of individual group of aquifers and hydrochemical facies to which they belong have been studied. Radio-isotope studies ($\delta^2\text{H}$ - $\delta^{18}\text{O}$) have been carried out in the laboratory of BARC, Mumbai. Tritium and ^{14}C studies give an idea about different ages for each aquifer. A Comprehensive assessment of Near-Surface Sand Dune aquifers suggests that about 30 MCM (million cubic meter) of fresh groundwater is available and this dynamic ground water resource will be able support at least partially the drinking water need of the population. In view of future climate change scenario, this water resource can provide a suitable option.

Keywords: *Near-Surface Aquifer, Climate Change, groundwater potential, Drinking Water.*

DISSOLVED RADON IN GROUNDWATER IN GANGETIC ALLUVIUM AND COST EFFECTIVE MEASURES FOR ITS REMOVAL

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Abstract

The River Ganga debouches from Siwalik hills and enters into plains at the city Haridwar. The city Haridwar has evolved along the western bank of the river Ganga. It is bounded on its either sides by Shiwalik hills and the river Ganga canal passes axially through the city. Roorkee is the major city in the district Haridwar. It is at a distance 30 km from the Haridwar and is located on the west of the river Solani that originates in Siwalik Hills. The geology of the region has developed from the sediments of the Himalayan origin deposited by the river Ganga and the sediments of Siwalik origin by the river Solani and its tributaries. For the study, groundwater samples from Haridwar and Roorkee were collected and the radon concentration were measured using RAD7. Sampling of groundwater was done through community hand-pumps that are being used for drinking water needs. Sampling was done in pre-monsoon period (February-April,) of 2019 to avoid dilution from monsoon rains. Groundwater was sampled from 5 different geomorphic settings. The measured radon concentration was observed to be high in Haridwar region and low at Roorkee. In Haridwar, near to the river Ganges it is observed to be in the range of 0 Bq/m³ to 15700 Bq/m³ in Kankhal, 754 – 12900 Bq/m³ Shankaracharya Chowk, 184 - 16900 Bq/m³ in Mansa Devi Road; and at foot-hill of Shiwalik it reduced to 294-11400 Bq/m³. Samples collected at Roorkee recorded radon concentration 1100 – 2650 Bq/m³. The results indicate high radon concentration in alluvial sediment of Himalayan origin and average concentration in sediments derived from Shiwaliks. It is known fact that radon is carcinogenic to humans. Therefore, proper treatment of groundwater of high radon concentration becomes necessary before supply of such water for potable means especially in the city like Haridwar where millions of pilgrims & tourists visit the place annually.

Keywords: *Radon, Concentration, RAD7, Removal, Haridwar*

MONITORING OF WATER QUALITY INDEX (WQI) OF SALINE WATER INTRUSION USING SR STABLE

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Abstract

Hydrosphere is an indispensable part of mother earth. Lack of freshwater for domestic, agricultural and industrial uses is presently hindering development in many parts of the world. Limited freshwater resources available in regions like arid to semi-arid and coastal region are also threatened with deterioration in quality owing to human-induced hydrological changes. Both stable and unstable isotopes are useful in groundwater applications include studies of recharge and discharge processes, precipitation, infiltration, salt water intrusion in coastal region, flow and interconnections between aquifers, and the sources and mechanism of pollution. Water quality index and quality monitoring can dictate from various isotopic data. Hydrosphere contain both stable (^2H , ^3He , ^{11}B , ^{81}Br , ^{87}Sr , ^{13}C etc.) and radiogenic (^{39}Kr , ^{39}Ar , ^{129}I , ^{36}Cl , ^3H etc.) atmospheric isotope. Strontium (Sr) is a stable isotope having natural abundance 0.709939 atoms/atoms can be used in quality monitoring of salt-water intrusion in Chilika Lake (saline Lake of Odisha). High residence time and long half-life of it can be used as its property for monitoring of WQI and to which pollutant or particle it can make a compound form to sustain in both saline and fresh water as well as in transition zone of intrusion.

Keywords: *Strontium, Half Life, Salt Water Intrusion, Residence Time*

EVOLUTION OF ISOTOPIC SIGNATURE (δD AND $\delta^{18}O$) OF GROUND WATER AND PRECIPITATION IN ARID AND SEMI-ARID REGIONS IN INDIA

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Abstract

Isotopic composition of monthly composite precipitation Samples across India between Latitude 8.72 to 33.50 N and Longitude 72.00 to 91.00 E were studied along with ground water from tropical southern tip to temperate and alpine in the Himalayan northern tip, where elevated regions receive sustained winter snowfall. The average stable isotope values in precipitation at Equatorial winter dry station were $\delta^{18}O$ -3.08‰ , $d = 7.12\text{‰}$ and $\delta^{18}O$ -2.77‰ , $d = 4.68\text{‰}$ and $\delta^{18}O$ -7.6‰ , $d = 6.30\text{‰}$ respectively. Wet tropic station $\delta^{18}O$ -4.10‰ , $d = 9.99\text{‰}$ and semi-arid station across southern India observed $\delta^{18}O$ -3.94‰ , $d = 6.78\text{‰}$. While in hot arid stations shows $\delta^{18}O = -3.76\text{‰}$, $d = 6.22\text{‰}$. Temperate winter dry, hot summer having $\delta^{18}O$ -6.91‰ , $d = 0.67\text{‰}$. winter dry cool summer places Gangotri and Gomukh shows $\delta^{18}O$ -11.7‰ and 15.2‰ , $d = 14.28\text{‰}$ & 14.7‰ respectively. Ground water in Kashmir Valley has $\delta^{18}O = -5.5\text{‰}$, d -excess = 11.9‰ and Jammu $\delta^{18}O = -7.3\text{‰}$, d -excess = 14.8‰ respectively. These differences are mainly attributed to the latitudinal differences and climatic conditions. The depletion in $\delta^{18}O$ in southern tip relative to the Central and Himalayas points is due to the rain out effect of water vapour. δD versus $\delta^{18}O$ indicates that ground water sample have very high d -excess in Northern part indicating western disturbance and lower in south western coast indicating monsoonal as the source of ground water.

Keywords: *Isotopes, Himalayas, groundwater, Kashmir valley.*

TS - 3
**(SOIL WATER FLOW AND SOLUTE TRANSPORT IN
SUBSURFACE)**

Keynote Paper

**SIMULATION OPTIMIZATION TECHNIQUES FOR PARAMETER ESTIMATION/
SOURCE IDENTIFICATION**

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Abstract

In the recent times due to the over exploitation of groundwater resources, the need for development of robust and reliable groundwater management systems has increased. Application of simulation - optimization approach, wherein a coupled optimization and groundwater flow/ transport model is used to solve management objectives is widely adopted. Parameter estimation of flow or transport process or, calibration of the simulation model is very essential for better model predictions. Estimation of aquifer parameters (such as permeability, transmissivity, porosity, dispersivity etc.) in the field is generally costly and time-consuming. Another economical and effective alternative to this is the use of simulation- optimization model for estimation of field variables. Further, in groundwater contamination problems, contamination source identification is very important for appropriate remediation measures. For parameter estimation or source identification, the simulation and optimization models are linked together to predict the unknown parameters or sources. The prediction is done with respect to the head or concentration values at observation wells located throughout the study area.

The efficiency of the simulation model is one the major reason to obtain the best solution for a management problem. In this study, we examine the advantages of the Meshless Method for designing an optimal groundwater management system under given water demand. Although there is wide availability of modeling software's in groundwater hydrology based on numerical techniques like Finite Difference Method (FDM) and Finite Element Method (FEM), this study

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shows how the shortcomings of the former methods like high costs in meshing and re-meshing, difficulty in adaptive analysis can be dealt using latest developed Meshless methods. For optimization, Particle Swarm optimization (PSO) model is used. The coupled model is developed for parameter estimation and source identification. The models were applied for few case studies. The results from the proposed model demonstrated the effectiveness of such techniques in parameter estimation and source identification. The models can be applied to large scale field problems.

Keywords: *Groundwater management; Simulation-optimization; Meshless method; Particle swarm optimization; parameter estimation; source identification.*

**GENERALIZED DISPERSION THEORY IN SOLUTE TRANSPORT MODEL BY
HOMOTOPY ANALYSIS METHOD**

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Abstract

This study adopts generalized dispersion theory in one-dimensional advection-dispersion equation (ADE), where time-dependent dispersion and velocity are considered. The generalized dispersion theory allows mechanical dispersion to be directly proportional to seepage velocity with power n , where n is any real number. Homotopy analysis method (HAM) that uses a simple algorithm is adopted to handle the non-linearity occurred in the ADE under the generalized dispersion. A point source is introduced to the entry boundary and a line source is introduced to the entire model domain. Three time-dependent point sources in the form of, (i) exponentially decreasing function, (ii) linear function and (iii) sinusoidal function, at the entry boundary are considered. Two-line sources are considered in the form of, (i) linear space-dependent function and (ii) nonlinear space-time-dependent function. Using the HAM, semi-analytical solutions for any power n are derived and semi-analytical solutions for $n = 1$ and $n = 1.5$ are discussed in particular. Comparison with the analytical solution is discussed and found good agreement for 6th order of solution obtained by HAM.

Keywords: *Solute Transport, Dispersion, ADE, HAM*

COLLOID TRANSPORT IN PARTIALLY SATURATED POROUS MEDIA: A PORE-SCALE PERSPECTIVE

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Abstract

Accurate prediction of the movement of colloids in porous media is essential for protecting the drinking water wells from contamination, riverbank filtration, deep bed filtration, and bioremediation of contaminated sites. Among the various factors, unsaturated conditions have been found to significantly enhance the retention of the colloids in porous media. However, the role of various mechanisms involved under partially saturated conditions has not been understood completely. In this study, a mathematical model is developed to simulate colloid transport in a triangular pore partially filled with water and air under steady flow conditions. Colloid deposition rate coefficients at the solid-water and air-water interfaces are calculated from the DLVO energy profile. Pore-scale results show that colloid deposition at the air-water interface plays a major role under partially saturated conditions.

Keywords: *Colloid, Porous Media, DLVO energy profile*

**INFLUENCE OF NEW ALGAE BIOCHAR DEDUCED FROM SOUTH CHINA SEA ON
SOIL EVAPORATION AND CRACK DEVELOPMENT**

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Abstract

The application of algae biochars (made from the abundant algal wastes along coastal area of China) for reducing soil evaporation and cracks development has been rarely valued. Such application will help not only manage abundant coastal waste but also enhance performance of bare infrastructure. This research targets to introduce a newly algae biochar derived from *Sargassum horneri* for suppressing soil evaporation and crack development. Performance of new biochar has been compared with traditional biochar (from *cedar* wood) under different compaction degrees (60% and 80%) and biochar contents (0%, 5% and 10%). Drying-wetting cycle experiments were performed on clay soil treated with biochars. The results indicated that both kinds of biochars could significantly reduce the development of cracks and prevent soil evaporation. Wood biochars with highly porous structure shown a better advantage on reducing cracks and evaporation than algae biochar. The influence of the degree of compaction is more significant than biochar content.

Keywords: *Algae Biochar, Soil Evaporation, Crack Development*

**MODEL TO DELINEATE FRESH-SALINE INTERFACE FOR SUSTAINABLE
GROUNDWATER MANAGEMENT OF COASTAL CITIES IN AND AROUND SMART
CITIES OF HALDIA AND DIGHA, EASTERN INDIA**

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Abstract

The idea of developing ‘Smart cities’, in which various technology and citizen engagements are used to more efficiently manage infrastructure and services, is increasingly gaining ground. A neo middle class is emerging which has the aspiration of better living and high quality standards. One of the areas of challenge in building Smart city is water management and groundwater in particular. Groundwater has had a huge role on the socio-economic sustainability and development of Smart cities. The coastal area of Haldia and Digha is generally characterized by high fertile soil and huge water resources with an appreciable density of population. Agricultural activities in these areas are intensive. Groundwater is an important source of fresh water and there is increasing dependence of water supplies on groundwater resources. Ever increasing demand of water is being felt to meet the growing requirement of the industrial sector of Haldia and Digha in the coastal tracts. But salinity hazards due to proximity of the sea shore and sea water intrusion constrain its development. As the fruits of development reach an increasingly large number of people, the pace of migration from the rural areas to the cities is increasing. This paper is aimed towards conducting a thorough and in-depth study on the mapping and modelling the salinity variation in the coastal area, particularly, industrial town of Haldia and resort towns of Digha in parts of Kasai-Suvarnarekha basin, eastern India. The source of saline water in the coastal aquifers has been due to two factors; sea water invasion during cyclones and floods or salt water entrapped in sediments deposited in the marine environment and the other is due to overexploitation of fresh water aquifers which results into saline water intrusion. Keeping in view of the above complexity of the coastal aquifers, integrated study was adopted which includes sub-surface characterization using hydrogeological and geophysical methods supplemented by groundwater quality analysis. The sub-surface model is developed to accurately defining the interface geometry of the fresh water-saline water contact. The accurate determination of fresh water – saline water interface through modeling studies allowed, for proper groundwater management plan that will provide sustainable future at regional, national and global scales to build smart cities.

GAS PERMEABILITY AND WATER RETENTION IN SOIL AMENDED WITH DIFFERENT BIOCHAR PROPORTION

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Abstract

Biochar (BC) has been used as an environmentally friendly material in amending soil. Previous studies have focused on the hydraulic properties (e.g. suction and water retention) of soil amended with biochar. However, its effects on gas permeability under different BC contents is not fully understood. The major objective of this study is to investigate the gas permeability (k_g) of BC amended soil (BAS) under different BC contents and its relationship with suction and water content. In this study, BC-soil mixture at three different biochar contents (0%, 5% and 10%) was compacted and soil properties such as suction, water content and k_g were continuously monitored for a drying-wetting cycle. Results showed that BAS with 10% BC shows the best moisture content (max. 55.9%, min. 22.1%). However, the moisture content of BAS with 5% BC (max. 31.8%, min. 16.2%) was even lower than bare soil (max. 34.8%, min. 19.5%). The addition of BC reduced the k_g of soil, meanwhile, k_g of BAS with 5% BC was the lowest. k_g increased with an increase of suction, regardless of the BC content. Moreover, when the maximum moisture content and porosity of soil were small, k_g was correspondingly small.

Keywords: *Gas Permeability, Water Retention, Biochar*

APPLICATION OF NUMERICAL MODELING TO EXAMINE BASALT HARD ROCK AQUIFER CHARACTERISTICS UNDERLYING JETPUR PAVI BLOCK, GUJARAT

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Abstract

Primary requirement in evaluation of underlying aquifer characteristics is the development of regional groundwater flow and contaminant transport models that drives decision making system. The importance of such flow and transport models is in sustainable groundwater resource development, estimation of artificial groundwater recharge, improvement in groundwater quality and aquifer remediation. A well calibrated groundwater flow model provides optimum values of different aquifer characteristics such as Hydraulic conductivity, Transmissivity, Porosity, Dispersivity, Specific yield of aquifer strata and Storativity. Data required to generate a groundwater flow and contamination transport model are topography and digital elevation model of the site being modeled, borehole and well log data to define aquifer stratigraphy, hydrogeological properties of various materials present in stratigraphy, precipitation and groundwater recharge, groundwater evapotranspiration, river and well discharges along with computing tools such as GIS and GMS. Here, an attempt has been made to examine aquifer characteristics for current study region based on existing data with the help of MODFLOW, Model Calibration and Parameter Estimation tools available in GMS. The underlying aquifer system has been characterized by calibrating model and running a Parameter Estimation inverse model run to optimize hydraulic conductivity (m/d), recharge zones (m/d), specific yield and storage coefficient. Hydraulic conductivity values differ in the range of 0.01 to 100 m/d for different geological polygons created in aquifer coverage. Calibrated values of specific yield are in the range of 1% to 5% which matches with recommended values. Storage coefficient has been found in the range of 0.0001 to 0.00001.

Keywords: *Aquifer, Characteristics, Calibration, PEST, MODFLOW*

NUMERICAL MODELING OF SOLUTE TRANSPORT ALONG GROUNDWATER FLOW THROUGH TWO-DIMENSIONAL FINITE POROUS MEDIUM

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Abstract

Present work deals with two-dimensional solute transport through finite homogeneous porous medium in presence of constant input source concentration. It is supposed that the porous medium already has some constant solute concentration decaying exponentially with space throughout the medium at initial time. At the final boundaries, solute fluxes are assumed to be zero. For the numerical solution, Forward-Time Centered-Space (FTCS) finite difference scheme is used to approximate the governing solute transport equation. All the numerical results are obtained in graphical forms with the help of computer software.

Keywords: *Homogeneous, Porous Medium, Solute Transport, Exponentially Decay, Finite Difference*

EVALUATION OF CONTAMINANT TRANSPORT PHENOMENA USING GMS IN THE REGION BETWEEN TRIBUTARIES OF ORSANG RIVER, CHHOTA UDEPUR, GUJARAT, INDIA

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Abstract

River Orsang being a non-perennial river, the majority population of Chhota Udepur and Jetpur-Pavi tehsils for their water usage depend on groundwater as it is available at shallow depths up to 16 meters. But its quality for drinking purposes is found questionable after analyzing laboratory test results obtained from GWRDC and NRDWP. This research evaluates contaminant transport phenomena through groundwater flow-net using stratigraphy modeling based on geological characteristics of the underlying aquifer system. Significance of stratigraphy model perceived in terms of the provision of grid independent layer elevations as well as interpolation of layer data applied to remove pinch-outs and embedded seams to create groundwater flow. Boreholes, Horizons, Solids, MODFLOW and MT3DMS modules have been utilized for model development in Groundwater Modeling System (GMS). Stratigraphy model clearly defines the extent of each solid which are sand, quartzite, phyllite, granite, gneiss and basalt with differentiating hydraulic properties such as hydraulic conductivity, porosity and specific yield applied separately for each material. Model with a steady state simulation generated flow-net with variations in higher and lower permeable strata showing the north-east to south-west groundwater flow direction. The outcome, simulated from transport model gives a time series plot for 10 years starting at May 2017 with respect to reduction in mass loading of Nitrate from 261 mg/l to 25 mg/l for advection-dispersion transport explaining the migration of Nitrate Contaminant. Groundwater, Stratigraphy, MODFLOW, MT3DMS, Contaminant-transport, Modeling

Keywords: *Contaminant, Stratigraphy, Steady State Simulation, Stratigraphy*

CRITICAL FRACTURE SKIN DIFFUSION COEFFICIENT FOR CRYSTALLINE FRACTURED FORMATIONS

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Abstract

Most of the studies reported in literature on fluid flow and mass transport in fractured formations are based on the assumption that fractures control the overall conductivity of the rock and the porous matrix just provides storage. However, field observations of rock fractures at many locations have shown that fractures in the field can be rather very complex. Observations at some sites have revealed that the portion of the rock matrix adjacent to many open fractures, referred to as the fracture skin, have different transport properties compared to that of the undisturbed rock matrix. This, in turn, is likely to influence the transport of solutes through these formations. To perform modelling in this situation, a numerical model is developed in the present study based on triple continuum approach incorporating the fracture skin as the third continuum. The numerical model is based on the finite difference method and employs a fully implicit formulation. Sensitivity analyses are performed to investigate the impact of different fracture skin properties on the spatial evolution of contaminant concentration in the fractured formation. Fracture skin porosity and fracture skin diffusion coefficient are found to be the most critical parameters controlling the migration of contaminants through a fractured media. An attempt is also made to evaluate critical fracture skin diffusion coefficient for crystalline fractured formations.

Keywords: *Numerical mode, Contaminant transport, Fractured formations, Fracture skin, Triple continuum*

TWO-DIMENSIONAL SOLUTE TRANSPORT WITH DEPTH-DEPENDENT INPUT SOURCE CONCENTRATION IN HETEROGENEOUS POROUS MEDIA

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Abstract

Two dimensional contaminant transport with depth dependent source concentration in finite heterogeneous porous formation is studied. Longitudinal and transverse dispersion coefficient are considered both space and time dependent and also advection is considered both space and time dependent along the groundwater flow direction. Aquifer is initially uni-formally contaminated with a uniform constant background concentration. Under the sorption condition first order degradation rate is included. At the inlet boundary some depth dependent decaying exponentially source concentration is assigned. At the other end of the boundary flux are vanished. Laplace transform technique has been used to solve the proposed model analytically. Solute transport source in porous media is obtained graphically for various geological input data. Numerical solution also obtained of the governing equation by Crank-Nicholson finite difference method. The numerical solution is compared with the analytical solution and find good agreement between them.

Keywords: *Advection; Dispersion; Contaminant transport; Groundwater flow; Porous media*

POLLUTANT TRANSPORT IN FINITE HETEROGENEOUS POROUS MEDIA UNDER NON-LINEAR SORPTION CONDITION AND DECAY

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Abstract

Pollutant transport in one-dimensional finite heterogeneous porous media is discussed under non-linear sorption isotherm and first order degradation. Initially, the porous medium is supposed polluted with some background pollutant. Input point source is taken as temporally dependent at the inlet boundary. At the exit boundary, pollutant flux is assumed to be zero. Due to heterogeneity of the porous media, pollutant dispersion and advection depend on space and time. These terms are made constant on applying suitable transformation. The governing equation is solved by Crank-Nicolson finite difference scheme to investigate the pollutant transport behaviour in finite heterogeneous porous media. All the numerical results are obtained in graphical forms for various hydrological input data. The numerical solution is validated with existing analytical solution for particular case.

Keywords: *Advection, Dispersion, Porous medium, Pollutant transport*

SIMULATION OF EXPERIMENTAL BREAKTHROUGH CURVES USING CTRW IN POROUS MEDIA

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Abstract

In this study, various tracer transport experiments have been performed in a rectangular tank of dimensions (1.5*0.10*0.50) m, filled with glass beads. The influence of variability in physical heterogeneity portrayed as spatial variability in hydraulic conductivity on breakthrough behaviour of tracer has been incorporated in the experimental model. A pulse of chloride has been injected as a conservative tracer to investigate the transport through porous media. Spatial variations in porosity and hydraulic conductivity have been made by using a needle vibrator in the fully saturated medium. Porosity thus calculated was verified by using numerous empirical formulae incorporating hydraulic conductivity and grain-size distribution. Flow through fully saturated glass beads was simulated using continuous time random walk (CTRW) Matlab Toolbox. The simulations using Truncated Power Law model from CTRW successfully replicated the concentrations as obtained from experimental breakthrough curves. The aim of the experimental studies is to verify the use of various porosity model and their effect on the prediction of experimental breakthrough curves.

Keywords: *Breakthrough Curves, CTRW, Physical Heterogeneity, Conservative Tracer*

EFFECT OF CHEMICAL HETEROGENEITY ON COLLOID TRANSPORT AT PORE SCALE

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Abstract

Chemical heterogeneity of soil grains has been found to create favorable conditions for colloid deposition. In this study, a mathematical model is developed to study colloid transport in a chemically heterogeneous porous media at the scale of a single pore. Colloid is assumed to be spherical in shape, physically and chemically homogeneous. The pore surface is assumed to be chemically heterogeneous with the average grain surface charge to be negative, representative of environmental conditions. Chemical heterogeneity is incorporated as patches of positive and negative charges on the pore surface. Colloid transport is governed by advection, diffusion and colloid-soil interaction forces. The interaction energy profiles for the heterogeneous surface is calculated using Modified-Derjaguin approach. The governing equations are non-dimensionalized which resulted in eight dimensionless pore-scale parameters describing the pore-surface heterogeneity, particle size, pore size, pore-water velocity, and ionic strength. Simulations are performed for a range of values of pore-scale parameters. Pore-scale results show that chemical heterogeneity significantly affects the transport and deposition of colloids. Even a small fraction of chemical heterogeneity on the collector surface has been found to make the conditions favorable for colloid deposition.

Keywords: *Colloids, Heterogeneity, Pore-Scale, Deposition*

CONCEPTUAL MODEL DEVELOPMENT AND ITS APPLICATIONS

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Abstract

Development of conceptual model is an important task for dealing with the simulation of real world problem. In this study a conceptual model has been developed using GMS (Ground water Modelling system) utilizing the MOD FLOW tool for calculating the groundwater head at different points. Conductance values, recharge values, porosity, hydraulic conductivity and layer elevation were used for the input given to the model. Wells head were measured in the field and compared with the simulated head to validate and calibrate the conceptual model developed. The field result and simulated result shows error being less than 5%. If the conceptual model is updated with new information, then more accurate results can be obtained. the developed conceptual model has wide applications. Two major applications have been discussed in this study.

Keywords: *Conceptual model, Multi-Phase flow, Conductance, Nitrate*

NUMERICAL MODELING OF NITRATE TRANSPORT IN FRACTURED POROUS MEDIA

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Abstract

Nitrate contamination in groundwater is a common problem due to the agricultural activities and many other sources. Once the groundwater gets contaminated from the source, the further movement of contaminant in the aquifer may distress large area. Since, fractured aquifer is very common in Indian subcontinent the nitrate movement through the fractured aquifer needs to be investigated. To achieve this, it is essential to develop a mathematical model to predict the quality of water in fractured porous system. In this work, a one dimensional numerical model has been developed to understand the transport and transformation of nitrogen species in fractured porous media using dual porosity technique. The governing equations pertain to the transport of nitrogen species in fracture and matrix are solved using finite difference technique. The nitrogen cycle used in numerical modeling assumes first-order rate coefficients for both nitrification and denitrification processes. The preliminary results suggest that the ammonium nitrogen and nitrate nitrogen concentrations are predominantly influenced by the advection process in the fracture, whereas the diffusion process affects the transport in the matrix. The consequence of porous matrix diffusion coefficient, matrix porosity, fracture aperture, fracture velocity, fracture dispersion coefficient, fracture spacing and bio-kinetic reaction rates are also studied on the migration of nitrogen species in the fracture and matrix.

Keywords: *Nitrogen Transport, Numerical Model, Fractured Porous Media, Groundwater Contamination*

EFFECTS OF INHOUSE PRODUCED BIOCHAR ON EROSION OF SOIL USING A LARGE-SCALE FLUME EXPERIMENT

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Abstract

Previous studies on use of biochar for soil erosion has been conducted mainly on a small-scale laboratory-based studies, where generally flow is assumed 1-D with constrained boundary conditions, that usually do not occur in large scale set up. Large scale flume study present boundary condition (including particle size) that are closer to real field. This study aims for a detailed investigation of the effects of biochar on soil erosion under high rainfall intensity with different biochar contents (0%, 5% and 10%). A large scale experimental (2.4 m x 1.8 m x 0.3 m) set up was built in-house for achieving objectives. In each experiment, the soil-biochar mixture was compacted in a set up. The entire set up was then simulated with rainfall intensity of 50 mm/hour for duration of 2 hours. During and after rainfall (for at least 24 hours), suction and water content was measured. Experiment was performed and data was collected simultaneously and after examining the runoff. Statistical significance was calculated to distinguish effects of different parameters.

Keywords: *Erosion, Biochar, Large scale flume, Suction*

SENSITIVITY OF FLUX LIMITERS USING FINITE VOLUME TECHNIQUE FOR CHARACTERIZING MIGRATION OF SUBSURFACE PETROLEUM HYDROCARBONS

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Abstract

Release of petroleum hydrocarbons into the subsurface and its subsequent dissolution followed by onshore oil spills lead to groundwater contamination. A comprehensive understanding of its fate and migration is imperative in planning proper remediation strategies. With inadequate field and laboratory data, accurate numerical modeling helps in characterizing the transport of the petroleum hydrocarbons in the subsurface system. Flux limiter TVD schemes in finite volume techniques are capable of eliminating numerical dispersion and providing accurate, oscillation free solution, making it appropriate for advective dominant contaminant transport modeling. Previous studies explored the application of this scheme for simulation of transport involving advection, dispersion, reaction etc. In the present study, an attempt has been made to investigate the application of flux limiter TVD schemes in numerically modeling the migration of benzene in saturated porous media and a numerical study is proposed to investigate the sensitivity of various flux limiters on the dissolution of benzene. Governing equation for one dimensional transport of benzene considering dissolution mass transfer coupled with advection and dispersion is numerically solved using flux limiter TVD schemes to predict the fate and transport of petroleum hydrocarbons in a saturated subsurface system. Sensitivity studies have been proposed to investigate the effect of dissolution mass transfer of benzene along with that of advection and dispersion, on various flux limiters, in predicting the spatial and temporal evolution of the contaminant. The impact of dissolution of benzene on various flux limiters such as van Leer, MC, van Albada, Superbee, Minmod are discussed for various boundary conditions.

Keywords: *Benzene, Numerical Modeling, Flux Limiter TVD Schemes, Dissolution, Advection, Dispersion*

INTEGRATION OF PHYSICAL AND NUMERICAL MODELLING OF SOLUTE TRANSPORT IN A LABORATORY AQUIFER MODEL USING VISUAL MODFLOW

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Abstract

Visualising subsurface fate and transport of solute and building intuition about the involved parameters is a complex process that requires the coupling of mechanistic models with appropriate data of the porous medium. The present work demonstrates the novel integration of laboratory physical aquifer model and computational model using Visual MODFLOW. An inorganic tracer was continuously injected at steady state on three different types of soil media viz. laterite soil (L), laterite soil mixed with fine sand (LS) and uniform mixture of laterite, sand and clay (LSC) to estimate the hydrodynamic parameters and natural attenuation within the physical aquifer model. An implicit finite-difference numerical model was also developed to simulate the advective dispersive transport of the solute considering the equilibrium-controlled sorption. The resulting transport equation was solved by the MT3DMS code which successfully reproduced the spatial and temporal distribution of solute in 3D experimental aquifer. The breakthrough curves (BTCs) obtained at different observation point of the physical model exhibit relatively regular, sigmoidal (S-shaped) distributions for L and LS type soil, whereas irregular shaped curves for LSC soil. Tracer velocities and hydrodynamic dispersion coefficients were estimated by fitting the analytical solution of the advection-dispersion equation to the observed BTCs. The numerical model was further verified by calculating the correlation coefficient and root mean square error (RMSE) with the observed data to confirm its ability to simulate the physical process. Finally, this integrated modelling framework demonstrates the need of laboratory aquifer model for the verification and calibration of mathematical models.

Keywords: *Aquifer Model, Visual MODFLOW, Tracer, Subsurface Fate*

**ASSESSMENT OF MIGRATION OF MANGANESE THROUGH SOIL MEDIA AND
CONTAMINATION OF GROUNDWATER FROM THE COAL MINE SPOILS IN
BARJORA AREA, WEST BENGAL, INDIA**

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Abstract

Inappropriate management of coal mine spoils creates environmental hazards. In many countries, high concentration of Mn was found in groundwater near to the coal mine spoil dump sites. Clay minerals (mainly illite + muscovite and chlorite) in shale contain exchangeable Mn concentration. Acid digestion, TCLP and batch leaching studies were performed to estimate Mn concentration in coal mine spoil (mainly in shale), which results 0.71 mg/l, 0.46 mg/l and 0.21mg/l of Mn concentration in leachates respectively. The acceptable limit of Mn in drinking water is 0.1 mg/l. The aquifer in this region is mainly unconfined type and the water table is very shallow. In situ soil is characterized by 44.3% sand, 37.5% silt and 18.2% clay with a hydraulic conductivity of 5.58 cm/day. Therefore, the aquifer is vulnerable to contamination of Mn from mine spoils. Column study and numerical modeling like Hydrus-1D were done to simulate Mn migration through the subsurface to the aquifer. Furthermore, a groundwater flow model had been developed based on available geological and hydrological data in Visual Modflow 2009.1 software and the movement of Mn in the aquifer was visualized using MT3DMS code.

Keywords: *Manganese, Soil Media, Groundwater Contamination, TCLP*

A STUDY ON TRANSPORT OF TOXIC METALS LEACHED FROM BORAGAON LANDFILL REFUSE BY THREE-DIMENSIONAL MODELING

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Abstract

This research work focuses on three-dimensional numerical modeling to investigate the migration behavior of toxic metals that leach into the subsurface hydrologic environment underneath the Boragaon waste landfill site of Guwahati city in India. The method of disposal of MSW in this locality is open dumping without any clay liner at the bottom and covering at the top of the dumped wastes. The importance of this research work is greatly amplified because of the presence of Deepor Beel Lake at the west side of the dumpsite. The development of the model is performed in HYDRUS-2D/3D computer-aided software, which solves Richards' equation for unsaturated flow and the advective-dispersive equation for solute transport. For the numerical analysis of the computational domain, time-varying precipitation data is applied at the upper boundary to represent the actual scenario of concentration breakthrough curves of Lead (Pb) and Cadmium (Cd) beneath the dumpsite. In the modeling approach, the solute transport is predominantly governed by advection, dispersion, and equilibrium adsorption, whereas the effect of diffusion is negligible. The model simulation result indicates that because of comparatively high adsorption coefficient K_d , the migration of Pb is limited up to the depth of 5.1 m from the soil surface, whereas, Cd migrates up to 10 m below the soil surface of the computational domain. In addition, at any time instant and a particular depth, the relative concentration of Cd is higher compared to that of Pb. Also, the transverse dispersion of Cd is more prominent compared to that of Pb.

Keywords: *Toxic Material, Leaching, Landfill*

NUMERICAL MODELING OF COLLOID-FACILITATED CONTAMINANT TRANSPORT IN KRISHNA VIHAR INDUSTRIAL SITE

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Abstract

The research work investigates the migration behavior of colloid and colloid-facilitated contaminant under transient flow condition comprising the attachment-detachment mechanism. The study area considers Krishna Vihar industrial site which is one of the uncontrolled e-waste dumping sites of New Delhi. The unscientific disposal of excessive e-waste results an increase in concentrations of the toxic metals and growth of the microbial organisms. To address this problem, one-dimensional numerical modeling is implemented in HYDRUS-1D for a two-layer soil system considering loam soil underlain by clay loam soil. The model assumes that the contaminant can be dissolved in liquid phase and also be sorbed instantaneously to the solid grains, mobile, and immobile colloids. The model incorporates time-varying daily precipitation data to interpret transient subsurface flow. The important parameters for the colloid-facilitated contaminant transport are incorporated such as attachment and detachment coefficient, adsorption coefficient, dispersivity. The infiltrated water flux is found to be dominating criteria in migration of the colloid and the contaminant compared to the initial moisture content of the medium. The analysis reveals that the mass transfer between the mobile and immobile colloids leads to higher adsorption of the contaminants to the colloids for increasing depth from the soil surface. The contaminant is co-transported with the mobile colloids after achieving peaks representing the actual scenario of migration of microbes with heavy metals. The spatial variations on the peaks of concentrations for the colloids and dissolved contaminant tend to move downward, indicating long-term effect of toxicity due to the contaminant in the dumpsite.

Keywords: *Colloid, Contaminant, Dispersivity, Toxicity*

MESHLESS SIMULATION OF MULTISPECIES REACTIVE TRANSPORT IN A POROUS MEDIUM USING THE ELEMENT-FREE GALERKIN METHOD

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Abstract

Multispecies reactive transport equations are often used to simulate the transport processes such as radioactive decay, denitrification, and bioremediation of organic compounds in the subsurface region. The various analytical solutions have been derived for such problems in the previous studies and are applicable to simplified problems. Therefore, mesh based finite difference (FDM) and finite element methods (FEM) have been used for complex reactive transport studies. However, meshless methods which work without computational mesh, a time consuming prerequisite step in FDM/FEM, has drawn the attention for contaminant transport studies in recent years. This work presents the element-free Galerkin method (EFGM) for solving the multispecies reactive transport in a porous medium. EFGM is based on the moving least square (MLS) approximation for approximating the unknown species concentration and calculating the shape functions. In this study, a MATLAB code is written for the EFGM based multispecies transport model and tested on a three species reactive transport problem with sequential first order decay reactions. The developed EFGM model is found to give numerical results very close to FEM results. Therefore, the present study shows the applicability of the EFGM to multispecies transport problems.

Keywords: *Meshless Simulation, Reactive Transport, Galerkin Method*

ESTIMATION OF FLOW AND TRANSPORT PARAMETERS FOR A CONFINED AQUIFER USING A MESHFREE SIMULATION AND PARTICLE SWARM OPTIMIZATION

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Abstract

Groundwater flow and transport models are essential tools for management of groundwater resources. Estimation of aquifer parameters in the simulation models is of prime importance for accurate assessment of water availability, fate of contaminants and remediation. In this study, the flow and transport parameters of a confined aquifer are determined through a simulation-optimization model. A coupled flow and transport model based on meshfree radial point collocation method (RPCM) is developed to simulate the head distribution and spread of contaminants in the aquifer. Unlike the grid/mesh based methods, the proposed simulation model uses set of scattered nodes in the domain without any nodal connectivity. Multi quadrics radial basis functions (MQ-RBFs) are used to approximate the state variables (head or, concentration) in the domain. The Particle Swarm Optimization (PSO) model is linked externally with the simulation model to estimate the state variables for flow and transport. The goal is to minimize the objective function i.e. the sum of squared differences of measured and simulated head and concentration values at the observation wells. The developed model will be used for parameter estimation of hypothetical/ field aquifer problems. This study demonstrates the capability of RPCM-PSO model for aquifer parameter estimation.

Keywords: *Inverse Modelling, Particle Swarm Optimization, Meshfree Method, Radial Point Collocation Method*

MATHEMATICAL MODELING OF RESERVOIR SEDIMENTATION PROCESS

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Abstract

Sustainability of reservoir storage is a major concern considering the steady increase in the sedimentation process. To understand the process of sedimentation, in this study a mathematical model is developed and used. The flow within the reservoir is considered to be one-dimensional quasi-steady. The reservoir is divided into fluvial and turbidity regions. In the fluvial region, gradually varied flow equation is numerically solved by the predictor-corrector method to find the water surface profile. In this region, the sediment transport equation is numerically solved by forward finite difference scheme, to find the bed elevation profile. In the turbidity region, the plunge point is located by using an empirical equation. From the plunge point, the interface between clear water and turbid water (an internal hydraulic jump), depth averaged flow velocity and depth averaged volume concentration of mud are numerically computed from the governing partial differential equations for the water mass balance, sediment mass balance and sediment moment balance by using the Warming-Kutler-Lomax (WKL) scheme. When the interface level remains below the reservoir height, no flow boundary conditions are used to get the trap efficiency of 100 percent and over flow boundary conditions are used for the interface above the reservoir height to get the trap efficiency less than 100 percent. Bed elevation is calculated by solving the sediment transport equation for mud using finite forward difference scheme. The model is validated by simulating the results of a laboratory scale experiment. The model is also implemented to simulate a hypothetical field scale reservoir.

Keywords: *Mathematical Model, Reservoir, Sedimentation, One Dimensional, Deposition*

A NUMERICAL MODEL TO STUDY THE EFFECT OF MATRIX FRACTURE SHAPE FACTOR FOR A COMPRESSIBLE FLUID IN STRESS SENSITIVE FRACTURED POROUS MEDIUM

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Abstract

The matrix fracture shape factor is an important component for the reservoir simulation of fluid flow through a fractured porous medium. Many earlier studies have investigated the matrix fracture shape factor for a single-phase slightly compressible fluid in a fractured medium using constant or variable fracture pressure boundary conditions. As opposed to the slightly compressible fluid, the highly pressure-dependent viscosity and compressibility of compressible fluid make the fluid flow equation highly nonlinear. In recent studies, the matrix fracture shape factor for a compressible fluid in fractured reservoirs has been presented using a nonlinear diffusivity equation in the matrix. These studies were done using a non-coupled approach in a fractured reservoir by treating variable fracture pressure depletion regimes and deriving the shape factor for different geometries and various distributions of matrix block sizes. Also, these studies treat the fractured reservoir as incompressible. In reality, with the production of reservoir fluids, the decrease in reservoir pressure leads to an increase in the overburden stress resulting in a reduction of fracture permeability. The reduction in fracture porosity, matrix porosity, and matrix permeability is not that significant. The focus of the present work is to study the effect of matrix fracture shape factor for a single-phase compressible fluid in a stress-sensitive fractured porous medium. In the present study, a numerical model has been used to account for the stress sensitivity of the fracture permeability for a compressible fluid in a fractured porous medium using a coupled nonlinear fluid flow approach in a dual-porosity medium. Here, an attempt has been made to improve the understanding of the fluid flow through a fractured porous medium.

Keywords: *Single-phase flow, Fractured gas reservoirs, Dual-porosity systems, Matrix-fracture fluid transfer, Stress sensitivity*

MODELING OF SPATIAL RAINFALL INTENSITY DISTRIBUTION AND STORMWATER RESPONSE FOR URBAN AREA AND ITS IMPACTS ON POLLUTANT LOADING IN COMBINED SEWERAGE SYSTEM

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Abstract

The selected urban and suburban watershed regions of Bathinda (Punjab) were used for the modeling of spatial rainfall intensity distribution and the Stormwater response of urban regions and its impacts on pollutant loading in the combined sewerage system. Precipitation was measured at individual gauges. Spatial interpolation using averaging schemes (Theissen polygon method) and other similar approaches based on spatial correlation of rainfall yield were used to compute areal precipitation rates from those measured at individual gauges. The quantity of precipitation not captured by initial depression storage and not infiltrated into ground surface was computed as a linear convolution of the individual contributions for each time interval. Flow rates at different points along drainage lines (sewerage channels) were calculated using a method based upon continuity equation, to route flow from upstream locations to points downstream. Site-specific pollutant mean concentration was determined based upon predicted build-up and wash-off processes for the entire catchment area. Based upon results (by using pollutant build-up models) pollutant mean load of different pollutants (heavy metals, chloride, and ammonia) for runoff events from urban areas was calculated. Suitable filter media with good sorption/binding and pollutant removal capabilities for use in the constructed wetland was recommended for the advanced treatment of cumulative stormwater runoff coming from the urban and suburban watershed of Bathinda (Punjab) region.

Keywords: *Watershed, Rainfall, Runoff, Yield, Drainage Lines, Pollutant Load, Build-Up, Wash-Off, Filter Media, Advance Treatment*

MOVEMENT OF NON-SPHERICAL COARSE SOLITARY PARTICLES

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Abstract

Sediment transport computation is important as it is instrumental in solving various problems like erosion, reservoir sedimentation, design of stable channels, river morphological predictions, and effect of deposition of fine sediment on aquatic life. In mountainous regions sediment transport occurs in the form of coarse gravel particles. The sediment transport process is very complex phenomena owing to involvement of large number of variables related to channel, fluid and sediment characteristics. Ample research has been done to know the effect of these variables but a very little work is reported in the available literature to study the effect of orientation of sediment particle on its movement. This study was undertaken to quantify the effect of orientation of non-spherical coarse solitary particles of different sizes on the movement of the sediment particle. Based on the hypothesis conceived in this study, the orientation of sediment particle becomes important to consider in case of non-spherical and non-cubical particles. It has been observed that with the change in orientation of the particle, the surface area facing the flow and the area in contact with bed of the particle change for the same particle and accordingly, acting and resisting forces change for different orientations which changes force dynamics acting on particle. Various equations and graphical representations in terms of dimensionless bed shear stress, grain Reynolds number, ratio of exposed area to base area, and shear force were developed to determine the effect of particle orientation on its movement.

Keywords: *Bed Shear Stress, Particle Movement, Particle Orientation*

APPLICATION OF BENTONITE CLAY IN THE REMOVAL OF POLLUTANTS FROM CONTAMINATED WATER

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Abstract

Water is one of the most vital natural resources. A considerable amount of pollutants is brought to water through urban development, human-induced activities and industrialization. The existence of natural organic matter, heavy metals, pesticides, dye and insecticides makes the water unsuitable for human consumption. These pollutants seem to have a detrimental impact on human health and aquatic ecosystems. With the development of technology; more efficient, low-cost and robust techniques have been used to treat wastewater that has little effect on the environment and human health. In the past few years, extensive studies have been carried out to find alternative and economically viable water and wastewater treatment techniques. Among adsorbents, clay minerals are prevalent and commonly used to treat heavy metals, organic matter, bacteria and pathogens. Clay mineral has therefore been able to adsorb because of the higher surface area. Clay minerals like bentonite are inexpensive, high chemically and mechanically stable, abundant and appropriate textural properties make it a suitable adsorbent in comparison to others. A comparative study of bentonite clay with other adsorbents highlights the key findings of adsorption studies to treat wastewater. It has been found that the adsorption capacity of bentonite clay was found to be higher due to its textural structure that will be used in the water treatment applications. Bentonite clay has several medicinal uses that enhance its utilization and also, no secondary contamination results.

Keywords: *Bentonite Clay, Adsorbents, Wastewater, Contamination*

VIRUS TRANSPORT THROUGH HOMOGENOUS UNSATURATED ZONE USING HYDRUS-1D

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Abstract

A one-dimensional numerical model is developed to study the vertical movement of the water and virus transport through homogeneous unsaturated porous media. The flow through a variably saturated zone is complicated and it is difficult to describe it quantitatively. As there is often changes in the state and content of soil water during flow so the flow through this zone is considered to be a highly nonlinear problem. In this study finite element scheme computer coded software, HYDRUS-1D is used to simulate the one-dimensional flow equation and virus transport equation. This study is mainly carried out for a particular location of Guwahati city, Assam, India. The study uses a transient flow condition of water flow that is coupled with the convective-dispersive equation for subsurface solute transport. For simulating the partial differential equation of virus transport equilibrium solute transport model is selected with Crank-Nicholson as time weight scheme and Galerkin finite elements as space weight scheme. The viruses that are been employed in this study were the male-specific RNA coliphage MS2, and the Salmonella typhimurium phage, PRD1. The result from the simulation indicates that the presence of water content has influenced the transport of virus through the unsaturated zone.

Keywords: *Virus, unsaturated, Crank-Nicholson, Galerkin finite element*

APPLICATION OF MODIFIED ZERO VALENT IRON NANOPARTICLES FOR ARSENIC (III) REMEDIATION

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Abstract

Large active surface area and high arsenic adsorption capacity make nano-zero valent iron (nZVI) a promising adsorbent for arsenic removal, however, due to high surface energy and the inherent magnetic forces of nZVI, it gets agglomerated and reduces its efficiency for adsorption. The objective of the present study was to develop supported nZVI over the porous material, Pumice, and its subsequent use for As (III) removal in the continuous flow system. Liquid Phase Synthesis was used to impregnate the iron nanoparticle on the surface of the porous material via reduction of iron in the presence of the base material by sodium borohydride. Batch experiments demonstrated a quick removal of As (III) at initial stages followed by a slower removal rate, making it a two-stage process. The developed composite was applied in a continuous flow column study for 30 days, and it demonstrated 99 % removal of arsenic with an average arsenic loading of 0.94 mg/gm over the adsorbent. The hydraulic conductivity of the adsorbent media was observed to be reduced by approximately 20 % during the experiment, but it was still comparable enough to the average conductivity of the arsenic affected aquifer media. High removal efficiency over wide pH range, low cost and better hydraulic and mechanical properties makes it a promising adsorbent for field application.

Keywords: *Arsenic, nanoparticles, zero valent iron, hydraulic conductivity*

SOLUTE TRANSPORT MODELLING IN THE VARIABLY SATURATED ZONE OF VINDHYAN-GANGA SEDIMENTARY DEPOSITS

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Abstract

The objective of this study is to model the vadose zone of the Vindhyan-Ganga sedimentary deposits near Mirzapur, U.P. for mapping the vulnerability to groundwater contaminants. A total of 12 Vertical electrical soundings (VES) are performed to obtain the stratigraphic data of the area. Lithological data from the VES are used to define the grid cell and layers of the model. Modified Richard equation along with advective-dispersive equation combining with Fick's law is used for the modeling purpose. Determination of unsaturated hydraulic properties like $\Theta(h)$ and $K(h)$ is quite difficult and generally their precision determines the accuracy of the model. Keeping the heterogeneity of the area in mind, Van Genuchten (1980) model combined with statistical pore-size distribution model of Mualem (1976) is used to determine these unsaturated hydraulic properties. Constant head boundary condition is used in the model and solute concentration profiles are plotted for every 100th day starting from $t = 0$ days to $t = 500$ days. For each hydrogeological location three different nodes at top, middle, and bottom of soil strata are selected for computing the varying solute concentration with time. The cumulative solute flux applied at the surface and collected at the bottom most node (representing the groundwater table) is plotted for the mass balance. The time required for surface solute to reach the underground resources is found to be the highest for Chhitampur; therefore, this location is assigned a lowest vulnerability index value of 1. Comparative values of vulnerability index for remaining locations are obtained by normalizing their respective transit time. For the study area, groundwater near the Lusa-Atari is more vulnerable to pollution as the time taken by contaminant plume to reach the water table is minimum for this location. The findings of this study directly help in effective management of groundwater resources.

Keywords: *Groundwater vulnerability, Vertical Electrical Sounding, Vindhyan-Ganga sedimentary Formations, Solute transport modeling*

TS - 4

(REMEDICATION OF CONTAMINATED SOIL-WATER)

Keynote Paper

BANK FILTRATION AT HIGHLY POLLUTED RIVERS

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Abstract

Bank filtration (BF) has been well-established as a sustainable technique for natural water treatment through highly effective removal of a large number of pollutants at low costs. At many sites worldwide, BF schemes at streams, rivers, lakes, ponds and basins have been successfully operated for several decades. Most BF schemes in Europe are monitored to ensure optimization of processes in the river/lake bed and in the aquifer. Some inefficient schemes have been closed due to clogging or water quality concerns. Although in Europe the development of new BF sites is rare due to decreasing water demand, there is a wide scope for BF technology in India, South Korea, Egypt, Thailand and other countries even at highly polluted rivers. A complex and comprehensive assessment of hydrological, hydrogeological, hydrochemical aspects together with state-specific regulations, land use, cost and other issues is necessary for optimal BF siting. It is essential to have a clear understanding of how BF will be utilized (e.g., as a means of pre-treatment or as a primary treatment) prior to commencing site location planning studies.

In the case of wastewater-polluted river water, river bank filtration (RBF) offers a natural cost-effective pre-treatment step, achieving the removal of pathogens, a reduction in disinfection by-product formation, better taste of water, and protection against shock loads of chemicals and pathogens resulting from accidents. The authors see a huge potential for wider use of RBF worldwide, especially because the removal of microbial pathogens in drinking water from surface

water through RBF would be a crucial factor. Thus, it could serve as an alternative to direct river water abstraction. At a minimum, bank filtration acts as a pre-treatment step in water production for drinking, industrial and agricultural use. Even if treated wastewater contributes to a high percentage to river discharge, RBF may be feasible to improve water quality for further use of the river water.

The future utilization of RBF requires an integrative assessment of the sustainability of bank filtration under changing boundary conditions, e. g. caused by potential climate change and wastewater input. Such boundary conditions are mainly the frequency, duration and peak behavior of floods and droughts affecting the available water quantity, changing river water temperature and concentrations of biodegradable organic matter and redox species resulting in changing biomass production and biological activity and thus influencing the water quality and treatment capacity. To our present knowledge, the potential climate changes do not jeopardize the bank filtration effectiveness, although adaptation strategies have to be developed to account for an increase in extreme events. To cover low flow periods, integrated water resources management becomes crucial. In the United States and in India, horizontal collector wells have been installed with laterals directly beneath the river bed. Thus, there is sufficient water abstraction during low flow periods, but the pre-treatment effect is limited due to short retention times (several hours to a few days). Furthermore, high abstraction rates cause clogging of the riverbed. Low flow conditions are critical for RBF operation if the extraction rates per unit area of the river bed/ river bank are high. From long-term experiences, an average infiltration rate of less than $0.2 \text{ m}^3 \text{ m}^{-2} \text{ day}^{-1}$ over the river bed ensures limited clogging and stable infiltration conditions.

Results from a literature survey and field experiments using abstraction wells and observation wells to study the removal efficiency of RBF sites located at heavily polluted rivers by non-treated and treated wastewater in India, Egypt, South Korea and Russia will be summarized. Problems and limitations of RBF related to source water quality will be highlighted. It will be shown that BF can act as a safety measure against spills of contaminants into the river and as a cost effective pre-treatment step. Experiences from existing sites in Europe and Asia will be used as a benchmark for planning new sites setting a focus on feasible surface water quality. Regional differences in source water quality, design and operation of BF schemes will be highlighted. BF as an element of IWRM, coupling of BF with innovative techniques for post-treatment (AquaNES project) as well as proposed steps for wider application and acceptance of BF in Asia will be discussed.

**VISIBLE LIGHT ACTIVATED PHOTOCATALYTIC SYSTEMS FOR EFFICIENT
DETOXIFICATION OF POLLUTANTS TOWARDS WASTEWATER TREATMENT
APPLICATIONS**

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Abstract

Water pollution is an emerging problem across the world due to rapid population growth and modern industrialization. Waste water contains organic (such as phenolic derivatives, polycyclic aromatic hydrocarbons etc.) and inorganic compounds (e.g. heavy metals) which can cause serious disorder. Photocatalysis is an advanced oxidation process, considered an effective technique for treating wastewater laden with organic contaminants. The method successfully harnesses abundant and sustainable solar energy for water purification. ZnO and TiO₂ are well known photocatalysts to degrade organic and inorganic pollutants. However, these materials still require modifications with other nanomaterials because these materials absorb only ultraviolet part of sun light due to wide bandgap and the excitons created under the UV light recombine rapidly. In this talk, I will present our group's recent work about visible light activated nanostructured photocatalysts for removal of dyes and toxic heavy metals. Photocatalytic activity was enhanced through sensitization with carbon/quantum dots, doping with transition metals and functionalization with metal nanoparticles. Developed materials are reusable, and their nanostructures do not change after repetitive usage. Finally, development of inexpensive prototype photochemical reactor will be discussed towards continuous flow operation. Our current research focus is to develop visible light activated low-cost and scalable photocatalysts to treat effluent water from industries in particular, pharmaceutical and tannery.

Keywords: *Photocatalyst, Dye removal, Water treatment, Nanofibers, Quantum dots*

**ARSENIC CONTAMINATION OF GROUNDWATER IN CENTRAL GANGA BASIN
AND POSSIBLE REMEDIATION METHODS: A REVIEW**

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Abstract

As concentrations in groundwater have become global concerns due to its toxicity and adverse effects on human health, contamination mainly the outcome of geogenic sources. The large number of population from Ganga basin has highly dependent on groundwater for drinking, irrigation and other uses even though it contains a high level of As. The concentration levels of As varies from 50 to 1861 ppb in some areas of Ganga plain in the state of Uttar Pradesh, Bihar and Jharkhand. 20 districts out of 75 in Uttar Pradesh, 15 districts out of 38 in Bihar and 1 district out of 24 in Jharkhand state are contaminated with arsenic greater than 50ppb. It is reported that groundwater has been contaminated by As mainly in the shallow aquifer. Different hypothesis viz. oxidation of organic matter by microorganisms and reductive dissolution of oxy-hydroxide of Fe and Mn shows the pathway of As release in groundwater and combined effects of NaHCO₃ and high pH values also play an important role to mobilize the arsenic from the surface of iron oxides, other minerals and subsurface sediments. In the present paper, various theories for arsenic occurrence have been deliberated. The remedial measures adopted for arsenic removal is also discussed.

Keywords: *Arsenic mobilization, Central Ganga basin, Groundwater, and Remediation.*

**PERMEABLE REACTIVE BARRIER FOR IN-SITU REMEDIATION OF SHALLOW
CONTAMINATED AQUIFER: AN OVERVIEW**

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Abstract

Due to several anthropogenic activities, such as expansion of industries, application of persistent chemicals in agriculture and changing lifestyle, the vulnerability of groundwater resources in terms of pollution is rapidly increasing. Now, groundwater in many cities, such as Delhi, Mumbai, Chennai, is not used for drinking purpose. Persistent pollution due to chemicals such as Arsenic, lead, chromium, cadmium etc. has also been observed in many places in India. The rapid groundwater pollution is a serious threat for humans and all living organisms of earth. Extracting groundwater and then treating it for different uses, is a costly affair and it cannot stop the contaminated plume to move further. In-situ remediation of contaminated groundwater is a promising technology which is emerging and presently used by some of the developed country. Permeable Reactive barrier (PRB) is one of such in-situ remediation technique used to remediate contaminated groundwater. These barriers are installed in the flow path of contaminated plume. Zero valent iron (ZVI) is the most common reactive material used for this technology. Other reactive materials such as granular activated carbon, limestones, agricultural byproducts are also used as reactive material for PRB. PRB is advantageous over other in-situ technology, since it has a tendency to remediate both organic contaminant as well as inorganic contaminant such as heavy metals. All though, batch experiments have shown great potential of absorption of heavy metals with reactive materials such as ZVI, but still the installation and management of PRB is a matter of investigation in India.

Keywords: Permeable Reactive Barrier, Groundwater In-Situ Remediation, Zero Valent Iron, Granular Activated Carbon

WATER QUALITY OF RIVER DIKRONG IN ARUNACHAL PRADESH, INDIA

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Abstract

The rivers flowing through Arunachal Pradesh have been considered to be clean and uncontaminated water in the past. However, few studies indicated that these rivers are now getting polluted due to domestic, industrial and agricultural wastes. Thus, the present study aims to assess the water quality of Dikrong river (a tributary to River Bhamputra) in the stretch from Pappunallah to Kankarnallah of Naharlagun township in Papumpare district of Arunachal Pradesh (India). Naharlagun is a twin city of the capital complex of Itanagar, Arunachal Pradesh. Some part of the data used in this study is obtained from Arunachal Pradesh State Pollution Control Board and the other part is tested in the Laboratory. This river receives untreated industrial, domestic and solid waste disposal along this stretch. During wet season the river also receives pollution from agricultural land. The present condition of the river is analyzed by water sampling at some selected locations.

OPTIMIZATION OF RICE-HUSK DERIVED BIOCHAR THROUGH RESPONSE SURFACE METHODOLOGY FOR THE REMOVAL OF FLUORIDE FROM GROUNDWATER

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Abstract

Excessive exploitation of groundwater and weathering of parental rocks incorporates fluoride in groundwater resources. The presence of fluoride in drinking water exhibits beneficial as well as toxic effects on human health. High concentrations of fluoride cause several health problems such as fluorosis due to the accumulation of fluoride in soft tissues, bones and teeth. To reduce the concentration of fluoride from drinking water several conventional and non-conventional methods are available such as coagulation, ion exchange, membrane filtration, and adsorption. Adsorption is most widely used method due to its inherent advantages such as low-cost, easily availability and eco-friendly. This study employs rice husk derived biochar as an adsorbent to treat fluoride contaminated groundwater. Process parameters play a crucial role in governing the physical and chemical properties of biochar. A response surface methodology (central composite design) was employed to identify the linear and interaction effects of process parameters (temperature, heating rate and time) on fluoride removal. The optimized values for temperature, heating rate and time were found to be 350°C, 7°C/min and 40 min respectively. Batch adsorption studies conducted with groundwater samples indicated 67.40% removal of fluoride, which enhanced considerably to final removal of 95.44% after three consecutive cycles of adsorption. Langmuir isotherm model was found to be applicable with a maximum monolayer adsorption capacity of 1.85 mg/g. Thermodynamic studies demonstrated enhanced adsorption at a lower temperature. This study demonstrates through a systematic optimization methodology, that rice-husk derived biochar is a cost-effective and sustainable technology for the treatment of fluoride contaminated groundwater.

Keywords: *Fluoride, Biochar, Groundwater, Response surface methodology, Pyrolysis*

REMEDIATION OF CONTAMINATED SOIL- WATER WITH VOC- OIL SPILL IN NORTH CHENNAI

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Abstract

Operations in petroleum, have historically resulted in leakages from pipelines, oil wells, and USTs, causing contamination of the surface, groundwater, and soil. Once the spill occurs, there are various important steps that are required to assess the source, impact, quantity, and its remediation, collectively called as an environmental site assessment (ESA). Over the last 20 years, Stratus has been involved in a number of hydrocarbons impacted site assessments and subsequent remediation efforts in the USA. We (Stratus) are presenting our recent experience in the assessment and remediation of an Oil spill site in Tondiarpet, Chennai. In 2013, an oil spill occurred in the vicinity of Varadarajan Perumal Koil Street and Tirivattoyur high Road, Chennai. Stratus was retained to assess the lateral and vertical extent of impact to soil and groundwater and mitigate the petroleum hydrocarbon impact the subsurface. The first step adopted was the removal of free product from the private borewells using absorbent socks and manual bailing. Stratus used a hollow stem auger rig to collect depth specific soil and groundwater samples. Using the lithologic data, field observations, and analytical data obtained from the depth-specific soil samples, Stratus designed and installed a monitoring well network and developed a site conceptual model. Stratus conducted an evaluation of remedial alternatives based on implementability, effectiveness, and cost and developed a corrective action plan. Stratus selected and successfully installed a remediation system consisting of “soil vapor extraction” (SVE) and “air sparging” (AS), that has been mitigating the impact to the subsurface.

Keywords: *Oil Spill, Preliminary steps, Assessment, Remediation.*

UTILIZATION OF WASTE MARBLE POWDER FOR THE SYNTHESIS OF CALCIUM BASED PHOTOCATALYST: AN APPROACH TOWARDS SUSTAINABILITY

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Abstract

In this paper waste marble powder was used to prepare calcium based photo-catalysts. A successful synthesis was done by solid state method for the preparation of different photocatalysts which were characterized for the determination of related physical and chemical properties. Samples were analyzed by XRD, SEM, FTIR, UV-DRS and PL for the determination of chemical properties whereas SEM analysis was done for analyzing the structural morphology. A variety of calcium titanate were successfully synthesized using the solid state method and bringing variations during process synthesis such as by calcination temperature, sonication and use of either fresh or pre-calcined marble powder and their comparative study on their photocatalytic activity to degrade congo red was studied. It was found that Sonicated CT 650 gives best results i.e., 95.54 percentage of decolourisation and rate constant k i.e., 0.013 mole per second was obtained when congo red dye solution was treated with 1 g/L of prepared photocatalyst under 300 W visible light irradiation for 100 minutes at 25 °C.

Keywords: *Photocatalyst, Calcium Titanate, Solid state synthesis, Congo Red*

BIOSORPTION OF ZINC AND LEAD FROM GROUNDWATER USING WASTE FUNGAL BIOMASS AS EFFICIENT ADSORBENT

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Abstract

Heavy metals are important environmental pollutants, particularly in areas with high anthropogenic sources. These pollutants are extremely persistent in the environment, nonbiodegradable non thermo-degradable, therefore could readily accumulate to toxic levels. It has been observed by many researchers that drinking water was contaminated with two heavy metals (Zinc and Lead) in case of the areas adjacent to tannery industries. Biosorption is a very economical way to remove heavy metals from an aqueous solution that is exhibited very efficiently by bacteria, algae, fungi, and yeasts. In this study, we used dead fungal biomass collected from one pharmaceutical industry. Biosorption of Zn^{2+} and Pb^{2+} from single and binary aqueous solution by using waste biomass (MB2) were investigated. Various parameters including different pH (2-5), concentration of metal solution (5-50 mg L⁻¹), biomass concentration (0.25-4%) and contact time were standardized. Waste biomass (MB2) was able to removed 93% Pb^{2+} and 91% Zn^{2+} from single and 95% Pb^{2+} and 97% Zn^{2+} from binary metal aqueous solution containing 25 mg L⁻¹, pH 4. The adsorption capacity was found to be the highest for Zn^{2+} followed by Pb^{2+} in both single and binary sorption experiments. As metal ion concentration was increased from 5 to 50 mg L⁻¹, metal uptake by biosorbent was also increased for Pb^{2+} and Zn^{2+} in both single and binary metal sorption system. Correlation coefficient ($R^2 = 0.9543$ for single and 0.9582 for binary sorption system) indicate that the adsorption pattern for Zn^{2+} and Pb^{2+} followed the Freundlich isotherm.

Keywords: *Biosorption, Heavy Metals, Dead Fungal Biomass, Zinc and Lead*

EFFECT OF HEAVY METALS AND NUTRIENTS WITH DIFFERENT TROPHIC STATES ON AZOLLA CRISTATA, SALVINIA NATANS AND LEMNA MINOR.

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Abstract

Due to industrialization and population growth, quantum of wastewater is increased worldwide. Heavy metals and excessive Nitrogen, Phosphates and Potassium in agricultural, industrial and municipal wastewater impose hazardous effects on environment and human health. The treatment of waste water prior to discharge in water bodies is a vital necessity. Therefore, phytoremediation is an economically viable and eco-friendly plant based technique used to clean up contaminated aquatic environs. In this context, a study on phytoremediation was carried out to investigate the effect of different nutrients in different trophic states on the growth and survival rate of *Azolla cristata*, *Salvinia natans* and *Lemna minor* at different concentrations of nitrogen as 2.5, 1.0, 0.25, phosphorous 1.25, 1.875, 0.025 and potassium 2.5, 1.0, 0.125 mg/l in eutrophic, mesotrophic and oligotrophic conditions respectively and under multimetal concentrations of Zn, Cd, Cu, Pb and Hg at 1.5 mg/l and 3.0mg/l. It was found that the plants exhibited phytotoxicity at different concentrations. The samples were collected from open freshwater sites and taken to the laboratory for invitro experimentation for a period of 15 days. At 1.5 mg/l of heavy metal toxicity the plants did not show any changes in survival and growth in any of the trophic states. However, at concentrations of 3 mg/l, deleterious changes were displayed by the plants in relation to their growth and survival. The survival rate decreases with the increase in the time period of toxicity dose.

Keywords: *Azolla cristata*, Growth rate, *Lemna minor*, *Salvinia natans*, Survival rate, nutrients, heavy metals

MAGNETIC METAL OXIDE NANOPARTICLES LOADED REDUCED GRAPHENE OXIDE SHEETS FOR THE PHOTOCATALYTIC REMOVAL OF WATER CONTAMINANTS UNDER SUNLIGHT IRRADIATION

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Abstract

Water pollution is an emerging environmental issue causing severe damage to the globe and seeking immediate preventive measures. Industrial discharged water contains many harmful contaminants such as dyes, phenolic compounds, pesticides and heavy metals, which are considered very carcinogenic to human health and other leaving organisms. The rapid development of industries has introduced many serious problems to ecosystems and leading adverse effect to the human health and environment. Photocatalysis is one of the widely recognized most efficient techniques for the decontamination of industrial wastewater. Reduced graphene oxide (rGO) represents an excellent support for the synthesis of nanoparticles resulting in nanocomposites. Therefore, we have synthesized magnetic metal oxide/rGO nanocomposites adopting eco-friendly solution chemistry approach. The synthesized nanocomposites materials were characterized by different analytical tools and utilized as an efficient photocatalyst for the degradation of harmful dye molecules and phenolic compounds, pesticides and reduction of toxic heavy metal to non-toxic metal ions under direct sunlight irradiation. The graphene sheets in the nanocomposites restricted the recombination of electron-hole pair and enhance the photocatalytic activity of the metal oxide semiconductors.

Keywords: *Meta oxide, Photocatalysis, Dye, Phenol, heavy metal.*

REMEDICATION OF ROCKET FUEL CONTAMINATED GROUND WATER USING POLYELECTROLYTE MULTILAYER MEMBRANES

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Abstract

Surface modification is an effective method which can bring in new properties to a membrane surface. It was evident from our previous study that the polyelectrolyte deposited membrane surface can effectively remove perchlorate from water. The present study is to scale up the process to purify the contaminated ground water due to the pollution from a rocket fuel manufacturing plant. Polysulfone (Psf) 10 KD membranes were surface modified by depositing 5 bilayers of PEI/PSS polyelectrolyte combination which improved its perchlorate removal efficiency from 40% to 80%. The resultant membranes showed the same performance stability irrespective of feed concentration, trans-membrane pressure and coexisting ions in feed. It was found that the membranes retain their perchlorate rejection ability in long term usage as well. The membrane performance was evaluated for the removal of perchlorate from well water samples collected from a contaminated site. It was found that the membranes could remove ~80% of perchlorate. The performance or removal percentage remained steady for a prolonged interval (240 hours). It was found that the two step operation could further improve the perchlorate removal efficiency to ~ 95%. Finally, the resultant membranes were characterized using different analytical methods. It can be concluded that the surface modification and operation of Psf membranes in Cross-flow filtration mode is a suitable way to scale up the polyelectrolyte multilayer membranes for the purification of rocket fuel contaminated ground water.

Keywords: *Ground water, perchlorate contamination, membrane filtration, polyelectrolyte multilayer.*

IN-SITU PHYTOREMEDIATION OF HEAVY METALS CONTAMINATED GROUNDWATER

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Abstract

Groundwater contamination by heavy metals is originating either from natural sources or from anthropogenic sources. Groundwater remediation is a matter of concern because it is the only source of drinking water and people all over the world uses groundwater for drinking purpose. In situ remediation is the remediation technique without excavation of contaminated sites. This technique is favoured over the ex-situ technique due to its low cost and reduce the impact on the ecosystem. Heavy metals cause significant damage to the environment and human health as a result of their solubilities and mobilities. These heavy metals are not degraded and they remain to persist in the environment and contaminate the groundwater sources. Phytoremediation is an emerging technique in which plants and their associated soil microbes are used to remediate the concentration of toxic effect of contaminants from the environment. It is an efficient, cost-effective, sustainable, eco-friendly and novel strategy. Phytoremediation is an area of current research work. Phytoremediation process will play an important role in attaining the goals of sustainable development in future prospects. One of the efficient methods of phytoremediation is rhizofiltration for remediation of heavy metals contaminated groundwater and its ability to be used as in situ or ex-situ application. The main aim of this paper is to provide an overview of a novel strategy called phytoremediation for treatment of contaminated groundwater. Newly efficient metal hyperaccumulators plants are being explored for this remediation purpose.

Keywords: *Groundwater, In-Situ Remediation, Heavy metals, Phytoremediation.*

PER- AND POLYFLUOROALKYL SUBSTANCES- AN EMERGING POLLUTANT OF CONCERN IN THE RIVER WATER

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Abstract

Per- and polyfluoroalkyl substances (together, PFASs) are unique chemicals preferred in various industrial applications for their chemical stability and low reactivity. PFASs are soluble in aqueous solution, hence easily transported in the water body. These chemicals are also extremely resistant to degradation; therefore, they get bioaccumulated from contaminated water sources. Human exposure to these chemicals on a long run has led to and may lead to adverse health effects such as cancer, obesity, and endocrine system disruption. Monitoring the sources of human exposure to these chemicals through drinking water is the need of the hour. In India there is no routine testing of water samples for PFASs. The detection of these chemicals is mandatory among the water sources close to hazardous waste dumping sites. This study is an attempt to detect the PFASs using LC-MS in all the river waters of Kasaragod, the northern most district of Kerala. The study faced several challenges because of background PFASs originated during the analysis. Concentration of PFASs in the water samples varied in the detection levels.

Keywords: *Exposure; LC-MS; Per- and polyfluoroalkyl substances (PFASs); Public health; River Water*

ECOLOGICAL RISK ASSESSMENT OF AN OIL SPILL AND BIOREMEDIATION MEASURES

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Abstract

Oil spills have always been a major environmental issue. Considering the immensity and toxic impacts of the oil spills, environmental risk assessment (ERA) was done for one of the largest oil spill that took place in Mumbai. Fault tree analysis depicted that human / mechanical error played the most significant role for the collision of the ships which resulted into the massive oil spill. Apart from this, communication error both on the part of the ships as well as control authorities has also been one of the reasons. Looking at the spontaneous nature of such incidents, event tree analysis suggests that these cannot be controlled effectively in short duration of time, and therefore, a well-planned mitigation strategy needs to be formulated well in advance. ERA may act as a tool which gives an insight about the severity of the problem and a way forward in formulating ameliorative measures for any future oil spill incidents. Existing bioremediation methods address the various contaminants in a uniform level. However, present study shows that if these methods could be applied at a specific level, considering the hazard potential of individual contaminant; the exposure time to various carcinogenic contaminants would be significantly reduced resulting in faster mitigation.

Keywords: *Bioremediation, Environment Risk Assessment, Fault Tree Analysis, Oil spill.*

CHROMIUM REMOVAL FROM TANNERY EFFLUENT WITH BIOLOGICAL WASTES AND VERMICULITE

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Abstract

Naturally occurring wastes like rice husk, sawdust, coirpith and naturally occurring mineral vermiculite have been used for their eliminating the Chromium from tannery effluent through column experiments. The sample concentration of Chromium is 184.8 this sample are passed from the column having dimension height 50cm and width 5cm; sample is passed through different biosorbent media and its other combination. The biosorbent and mineral vermiculite in columns were found very efficient in removing Chromium from the effluent. A outstanding reduction in total Cr (184.8–4.47 mg/l) was accomplished with the vermiculite plus coirpith column This study showed that biological wastes are likely adsorbents of Chromium, which could be successfully used to decrease the Chromium concentrations in tannery effluent.

Keywords: *Chromium, Tannery effluent, Biosorbent, Vermiculite.*

WASTE WATER TREATMENT USING CONSTRUCTED WETLAND: A REVIEW

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Abstract

Level of water table reducing day by day so we need management technique for efficient use of water resources. One of such technique is constructed wetland in which we use waste water after treating if using natural technology. Constructed wetland is treating BOD (Biochemical oxygen demand), COD (Chemical oxygen demand), and suspended solid. Water shortage and wastewater the executives are two difficulties that influence the biological system and the environment. So we need provide safe drinking water as well as treated water for agricultural uses. In this paper we examine the constructed wet for waste water treatment and its use. Constructed wetland consist of Essential Settling Cell (PSC) with the end goal of anaerobic pretreatment of suspended solids. Auxiliary Advanced Filter Cell (SAFC), that supports a stage of various sizes of stones and rock wherein anaerobic processing happens Tertiary Biological Wetland Cell (TBWC) made up of various layers of life supporting media, for example, those utilized in SAFC and planted with amphibian verdure, for example, Typha, Scirpus, Cyperus, Peltandra and Phragmites.

Keywords: *Constructed Wetlands, Tertiary biological wetland cell, Auxiliary Advanced Filter Cell.*

UPWARD ELECTRO-KINETIC REMEDIATION (UEKR) FOR REAL CONTAMINATED LAKE SEDIMENTS WITH HEAVY METALS

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Abstract

This study examines the treatability of contaminated lake sediments (Hussain Sagar, Hyderabad, India) with heavy metals by Upward Electrokinetic Remediation (UEKR) technique combined with active capping by activated carbon. The sediment poses high acid buffering capacity ($78 \text{ m mol kg}^{-1} \text{ pH}^{-1}$), cation exchange capacity ($26.37 \text{ c mol kg}^{-1}$) and contaminated with heavy metals such as Cd ($68.750 \text{ mg kg}^{-1}$), Zn ($312.50 \text{ mg kg}^{-1}$), Cu (187.5 mg kg^{-1}), Pb (281.5 mg kg^{-1}), Ni (225 mg kg^{-1}), Cr (62.5 mg kg^{-1}). Total five experiments were conducted by changing electrolyte concentration and voltage gradient to assess the removal and transport of heavy metals in contaminated sediments. The maximum heavy metals removal as Ni - 43.62 % , Cu-48.46 % , Cd-71.71 % , Zn - 49.335 % , Pb -60.762 % was achieved with 0.05 M HNO₃ and 1.5 Vcm⁻¹ voltage gradient. After UEKR treatment the strongly bound heavy metals fractions i.e. Fe and Mn oxide and organic bound fractions become easily available fraction as exchangeable and carbonate bound fraction. The transported heavy metals were found in the top 2 cm layer and in the electrolyte. The mobility of the heavy metals during UEKR were followed as Ni>Cd>Zn>Cu>Pb and pH played important role in heavy metal transport than applied voltage gradient.

Keywords: *Upward Electro Kinetic Remediation (UEKR), Contaminated Sediments, Heavy metals, Remediation.*

A COMPARATIVE STUDY ON DECOLORIZATION OF YAMUNA WATER BY USING DIFFERENT AGRO-WASTE BIOSORBENTS

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Abstract

Biosorption is an emerging green technology that can be used to remove contaminants from water. Biosorption involves use of agro-waste material for removal of pollutants like textile dyes, heavy metals and chemicals. Yamuna the second large tributary of River Ganga is extensively polluted due to direct discharge of domestic sewage and industrial effluents. Anthropogenic activities have rendered its water useless for drinking, domestic use and have impacted the natural aquatic ecosystem. In the present paper we have studied the efficiency of effects of biosorbents different biosorbents such as peanut hull powder, egg shell powder and crushed saw dust for decolourization of Yamuna water using continuous sorption in a packed bed reactors packed with different biosorbents such as peanut hull powder, egg shell powder and crushed saw dust separately. Peanut hull powder resulted in 97% colour removal. Saw dust shows 98% removal and egg shells shows 87% removal. This technique can be effectively employed in textile, food and pharmaceutical industries to remove colour and heavy metals. These reusable, biodegradable and cost effective bio-sorbents can prove to be sustainable solution for decolourization and remediation fo waste water.

Keywords: *Agro-waste, Biosorbents, Packed bed reactor, Sustainability, Yamuna river, Comparative Study.*

BIOSTABILISATION AND DYNAMIC STABILITY OF OPEN CAST COAL MINE OVERBURDEN HEAP - A SOLUTION TOWARDS SUSTAINABLE DISPOSAL OF WASTE

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Abstract

Revegetation is extensively used for monitoring erosion and stabilization of dump slope. An emerging remediation technology, phytostabilization has been used in this study. It is the biological reclamation of land by growing plant species. Formation of a vegetative cover results in bringing about long-standing stabilization and containment of dump soil. Native plant species such as Bamboo, Vegetable Hummingbird, Butter tree and Indian Beech have been considered. Pre-germinated seeds of these plants were planted under laboratory conditions in pots containing dump soil brought from an overburden heap of a nearby coal mine of Bardhaman district, West Bengal. Pot experiments were carried out for six months. The growth performances of the plants indicate that they have the capacity to tolerate and grow well in the dump soil. By the help of numerical modelling, it can be stated that factor of safety of the overburden heap can be significantly augmented by plant roots.

Keywords: *Phyto-stabilization, pot experiments, numerical modelling.*

REMEDICATION OF VOCS CONTAMINATED GROUNDWATER BY NANOCOMPOSITE MEMBRANES: A REVIEW

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Abstract

VOCs (Volatile Organic Compounds) are treacherous contaminants of groundwater which leads to the pollution of groundwater and number of environmental issues. Many technologies have been proposed and tested to remediate its contamination among which membrane separation is considered one of the most efficient tools for abating such substances because of environmental friendly production with least possible emission of noxious components, also it has low capital cost and easy scalability. The application of novel nanomaterials in membrane technology for groundwater remediation is becoming promising. A number of field and bench studies have demonstrated the effectiveness of nanomaterials. Most of the volatile organic compounds identified decreased the pollution level due to the existence of nanomaterials. In this review, the performances of nanocomposite membranes for groundwater treatment and environmental remediation is been discussed. Contaminants were broadly categorized, and the most efficient techniques in each category reported in the past were compared where availability, cost and environmental implications of technologies were also compared. Nanotechnology is becoming extremely important in meeting the stringent water quality standards for the remediation of emerging dangerous contaminants and abating increasing pollution. However, there are still challenges for this technology that need to be considered in near future such as investment and cost optimization. This can be addressed by introducing new membrane fabrication techniques, permeability, selectivity, membrane fouling mitigations and proposing scale up based on experimental research results. Challenges facing environmental application of nanotechnology is also discussed which can offer potential solutions.

Keywords: *Volatile Organic Compounds, nanomaterials, water quality, groundwater contaminants*

PERFORMANCE EVALUATION OF MICRO-ELECTROLYSIS INTEGRATED WITH CONSTRUCTED WETLAND FOR MUNICIPAL WASTEWATER TREATMENT

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Abstract

At this time, about 80% of the wastewater is discharged into the world's waterways where risks to health, environment and the climate are created. Additional extreme of nitrogen discharge to water bodies can cause eutrophication and results in deterioration of water quality and degradation of aquatic ecosystems. Constructed Wetlands (CWs), a sustainable and low-cost alternative to conventional wastewater treatment technologies are effective in treating a wide range of wastewater. Micro-electrolysis has been successfully utilized to treat wastewater. The present study work reported here is about an innovative way of designing ME-CWs for removal of pollutants from municipal wastewater. Integration of microelectrolysis was studied in *Eichhornia crassipes* planted constructed wetland. The removal efficiency of NH_4^+ , NO_3^- , Total Nitrogen, Total phosphate, Sulphate, COD, reached up to 95.48%, 37.54%, 84.20%, 56.12%, 57.55% and 84.85% respectively. Constructed wetlands are simple and low-cost techniques to treat wastewater having lesser load of pollutants.

Keywords: *Constructed Wetland, Integration, Micro-electrolysis, Eichhornia Crassipes, and Municipal Wastewater*

SCIENCE AND TECHNOLOGY DEVELOPMENT TO MITIGATE SALINITY IN GUANTÁNAMO, CUBA

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Abstract

The science development and technology use have allowed man to transform the environment. One of the causes of soil degradation is salinity, which affects agroecosystems, negatively disturbing their agricultural production. There are many technologies used in the world for the recovery of saline soils and particularly in Guantánamo, Cuba, capital washing of salts, introduction and evaluation of tolerant species at different levels of salinity, as well as the implementation of an integral technology for the management of soils affected by salts with the banana crop have been used.

Keywords: *Science, Technology, Salinity, Environment.*

IMPROVED PHOTOCATALYTIC PROPERTIES OF LEAD SULFIDE NANOCOMPOSITES FOR REMOVAL OF JANUS GREEN B DYE FROM WASTE WATER

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Abstract

The present work describes PbS nanoparticles are prepared by chemical displacement method using CTAB as a stabilizer, was adding in it. For the source of Sulphur ion, thioacetamide as fuel and metal salt like lead nitrate was used. The structural, morphological, metal percentage and optical study of as synthesized nanoparticles are investigated by using x-ray diffraction (XRD), UV-Visible Spectra; field emission gun Scanning electron microscopy (FEG-SEM) with EDAX, Fourier transforms infrared spectroscopy (FTIR) and High-resolution Transmission electron microscopy (HR-TEM). The x-ray diffraction patterns revealed that the particles exhibited a crystal structure at the suitable temperature. Calculate the average particle size of the nanoparticles from the x-ray diffraction analysis and also field emission gun Scanning electron microscopy shows morphology and structural shape of nanoparticles. The Transmission electron microscopy (HR-TEM) shows the crystalline size of structures. Further, the Photocatalytic activity of Synthesized PbS nanoparticles was investigated by photo catalytic removal of Janus green B as a model of organic pollutant. It shows good photocatalytic activity against Janus green B dye from Waste water.

Keywords: *Nanoparticles, Lead Sulfide, XRD, FTIR, UV-Vis, FEG-SEM, EDAX, HR-TEM.*

PHYTOEXTRACTION OF LEAD AND ZINC IN POLLUTED YAMUNA SOIL

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Abstract

Heavy Metal Toxicity is increasingly being recognized as dramatic in large parts of the developing world, particularly in India and China. Metals can escape control mechanisms such as homeostasis, transport, compartmentalization, and binding to specified cell constituents, thus they can have toxic and even lethal effects. Heavy metals are ubiquitous and recalcitrant, their entry into the body poses a potential health risk to human populations, thus causing a series of adverse effects on the body of humans and animals. Furthermore, Heavy metals can cause malfunctioning of the cellular processes via displacement of essential metals from their respective sites. Oxidative deterioration of biological macromolecules has been found to be primarily due to binding of metals to DNA and nuclear proteins. Environmental pollution by heavy metals has become a serious problem in the world. The ecological problem of water and soil heavy metal contamination is of great importance in today's global scenario. The mobilization of heavy metals through extraction from ores and subsequent processing for different applications has led to the release of these elements into the environment. Modern day industries and activities are known to generate various dangers and risks that endanger biological communities worldwide. Industrial operations and their unscientific waste transfer strategies are thought to be the primary source of heavy metal pollution in soil, water (ground & surface water). About 90 % of the wastes generated from the extraction of metals are in the form of sulfides and these squanders contains high amount of heavy metal toxicity. According to Environment Protection Agency (EPA), the eight most common heavy metal pollutants are As, Cd, Cr, Cu, Hg, Ni, Pb and Zn. The contamination of soil with heavy metals from seepage can potentially result in phytotoxicity. The harmful effects of metals are responsible for changed physiology of plants as well as causing contamination and damage to soil and soil-water properties. Phytoremediation is a financially savvy, non-intrusive and socially satisfactory approach to address the evacuation of natural contaminants and reduce, degrade or immobilize the environmental pollutants like heavy metals using crops/plants. Experts believe that Phytoextraction is an effective and eco-friendly approach to control soil pollution near Yamuna River. In this case study an effort has been made to study with the use of *Helianthus Annuus* for phytoextraction of lead and Zinc from polluted Yamuna river soil.

Keywords: *Heavy metals, Metal toxicity, Phytotoxicity, Soil Water Contamination, Phytoremediation, Phytoextraction*

BIOREMEDIATION OF HEAVY METALS FROM INDUSTRIAL WASTEWATER USING HALOPHILES

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Abstract

The aim of this study is to isolate heavy metal tolerant and antibiotic resistant microorganisms, from the salt pan nearby tannery dump site. The halophilic and halotolerant microorganisms may be suitable for bioremediation of such environment, since high concentration of anions and cations are required for their growth. Although, these microorganisms have already been utilized in bioremediation of oil, textile effluents and oxy anion pollutions, their potential for bioremediation and bioreduction of chromate has been sparsely studied. Moreover, the bacterial strains used for chromate reduction were isolated from either tannery effluents or hypersaline soda lakes. Halophilic microorganisms have shown resistance against human pathogen showing anti-bacterial property and found to be the most promising candidate for heavy metals remediation of contaminated saline soil and water discharge sites. However, not many reports are available to describe the bioremediation potential of halophilic bacteria for saline environment contaminated with heavy metals.

Keywords: *Bioremediation, Poly-extremophiles, anti-bacterial resistant and saltpan.*

REMEDICATION OF TOXIC IMPURITIES FROM INDUSTRIAL WASTEWATER USING NATURAL CLAY

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Abstract

A variety of dyes are being used in different industries such as textile, paper, plastic etc. There has been substantial increase in release of harmful dyes in water bodies with rapid increase of industrialization. The environmental pollution created due to the release of chemical dyes has become a critical problem for human and animal health. Removal of dyes from wastewater can be carried out by different methods such as adsorption, chemical oxidation, ion exchange, catalytic degradation, and biodegradation. Among these methods, purification of waste water using adsorbents is the most favorable method because of its low cost, simple and effective operating system. Naturally available different forms of Bentonite have reported as a good adsorbent for removal of some synthetic dyes from aqueous solution. Bentonite is composed of silica, alumina, iron and magnesium oxides. The effectiveness of adsorption for dye removal from wastewater has made it an ideal alternative to other expensive treatment options. Langmuir and Freundlich adsorption isotherm model can be use to study the role of Bentonite in dye removal on different process parameters. It is observed that adsorption using Bentonite is spontaneous and endothermic process and it might be both effective as well as economically attractive for color removal from wastewaters.

Keywords: *Adsorbent, Bentonite, Natural Clay, Adsorption isotherm.*

TS – 5
(HETEROGENEITY IN POROUS MEDIA)

Keynote Paper

**COUPLED FLOW AND TRANSPORT PROCESSES IN A DEFORMABLE POROUS
MEDIUM**

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Abstract

Deformable porous medium has several applications in geosciences, biological, and energy fields. In such a medium, the pore structure of the medium varies with time leading to alterations in macroscale properties. An example is that of clogging due to the precipitation in subsurface. This may locally arrest the flow. This leads to a change in the flow pattern. We will discuss some of the recent approaches to study a deformable porous medium. A system of coupled partial differential equations describe this phenomenon. This system of equations has a particular structure: it couples the two scales (microscale and macroscale) as well as describes the flow, transport and reactions. These are convection diffusion reaction type partial differential equations at macroscale coupled to a level set type equation at the pore scale. The resulting equation turns out to be posed in a 4 dimensional domain (2 Darcy scale and 2 for the cell problem) for an original two-dimensional domain. Hence, we need efficient solution strategies for computing the numerical approximations. We will study some solution approaches to these equations. Our approach consists of a parametrization of the pore-geometry and computing the hydraulic properties as a function of the geometric parameter and using these to compute the Darcy scale solution. We will also revisit the widely used Kozeny–Carman type relationship between porosity and permeability in the light of the homogenization theory. We will also present extensions to the non-isothermal case.

Keyword: *Porosity-permeability relationship, Non-isothermal, clogging*

INFLUENCE OF TRANSPORT PARAMETERS ON CONTAMINANT PLUME EVOLUTION IN SATURATED POROUS MEDIA: A NUMERICAL STUDY

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Abstract

Mass-transfer coefficient and dispersion parameters are the most important parameters that govern the contaminant plume mixing and spreading dynamics in saturated porous media. Spatial and temporal variation of these parameters plays an important role in controlling the natural attenuation of contaminant plume at the macro scale (field scale). The present study emphasizes on the effect of transport parameters (dispersion coefficient, mass-transfer coefficient), type of inlet boundary condition, and modelling approach on contaminant plume behaviour. The finite-difference based numerical solution was developed to solve the governing equations of contaminant transport (in dissolved phase) through saturated porous media below the groundwater table under steady flow conditions in the 2-D spatial domain. A synthetic example is utilized for the analysis of plume dynamics by considering conventional advection-dispersion equation (ADE) and mobile-immobile model (MIM) with constant and asymptotic time-dependent dispersion function (ADEC, ADEA, MIMC, and MIMA). Mass-transfer coefficient in MIM modelling approach was varied from 10^{-6} min^{-1} to 10^{-4} min^{-1} to understand the influence of intra-domain mass-transfer. It was observed that the inlet source boundary conditions had a significant effect on the plume shape as well as contaminant concentration value. Constant dispersion model predicted approximately 2 to 3 times higher concentration of contaminant compared to asymptotic time-dependent dispersion model. The results implied that the contaminant concentrations predicted by the former approach are on the conservative side and thus alternate approaches need to be considered for better results.

Keyword: *Contaminant transport, mobile-immobile model, boundary condition, asymptotic time-dependent dispersion, mass-transfer coefficient*

STABILITY ANALYSIS OF EXPLICIT DIFFERENCE SCHEMES FOR THE SPACE TIME FRACTIONAL ADVECTION DIFFUSION EQUATION

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Abstract

Stability analysis of explicit difference schemes for the space time fractional advection diffusion equation is carried out. Discretization is carried out using the weighted and shifted Grünwald difference operators of the fractional derivatives for the second order space fractional derivatives. Discretization of fractional time derivative is based on Liu et al. [App. Math. Comp., 191, 2007, 12-20]. The analysis is carried out using Von Neumann method. The applications of the partial differential equation include nonlocal reactive flow in porous media, non-Fickian flow of fluids in porous media and it addresses the heterogeneity of the solute transport in streams, rivers and groundwater Zhang et al. [App. Math. Comp., 242, 2014, 541-550].

Keyword: *Space time Fractional advection diffusion equation; Heterogeneity; Groundwater*

THREE-DIMENSIONAL TIME-FRACTIONAL ADVECTION DISPERSION EQUATION BY HOMOTOPY PERTURBATION METHOD

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Abstract

Mathematical modelling study has been carried out to formulate the three-dimensional time-fractional advection dispersion equation with increasing type source condition in finite domain. Fractional order derivatives preserve the memory and help us to realize the change in the system so time-fractional advection dispersion equation is considered. As a sub case of fractional order derivative we can get original non-linear advection-dispersion by considering $\alpha=1$. Space and time dependent dispersion and velocity profile is considered through-out the domain. Source condition has been incorporated in the fractional advection-dispersion equation. For a real life problem, it is very difficult to assign the boundary condition as it does not follow any proper formation but in the other hand one can easily get the initial condition for the aquifer by laboratory testing of the aquifer water. Without loss of generality the aquifer was considered initially contamination free. Dispersion and velocity are considered in such a way that the advection dispersion equation becomes highly non-linear when $\alpha=1$. To handle the time-fractional advection-dispersion equation homotopy perturbation method (HPM) has been used to solve the system semi-analytically. Matlab has been used to plot the solution of the problem. Result of this three-dimensional problem may be utilized as predictive tools to model real field situation.

Keyword: *Advection dispersion equation, Time-fractional, space-time dependent velocity and dispersion, HPM.*

REACTIVE TRANSPORT OF FERROUS ION IN THE SATURATED/UNSATURATED POROUS MEDIA UNDER THE DUAL POROSITY FLOW: A NUMERICAL MODELLING STUDY

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Abstract

Acid mine drainage (AMD), which drains out from mines, is a serious threat to the surface and subsurface hydrological environment. Transport of AMD and its reactive nature in the subsurface medium has to be studied intensively due to the presence of heavy metal and its reactive nature. Most of the simulation software solve spatial and temporal variations and can be used to predict the future outcome. The simple convective-dispersive equation alone may not be sufficient to predict or simulate the contaminant movement in the subsurface medium, because of the presence of physical non-equilibrium due to the immobile water in the void spaces. This study analyses the influence of physical non-equilibrium in reactive transport of AMD through saturated/unsaturated soils. The United States Environmental Protection Agency (USEPA) developed finite-element software FEMWATER is modified by incorporating reaction (ion-exchange) and the features of physical non-equilibrium inflow as well as in contaminant transport. The modified and validated model is then applied to the two-dimensional hypothetical domain to study the reactive nature of AMD component, ferrous ion, under the non-equilibrium condition. Results showed the advancement of plume movement due to the presence of immobile water. Irrespective of the transport nature, whether conservative or reactive, immobile zones affect the contaminant distribution. Since this is a single species transport model it has to be updated with multi solute reaction chemistry to get results which match with field results.

Keyword: *AMD, reactive transport, physical non-equilibrium, numerical modelling, finite element method*

AN IMPROVED MOBILE IMMOBILE MODEL TO SIMULATE SOLUTE TRANSPORT INFLUENCED BY PHYSICAL NON-EQUILIBRIUM

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Abstract

In this study, the dynamic behaviour of diffusive gradient for the porous medium affected by physical non-equilibrium is investigated. Through early initial breakthrough and long tailing in experimentally observed breakthrough curve (BTC), physical non-equilibrium is identified (Swami et. al. 2016). To simulate such BTC mobile immobile model is generally employed which is based on a lumped value of diffusive mass transfer coefficient. Since the concentration gradient within the recirculation zone is a dynamic phenomenon, which also governs the concentration in immobile region. For a time-limited source immobile regions behave as distributed sink and source which contribute to persisting tail concentration. To trace this dynamic a simplified approach is presented in this study, which estimates distinct diffusive mass transfer coefficient for rising and falling limb of BTC's using non-linear least square optimization algorithm. This approach is then compared with continuous time random walk (CTRW) model. It is observed that the distinct mass transfer approach for rising and falling portion of BTC is fitting the breakthrough curves much better than CTRW.

Keyword: *Physical non-equilibrium, diffusive gradient, time dependent mass transfer, mobile-immobile, rising and falling limb.*

COMPARISON OF SFT AND CTRW MODEL TO PREDICT FATE OF SOLUTE TRANSPORT THROUGH SATURATED POROUS MEDIA

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Abstract

In this work two contaminant transport experiments performed on heterogeneous porous media reported in literature are simulated. From experimental breakthrough curves (BTC's) it is observed that solute transport is influenced by physical non-equilibrium and is non-Gaussian which is clear from long tailings. To simulate these experiments, higher solute transport models i.e. slow fast transport (SFT) and continuous time random walk (CTRW) model are used. Classical multi-process non-equilibrium (MPNE) and mobile-immobile (MIM) model are based on a lump advective transport. But there will be some region of advective phase close to the medium particle which will have lesser velocities due to boundary layer formations. SFT is developed considering such effect and its numerical solution is obtained, which is verified with already published solution. Values of various parameters like slow velocity, fraction of fast moving liquid, mass transfer are calculated using genetic algorithm. For other model CTRW-MATLAB toolbox available is used. It is observed that both these models well captured experimental BTC's. Temporal moments are also calculated for both these models to compare mass recovery and degree of spreading. Also sensitivity analysis of various parameters is done to ascertain their effects on solute transport behaviour.

Keyword: *Boundary layer formations, advective phase, mass transfer, temporal moments, sensitivity analysis.*

STUDY OF FLOW AND SOLUTE TRANSPORT THROUGH UNSATURATED POROUS MEDIA USING HYDRUS

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Abstract

Vadose zone hydrology comprises of equilibrium as well as non-equilibrium flow. Proper estimation of non-equilibrium flow is still difficult as compared to the estimation of equilibrium flow using the classical modelling approach based on uniform flow and solute transport. Here, the objective is to explain Dual porosity approach to model non-equilibrium flow in comparison with the Uniform flow and transport model. Also, sensitive parameters associated with both the approaches are discussed along with their variations in the form of breakthrough curves. Both the approaches are discussed using HYDRUS software and the modules available in it. This type of analysis helps in better estimation of hydraulic properties and model groundwater flow and solute transport well.

Keyword: *Vadose zone, Non-Equilibrium flow, Solute transport, Dual Porosity, HYDRUS*

SOLUTE TRANSPORT PARAMETER ESTIMATION USING SIMULATION- OPTIMIZATION BASED APPROACH

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Abstract

Estimation of dispersion and mass transfer coefficient is one of the challenging aspects of studying solute transport through heterogeneous porous media due to ever-changing behaviour at spatial and temporal scale. The present study emphasizes on the estimation of solute transport parameters such as dispersion coefficient, mass-transfer coefficient using simulation-optimization based approach. The finite difference numerical solution of the mobile-immobile (MIM) model is coupled with the genetic algorithm (GA) to solve the inverse problem of parameter estimation. The objective function of the optimization algorithm is to minimize the sum of squared differences between the observed and modelled solute concentrations. The inverse procedure is tested for an illustrative hypothetical case study by generating solute concentration data using assumed transport parameters. Transport parameter such as the mass-transfer coefficient is varied from 10^{-6} /min to 10^{-4} /min, and dispersivity is initially guessed from 5% to 50% of the domain length. Results revealed that a wide range of the GA parameters could lead to convergence to appropriate estimations. Asymmetric breakthrough curves of solute transport are simulated well using coupled MIM-GA based method. The performance evaluation depicted the potential applicability of linked simulation-optimization based approach and found to be a robust approach. The presented approach is limited to the one-dimensional spatial domain, thus neglected the influence of transverse dispersion on solute transport modelling.

Keyword: *solute transport, parameter estimation, mobile-immobile model, genetic algorithm, dispersion coefficient*

**ASSESSMENT OF SOIL MOISTURE CHARACTERISTICS IN SOT CATCHMENT,
UTTAR PRADESH**

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Kumar**

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The most important natural resources on the earth on which welfare of the society depends is water. There is increase in water demand globally due to the lack of water supply which is coupled with increasing population and industrialization. Increasing demand imparts deteriorating effect on groundwater potential and thus management is very essential. To manage the groundwater resources, estimation of groundwater recharge and flow processes in the unsaturated zone plays very crucial role. Modelling of unsaturated flow is another important technique which requires soil moisture characteristics such as infiltration, conductivity and retention characteristics. In this study, an attempt has been made to estimate the infiltration rate and hydraulic conductivity of soils in the Sot catchment. Sot river is a tributary of the Ganga river in Uttar Pradesh and drains an area of 3,752.73 km². The Sot river has become a seasonal river since last two decades and its catchment area faces severe water scarcity as there is no surface irrigation water supply scheme. Infiltration tests using Double Ring Infiltrometer and permeability test using Guelph Permeameter have been carried out at 48 locations. The data observed from these tests are used in estimation of infiltration rate and conductivity of soil throughout the catchment. The analysis revealed that the rate of infiltration in the catchment varies from 0.047 to 8.59 mm/sec and permeability (K) varies from 1.42 E-06 to 2.76 E-03 mm/sec. The estimated infiltration rate and conductivity can be used in unsaturated flow and groundwater modelling for the Sot catchment.

Keywords: *Soil-moisture, unsaturated flow, catchment, Uttar Pradesh*

TS – 6

**(RAINWATER HARVESTING, MANAGED AQUIFERS
RECHARGE)**

Keynote Paper

**EVIDENCE DISPELS COMMONLY HELD VIEWS ON STREAMBED RECHARGE
STRUCTURES IN HARDROCK AQUIFERS IN RAJASTHAN, INDIA**

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Abstract

Four commonly held views on the effectiveness of recharge structures in ephemeral stream beds to enhance recharge in hardrock aquifers of India have been objectively evaluated in the Dharta catchment of Udaipur district in southern Rajasthan. It has long been claimed that: (1) groundwater level rise demonstrates that recharge structures are effective; (2) the greater the rise in groundwater level, the more effective is the recharge structure; (3) recharge from streambed structures is greater when the water table is shallower; and (4) recharge structures only benefit farmers in very close proximity. Three years of monitoring of rainfall at four stations, water levels in four checkdams and groundwater levels in 250 wells, have conclusively disproved these views, and in two cases the reverse is in fact true. Importantly this shows that monitoring practices in current general use are incapable of demonstrating the effectiveness of streambed recharge structures, nor their maintenance requirements. However the work has also demonstrated simple methods that can be used by farmers to evaluate recharge rates from streambed recharge structures, and this can be used for scheduling desilting. Increased information generated in this way will be valuable in siting and sizing of any future structures in a catchment, taking account of local and downstream impacts.

Keywords: *Streambed recharge, hard rock aquifer, Rajasthan*

GLOBAL STATUS OF MANAGED AQUIFER RECHARGE

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Abstract

Managed aquifer recharge (MAR), the intentional recharge of aquifers for recovery of stored water or for environmental benefit, has been growing steadily over the last 60 years. The IAHR Commission on Managing Aquifer Recharge set out in 2016 to quantify the global status. Although there are at least 62 countries in which MAR is undertaken, quantitative data on MAR capacity was available for only 34 countries. For these countries that account together for 42% of the global groundwater extraction (982km³), the annual capacity of MAR was found to be 10 km³/year. Hence MAR compensates for on average 2.4% of groundwater extraction in those countries (or 1.0% of global groundwater extraction). In 18 countries the annual volume of MAR exceeds 5% of groundwater extraction and in 10 countries it exceeds 10%. Uptake is very variable among countries as well as within them, and where applied it has proved locally significant for securing water resources, buffering against climate change, improving groundwater quality and enhancing the quality of drinking water supplies. However, the recent rate of growth of MAR, 0.5km³/year, is currently less than 1% of the average annual increase in groundwater extraction. Clearly, while MAR is having local benefits, global groundwater depletion continues. Informing groundwater managers on the success of MAR may help to accelerate uptake to at least 10% of global groundwater use, and also to make better use of MAR in supporting demand management strategies. This paper summarizes part of a journal paper submitted to Hydrogeology Journal. Enter description here.

Keywords: *Managed aquifer recharge, groundwater extraction*

OPPORTUNITIES AND CHALLENGES FOR MANAGED AQUIFER RECHARGE IN INDIA

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Abstract

As per the assessment of the ground water resource in the country the annual replenishable ground water resources have been assessed as 447 bcm and the net annual ground water availability is 411 bcm, keeping an allocation for natural discharge (March, 2013). The annual ground water draft is 253 bcm. The Stage of ground water development works out to be about 62%. However, this is not uniform across the country. The stage of development is exceedingly high in north-western and western states as well as in some states in central and southern India. Highly intensive development of ground water in these areas in the country has resulted in over – exploitation leading to decline in ground water levels, deterioration in ground water quality and sea water intrusion in coastal areas. Managed Aquifer Recharge is an increasingly important water management measure, alongside demand management, to maintain, enhance and secure stressed groundwater systems and protect and improve water quality. For facilitating managed aquifer recharge in the country, the CGWB has prepared a Master Plan for Artificial Recharge to Groundwater in India. Based on the hydrogeological conditions and availability of surplus monsoon runoff in different parts of the country, an area of **9,41,541 Sq Km** has been identified as suitable for recharge of 85,565 Million Cubic Meter of available surplus water through more than 11.1 million structures having area specific designs at an estimated cost of INR 79,1780 Million (approximately US\$ 11300 Million) in the country. Complete synergy in the activities of all the stakeholders involved and participation of the user community in water management initiatives holds the key for a water-secure India of tomorrow.

Keywords: *replenishable, stage of ground water development, managed aquifer recharge, demand management, synergy.*

**RAINWATER HARVESTING AND ITS IMPACT ON FLUORIDE CONCENTRATION
IN GROUNDWATER OF RURAL RAJASTHAN**

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Abstract

Rainwater harvesting structures in India have been heavily promoted by state and federal governments as a Managed Aquifer Recharge technique, to increase the proportion of the abundant monsoon run-off that percolates. However, their impacts on their environment and on the communities they serve are not properly understood. This study focused on a village facing water shortages, fluoride contamination and salinity issues. Various water harvesting structures such as check dams, series of chaukas (small enclosure made of earthen dykes) and ponds were monitored regularly to quantify the impact of rain water harvesting on the groundwater quality as well as on livelihoods. Surface water balances conducted during the early days of the monsoon showed high infiltration efficiencies over 90%, with a decreasing trend. Due to their large surface and small capacity, chaukas are unlikely to have any effect on aquifers. However, their primary benefit is to increase soil moisture, which provides grazing for 60% of the village's livestock. The check dam and ponds infiltrates significant amount of water during an average monsoon, which supports about 5% of the dry season agriculture. Fluoride levels are lower near the structures, though still above the 1.5 mg/L guideline value for drinking water. The studied structures showed modest but still noticeable local impacts, but their connections with upstream and downstream areas, as well as the effects of the numerous ponds in the village remain to be investigated.

Keywords: *Rainwater Harvesting, Fluoride, Managed Aquifer Recharge*

**IMPROVED RAIN WATER HARVESTING METHODS TO INCREASE GROUND
WATER RECHARGE AND IRRIGATION IN WATER STRESSED KOT BLOCK OF
UTTARAKHAND**

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Abstract

Kot Block, located in Pauri Garhwal district (Uttarakhand), is one of the 16 blocks of the district. As per the 2011 Census, Kothas 266 villages and 6,197 households. The population of the block is 23,754 with 11,242 males and 12,512 females. This block has 2,618 children in the age bracket of 0-6 years (1,355 boys and 1,263 girls). Literacy ratio in Kot Block is 68% with almost 80% males literate; however only 57% females are literate. Also, about 12,863 individuals have no regular employment, and of the 10,891 persons with a regular occupation, 7430 (70% of the working population) are completely reliant on agriculture of which 2503 are males and 4927 females.

Keywords: *rain water harvesting, groundwater recharge*

DEVELOPMENT OF SUITABLE RAIN WATER HARVESTING STRUCTURES FOR WATER DEFICIENT REGIONS IN INDIA

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Abstract

In India, a warming climate is drying up all surface water and rainwater harvesting for water conservation is a key element of any strategy that aims to alleviate the water scarcity in the country. Nowadays many researchers are involving to develop various methodologies and criteria to locate suitable sites and techniques for water conservation structures. Identifying a suitable method or guidelines for site selection is quite difficult. The main objective of this study was to develop suitable Rainwater structures for water deficient sites in India by assembling different methods and criteria practiced in ancient India. We categorized and compared 20 different water conservation structures built in different regions of India, which published in scientific journals and reports of national organizations. We then identified the main criteria for selecting Rainwater harvesting locations and the main characteristics of the most common RWH techniques used in Ancient time. The most important criteria for the selection of suitable sites for Rainwater Harvesting were slope, soil type, rainfall, distance to settlements/streams, etc. we should have to adopt these techniques and build more and more structure like this in India.

Keywords: *Rainwater Harvesting, Suitability criteria, Water deficient region*

RAIN WATER HARVESTING THROUGH ARTIFICIAL GRASS

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Abstract

Water plays a significant role in our lives since it is a precious natural resource. Over the past few years, there has been an increase of water shortages in several parts of the world. With the change in climate patterns, people need to be aware of the alarming water shortage that we face currently and the imminent danger of severe shortage in the future. Besides, many modern methods discovered for rainwater harvesting, artificial grass procedure is discussed in the present paper. More times than not, people assume that artificial grass prevents rainwater from reaching the earth beneath it. Many years ago this would have been true. But modern artificial grass products were designed to have superior vertical drainage to withstand the heaviest of rainfalls and had been proved by various tests. The aggregate base of the artificial grass can absorb many litres of water in a matter of seconds. The natural grass however, did not absorb water quick enough. This proves that artificial grass puts the rainwater back into the earth rather than having it run off into the streets, sidewalks and driveways.

Keywords: *Artificial grass, rainwater, water shortage, drainage.*

WATER ABSORBING ROADS THROUGH PERMEABLE CONCRETE

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Abstract

Rainwater harvesting is one of the methods that can be used for water conservation. In most cases, the water is usually collected from rooftops and other hard surfaces and stored for future use or in restoring the groundwater level. This new material, called **Topmix Permeable** allows the water to soak through to the ground below. This innovative material can soak up to 880 gallons of water a minute, which could either eliminate or reduce the threat of flash flooding. Tarmac says its product could be used in everything from parking lots to tennis courts to residential roads. The concrete has a permeable layer on the surface, made up of large pebbles so water can drain almost instantly. Under that layer is an ‘attenuation layer’, which pushes the water into a drainage system that connects with the city’s groundwater reservoirs. So, the water is directed straight back into the system for irrigation, drinking water and swimming pools. Another cool advantage of this permeable concrete is just that, it will also be cooler than regular concrete during the hottest months of the year. “During periods of rising temperatures and intense rainfall, water stored within the system evaporates creating cooling effect reducing surface temperatures. The paper discusses method, material and benefits of water absorbing roads.

Keywords: *Permeable Concrete, Flash Flooding, Water Absorbing Roads, Rainwater, Water Shortage, Drainage.*

WELLS AND JOHAD OF SHEKHAWATI REGION: THE BIGGEST INJECTED SYRINGE AND SEWERAGE LINK OF GROUNDWATER RECHARGE FROM RAINWATER

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Abstract

The semi-arid climate of *Shekhawati Rajasthan* region is an area spread over *Churu, Jhunjhunun and Sikar* districts. Due to lack of rainfall in this area, there is always shortage of water. The means of supplying water to the people is well or tube well. Here more than 3,000 tube wells are exploiting ground water. Groundwater has gone very low because of excessive tapping. Source of rain water harvesting in Johad Pond and dams *Agor* area route of roads and human habitations cannot be collected from the water. Every village town in *Shekhawati* area has historic wells, *johad* or ponds. Water in wells has ended 25-30 years ago today. Water in *johad* or ponds only falls short in the rainy season. As much as it comes, it also evaporates as a steam in the warmer climate. For further accumulation of rain water, their *Agor* area can be increased by cleaning. Extra water of these *johads* or ponds can be recharged by increasing the ground water level, if arranged to be inserted into historic wells and closed tube-wells, *hand pumps*. This can be done by linking the wells, tube-wells and *hand pumps* to the rooftops of *johad*, ponds and public buildings. Especially the *Shekhawati's* historic wells are so wide that it can absorb all the extra water in the womb of the land. If this is the case, then the history of wells will be a real restoration. It is necessary today or tomorrow it has to be done.

Keywords: *Wells, Johads, Ponds, Agor*

RAINWATER HARVESTING RECHARGING AND MANAGEMENT OF AQUIFERS

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Abstract

In today's progressive world due to rapid urbanization, industrialization, commercial agriculture and population explosion demand of water has risen sharply. We remember the importance of water during the crisis and devalue it during its abundance. The excessive withdrawal of water lowers the water table and finally depletes the aquifer. Now it is the time to maintain the groundwater storage to enjoy the uninterrupted supply of water for present and future generation of mankind. The best and cheap technique is to rain water harvesting and artificial recharge of aquifers. Rain water harvesting involves collection and storage of rain water which can be either used for different purposes or recharge to groundwater. Artificial recharging of aquifers is planned, human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in a corresponding increase in the amount of ground water available for abstraction. It conveys water from surface sources or store in-situ at places above the aquifer areas, where it is made to percolate and recharge the groundwater.

Techniques and Pre-Requisites are -Use abandoned structures e.g. Tube wells, Dug wells; In the absence of abandoned structures, make recharge pit or trench; Make bore hole in recharge pit/trenches, if formation is impervious; If the top layer is impervious /aquifer is deeper and area is large-make a shaft; Use existing tube well for roof top harvesting and use online filter; Where recharge is not possible store rain in tanks.

Keywords: *Rain water harvesting, Recharging, Management*

MANAGEMENT OF TRADITIONAL WATER SYSTEM AND CONSERVATION IN HARYANA

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Abstract

The State of Haryana is a one of northern state of India. The Haryana State is lying in-between North latitude from 27°39' to 30°35' and E longitude from 74°28' and 77°36' covering an area of 44,212 sq. km. The unconsolidated alluvial sediments cover around 98% of the state while hard rock's cover just around 2% areas. The state is drained by two major rivers Ghaggar and Yamuna [1] and forming largest plain in the state. State has four main geographical features: The Shivalik Hills in northeast, Semi-desert sandy plain in southwest and Aravalli Range in the south are situated. Water supply of Haryana is dependent on both Surface and Ground Water. The four Canals (artificial channels) namely: Western Yamuna, Bhakra, Agra and Ghaggar are formed the major irrigation system in Haryana state. The annual rainfall of state is 418 mm [2] by south western monsoon and winter showers. The state experienced the arid to semi-arid climate. The availability of net ground water in state for future use is 0.87 BCM. 78 blocks are overexploited and 24 block semi critical to critical among total 128 blocks. 47 and 61 blocks are affected by Fluoride and salinity respectively [3]. The Yamuna flows along the state's eastern boundary while the ancient Saraswati River said to be buried near Yamuna Nagar and main seasonal river is Ghaggar. The seasonal Markanda River is a stream, which in ancient times was known as the Aruna. Gathering volume of water from about a hundred tributaries in Rajasthan and the Mewat areas, it reaches voluminous proportions, forming a broad stream around Alwar and Patan (Sahibi). Three other rivulets in and around the Mewat hills, the Indori, Dohan and Kasavati all flow from East to West. Water is one key input to agriculture for obtaining high yield for any crop and survival of peoples in Haryana. The popular irrigation system e.g. Gravity / Flow, Lift, Drip and Ground Water Irrigation in Haryana are directly depends on revival of traditional wisdom, which is directly affected the quantity & quality of drinking water in Haryana. In the state Fluoride, Nitrate and iron have been reported more than permission limits at 92, 102 and 45 locations respectively by CGWB-2010 [4]. As per MoDWS: in Haryana locations 511-Fluoride, 83- Nitrate, 74- Iron, 1-Arsenic, 208-Salinity (TDS), and 3410-Bacteriological having number of Sources found contaminated (above IS - 10500 Permissible limit) and 1841 number of habitations affected by poor quality of water [5]. Therefore, revival of traditional water resources and their management by local wisdom are

required for improving the quality and quantity of water in the state. Based on long experiences of under existing soil and climatic conditions as well as availability of water resource, people of Haryana have developed typical systems of water management, which are very effective under the existing condition. Some of these systems are Sand bore, Bawari, Johad, Bandhi,/Talab, Stepwells /Jhalara, Check dam/ Pat system , Kuhls /Dhora , Kund, Sessional lake, Rooftop Rain Water Harvesting etc. This system need to be studied and analyses and reoriented. In this approach, Revival and renovation the traditional system for the water management and conservation through older traditional wisdom are helpful for the state in water stressed area.

Keywords: *Quality and quantity of water, Harvesting, Rainwater, Traditional system of water management.*

SCOPE AND SUSTAINABILITY OF RAIN WATER HARVESTING IN WATER CONSERVATION

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Abstract

Water is an important natural resource and is the very basis of our life. We use water for drinking, irrigation, industry, transport and for the production of hydroelectricity. Water is a cyclic resource which can be used again and again after cleaning. The best way to conserve water is its judicious use. Rainwater harvesting is one of the most effective methods of water management and water conservation. It is the term used to indicate the collection and storage of rain water used for human, animals and plant needs. It consists of a wide range of technologies used for collection and storage of rainwater at surface or in sub-surface aquifer before it is lost as surface runoff. These technologies can be divided into two main areas depending on source of water collected; namely, the in situ and the ex situ types of rainwater harvesting respectively. In essence, in situ rainwater harvesting technologies are soil management strategies that enhance rainfall infiltration and reduce surface runoff. The in-situ systems have a relatively small rainwater harvesting catchment typically no greater than 5-10 m from point of water infiltration into the soil. The ex situ systems are defined as systems which have rainwater harvesting capture areas external to the point of water storage. The rainwater capture area varies from being a natural soil surface with a limited infiltration capacity, to an artificial surface with low or no infiltration capacity. Commonly used impermeable surfaces are rooftops, roads and pavements. The concept of water harvesting, especially rainwater harvesting, has been in existence for over five thousand years, since the early development of settlements and agriculture. Rainwater harvesting has the ability to respond to localized and global hydrological pressures, in order to reduce dependence on depleting groundwater, erratic rainfall or on existing national supplies. In a monsoonal climate like that in India, the storage and filtration of rainwater at the point of precipitation for use throughout the year, especially during dry periods, is particularly important area for research and development. The harvesting of rainwater in a particular region is highly dependent upon the amount and intensity of rainfall and some other factors like catchment area and type of catchment surface. Rain water harvesting systems can be adopted where conventional water supply systems have failed to meet people's needs.

Keywords: *Rainwater Harvesting, Water Conservation, In-Situ and Ex-Situ Technology, Capture Area, Runoff*

RAIN WATER CONNECT METHOD OF ARTIFICIAL RECHARGE IN ALLUVIAL AND WEATHERED ROCK AQUIFERS

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Abstract

Artificial Recharge to groundwater at technically feasible sites is an effective way of groundwater management. Any method aiming at groundwater recharge has to undergo the process of de-silting, filtration and storage before the source water is linked with the aquifer. Generally rectangular trenches are excavated to construct three chambers to perform these processes. The recharge shaft is constructed in the storage chamber or outside in its vicinity. In this method instead of three, two chambers are required. The method involves the use of two pre-casted RCC cylinders for de-silting and storage. The de-silting chamber is provided with a baffle wall, the de-silted water overflows the baffle wall and passes to the storage chamber through a horizontally aligned Johnson pipe of 100mm diameter connected with the storage chamber. The recharge shaft, of 4mm diameter, is drilled in the centre of storage chamber. About 0.5m pipe of the shaft is kept above the bottom of the storage chamber. The shaft could be screened in accordance with the aquifer to be recharged. The filtration process is divided into two, through the chambers connecting horizontally aligned screened Johnson pipe and the coaxially designed dual screened pipes with diameter of 100mm and 200mm fitted above the recharge shaft. The annular space between the two pipes is filled with the pea gravel and activated charcoal. The pea gravel acts as filter media and activated charcoal as the water quality protector. The method is advantageous over the conventional methods as it could be made functional in less time and lesser cost. The cleaning of the filtration pipe is very easy using chemical rehabilitation solutions.

Keywords: *Rain water connect, Artificial recharge, weathered rock aquifer*

EFFICIENCY OF A RAPID SAND FILTER IN ROOF-TOP RAINWATER HARVESTING

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Abstract

The severe rise in population growth as well as the rolling development in industrialization in last few decades has arisen a bizarre demand for water round the globe. Rapid development has curbed the fresh water sources as well as quantity, also the alternatives available do not give a promising quality for domestic consumption as a potable water. This problem becomes more serious for the weaker sections of the society who are deprived of any technology and advancements. This current study discusses about the roof-top rainwater harvesting where a domestic rapid sand filter has been used for filtration of harvested roof-top rainwater and compares the efficiency of the filter for various depths of filter media on the basis of various drinking water parameters as per Indian Standards. This study will be beneficial by obtaining a standard design for a Rapid Sand Filter which will be easy to frame due to ease in availability of material required as well as economical and hence can be a bliss for the weaker sections of the society especially in rural areas who suffers to have adequate quantity and quality of potable water supplies.

Keywords: *roof-top, rainwater harvesting, potable, quality, filter*

TRENDS AND ADVANCEMENTS IN RAIN WATER HARVESTING

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Abstract

Water is the basic need of every living being. No one can survive without water but urbanization, industrial development and agricultural use a lot of water which results to depletion in quality of water and leads to water scarcity. To get rid-over these problems rain water harvesting is a good, revolutionary and vital supplementary option. This water replenishing method is already implemented in semi-arid and limited available water regions. This abstract mainly aims to explain the necessity of rainwater harvesting, its mechanism, problems during adaptation and its solutions. It also deals with new advancements, techniques and trends in rain-water harvesting.

Keywords: *Harvesting, Rain Water, Trends, Advancements, Techniques, Mechanism*

IMPACT OF RAINWATER HARVESTING ON GROUNDWATER RECHARGE IN CHENNAI CITY

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Abstract

As groundwater is the most commonly used for domestic purpose in urban areas, it is being overused without any limit thereby results in decline of groundwater levels. The groundwater levels can be improved by using the most essential and effective method “artificial recharge method” such as Rainwater Harvesting. Rainwater harvesting involves direct collection of rainwater which can be stored and recharged into ground. This study aims to assess the percentage of rainfall recharge due to the rainwater harvesting structure. variation of groundwater levels during recent years (2011-2018) by using data collected from “Chennai metro water supply and sewerage board”. Chennai city of Tamil Nadu is taken for study. The temporal and spatial distribution of water levels was studied. Change in storage and Recharge for the study area is been calculated from the water level, specific yield and area of influence by using “Groundwater Estimation Committee (GEC) norms”. The result shows that the groundwater recharge was decreased in the latest period due to improper maintenance of the rainwater harvesting structure.

Keywords: *rainwater harvesting, groundwater recharge*

A CASE STUDY ON SAVING TRADITIONAL WATER HARVESTING SYSTEM IN KUMAON REGION, UTTARAKHAND

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In the present scenario the whole world is desperate how to conserve water. This study uses traditional water harvesting system in the region of Kumaon, Uttarakhand. Water scarcity is one of the major problem in the Almora district of this region. Many traditional systems have been used from ancient time for harvesting water like *Naula (little depression aquifer)*, *Gadhera (small river tributaries)*, *Dhara (springs)* etc. Naula, naturally occurring aquifer catches dripping water from stream and springs and is a primary source of drinking water in Kumaon. Conservation of natural resources of water is one of the major challenge globally but still there is hope to keep them alive. This study describes the various structures, management systems and present scenario of traditional water resources and what are the major steps taken by the Government and society for recharging, regulating and monitoring them for the improvement of ecology.

Keywords: *harvesting, Naula, Gadhera, Dhara*

VILLAGE LEVEL WATER MANAGEMENT PLANNING THROUGH RAINWATER HARVESTING

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Abstract

Water crisis in India is due to ever increasing population, industrialisation and human waste combined with inadequate planning. For ensuring food security in this agriculturally powerful country the use of water is still lacking well management. This can be realised through village level water management planning to conserve rainwater. This needs step by step procedures based on hydrologic balance for providing best way of management of water resources and to secure precious agricultural land from man-made degradation. This study was conducted at a village Gohalura in Red and Laterite Zone of West Bengal. The major crops grown there are Aman rice; Groundnut during Rabi under both rainfed and irrigated farming situations and Boro rice. The major problems in crop production in that village are that some of the agricultural lands still remain rainfed with erratic and uncertain rainfall, along with high infiltration rate of soil. Shortfall in annual water balance could be managed through existing river lift irrigation from the nearest river Dulung, a tributary of Subarnarekha River, by the village. Creating and renovating water harvesting ponds in the mouza would facilitate multipurpose benefits including agriculture for farming community through such rational water management planning in that village.

Keywords: *water balance, rainwater harvesting, water management*

MODELLING OF DITCH DRAINAGE SYSTEM FOR DESALINIZATION OF SALINE AQUIFER CONSIDERING A SUBSURFACE SINK

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Abstract

Drainage plays an important role in the field of agricultural science, as it helps in removing excess water from the soil quickly. An analytical solution is developed for the prediction of transient seepage to a fully penetrating ditch drainage system receiving water from a ponded surface with an influence of subsurface source/sink. The proposed solution is quite versatile to tackle the presence of source and sink effect in the flow domain. A subsurface flow domain of confined nature is assumed as study area which is having finite extends in horizontal and vertical directions. The hydraulic property of the soil matrix is considered as homogeneous and anisotropic in nature. The accuracy of this solution is analyzed by comparing with numerical solution obtained from finite difference method and other existing simplified case on MATLAB programming software. With the imposition of the source and sink term in the flow domain, the path line and travel time of water molecules started deviating from their original position. It was observed that discharge to the drains has a strong influence of the source/sink term. It is expected that the proposed model will help in the understanding of the flow dynamics associated with the ditch drainage system subjected to source/sink in real field conditions.

Keywords: *Transient seepage, Ditch drains, Source/sink, Water logging*

TS – 7

**(MULTIPHASE FLOW, CO₂ GEO-SEQUESTRATION,
CLIMATE CHANGE AND (SUB)-SURFACE
HYDROLOGY)**

Keynote Paper

**TWO-PHASE FLOW IN POROUS MEDIA AND ITS IMPLICATIONS IN
GEOLOGICAL CO₂ SEQUESTRATION**

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Abstract

Two-phase flow in porous media is an important subsurface process that has significant impacts on the global economy and environments. To study two-phase system in porous media, capillary pressure (P^c), relative permeability (K_r), bulk electrical conductivity (σ_b) and bulk relative permittivity (ϵ_b) are often employed as characterization parameters. All of these parameters are functions of water saturation (S). However, the non-uniqueness in the P^c - S , K_r - S , σ_b - S and ϵ_b - S relationships pose considerable challenges in employing them for effective monitoring and control of the two-phase flow processes. The talk presents our recent results on laboratory scale experiments and numerical simulations for investigating the factors and conditions contributing to the non-uniqueness in the above relationships for supercritical CO₂-water flow in porous media with a special emphasis on geological carbon sequestration. The dynamic capillary pressure effect, which indicates the dependence of the P^c - S relationship on the rate of change of saturation ($\partial S/\partial t$) during two-phase flow in porous media is discussed. This work also demonstrates the application of a membrane-based system in the monitoring of the CO₂ in geological sites used for carbon sequestration. The response of the membrane-based system device in terms of the mass of permeated gas, permeability and gas flux for both CO₂ and N₂ are discussed. Finally, using numerical modelling, the talk will demonstrate robust application of two-phase flow principles for modelling CO₂ migration in geological formation.

THE IMPACT OF SUPERCRITICAL CO₂ INJECTION IN DEEP SALINE FORMATIONS: A NUMERICAL STUDY

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Abstract

In geologic carbon sequestration, supercritical CO₂ is injected into suitable deep subsurface formations and forms an immiscible pool with the surrounding saline aqueous phase. CO₂ being denser than resident brine moves upward under the influence of buoyancy force, accumulate beneath the caprock of the subsurface formation. This work mainly focusses on investigating CO₂ migration, its dissolution in resident brine and its different trapping mechanisms for secured geological sequestration. A series of simulation experiments have been performed for finding out the effect of subsurface heterogeneity on CO₂ sequestration and its subsequent migration in saline subsurface zone. The mass transport equation is solved numerically for a characteristic study domain to obtain multiphase migration of supercritical CO₂ in deep subsurface. The considered domain represents a typical deep saline aquifer at a depth of 1000 m for observing the migration of CO₂ under reservoir conditions. The results show that the injected CO₂ moves upward beneath the caprock emphasizing on structural trapping being the dominant mechanism. The migration front of CO₂ leaves behind a trail asserting on simultaneously occurring dissolution trapping in the considered domain. At same time, CO₂ reacts with brine and rock minerals and forms carbonates/bicarbonates making the stored CO₂ in stable form. The results of this study can be used in planning and quantification CO₂ sequestration in subsurface.

Keywords: *CO₂ sequestration, trapping mechanisms, multiphase and subsurface*

UPSCALING OF POLYMER EOR IN FRACTURED MEDIA

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Abstract

Polymer enhanced oil recovery (EOR) is one of the most common technologies among existing EOR techniques. In this talk, we try to tackle two of the challenges regarding reliable mathematical simulations at Darcy scale. First, developing reliable models for Discrete Fracture Network type models for fractured reservoirs. Secondly, we provide a characterization of the coefficient used in the Carreau type model depending on the underlying pore-scale geometry. Our tool for deriving reliable models for models in fractured media is the dimensional reduction strategy. This avoids constructing a computational grid, which resolves the fracture aperture. The typical procedure identifies the aperture to length ratio as the small parameter ε with the fracture permeability scaled as an exponent of ε . The reduced model is derived as the vanishing limit of ε . Our derivation provides new models in a hybrid-dimensional setting as well as models, which exhibit two-scale behaviour, and the fluid is treated like a non-Newtonian fluid. The model considers a Carreau model type fluid. The Carreau model has an alpha factor that describes the rheology parameters from micro scale at the Darcy scale; this alpha is referred to as the correction factor. We use a pore-network approach to determine this coefficient and characterize the dependency of alpha on the underlying pore scale geometry. The particular contributions in this work are in the derivation of the up scaled model through dimensional reduction in 2D using a formal asymptotic approach and the connection between pore network properties and Darcy scale properties. Several numerical examples provide additional insight.

Keywords: *Upscaling, Dimensional reduction, Carreau, EOR, Polymer*

FULLY COUPLED HYDRO-GEOMECHANICAL NUMERICAL INVESTIGATIONS IN A FRACTURED POROUS MEDIA

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Abstract

A fully coupled hydro and geo-mechanical study was conducted to investigate the pore pressure distribution, the effective stress distribution of a single-phase fluid flowing in a saturated fractured porous media with injection and production wells. The combination of vertical and horizontal fracture with and without edge connectivities are exclusively studied in this work. Heavy oil is considered as a fluid flowing in a porous media. Finite element method was used in the coupled model in-conjunction with the poroelasticity. Pore pressure distribution is significantly varied with vertical and horizontal loads. The porosity and permeabilities are considered as a function of volumetric strains in the porous media. The impact of Biot-Willis coefficient on the pore pressure and stress variations studied effectively. The stress failure study also conducted in the fractured porous media, to identify the more stress failure zones in saturated porous media as a function of applied load, fracture aperture, Biot-Willis coefficient. The impact of connectivity of the fractures at the end also investigated efficiently in this work. The implementation of the coupled hydro and geo-mechanical numerical models can improve the prediction of fractured porous behaviour efficiently.

Keywords: *Geo-mechanical, Fracture, Pore pressure, Effective Stress, Failure criteria*

**RECENT ADVANCES ON MATHEMATICAL MODELLING TECHNIQUES FOR
UNDERSTANDING MULTI PHASE FLUID FLOW IN A NATURALLY FRACTURED
CARBONATE RESERVOIR PRODUCING UNDER STEAM FLOODING EOR: A
REVIEW**

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Abstract

Approximately 2 trillion barrels of viscous crude oil is present in naturally fractured carbonate reservoir (NFCR), however, it accords negligibly to the world's oil production. These class of reservoirs portrays dual petro physical properties i.e. presence of low permeable matrix and high permeable fracture, hence these reservoirs can be termed as complex. Obtaining a reservoir simulation model for such reservoirs is a tedious task, but in recent times development of efficient methods has resulted in deriving models computationally accurate and inexpensive with time. In this study, a reservoir of type-II is taken into account in which the majority of the oil is present in matrix and fractures serves as a flow pathway. Steam injected in the reservoir first flows through fracture and then gradually moves from fracture to matrix leading to viscosity reduction of oil present in it. The mechanism linked to oil recovery from these reservoirs are complex and hence effective models are needed for capturing the physical process behind it. Advancement can be preferentially attributed to the use of continuous boundary condition at the matrix-fracture interface. In this paper, we will re-examine the key advancement in mathematical modelling, including key breakthroughs achieved in simulating in these reservoirs producing under steam flooding EOR. The drive of the present work is to highlight efficient and robust mathematical models and also to mark limitations associated with it.

Keywords: *Multi Phase Fluid Flow, Carbonate Reservoir, Under Steam Flooding*

STUDY ON HYDROLOGICAL PARAMETERS OF RIVER BASIN

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Abstract

Groundwater has emerged as the major source to meet the ever-increasing demands of irrigation, industrial and domestic sectors in Tamil Nadu. Considering all these facts in mind an effort was made to study on hydrological parameters of Amaravathi river basin. The hydrological parameters viz., Precipitation, Soil moisture content, Surface Runoff, Evapo-Transpiration, and Groundwater Recharge was estimated spatially and temporally by water balance method using SWAT model. The monthly and annual hydrological parameters were simulated by SWAT for the period 1990 to 2017. The annual mean of soil moisture content was found to be 92.11 mm. The minimum and maximum soil water content was 65.00 mm and 110.73 mm occurred in 2013 and 1993. The maximum runoff of 703.24 mm occurred in the year 2013 and minimum runoff of 52.18 mm occurred in the year 1995. The average annual actual evapotranspiration varied between 477.81 mm (2008) to 303.78 mm (1995). The maximum and minimum groundwater recharge of 351.89 mm and 2.15 mm occurred in 2013 and 1995 with an average groundwater recharge of 105.43 mm. The decrease in recharge manifested itself as reduced discharge to streams and hence reduced stream flow. Hence the atmospheric moisture demand of the basin indicating the need of water from external / underground sources for successful crop production.

Keywords: *Hydrology, River basin, SWAT, Recharge*

SPATIO-TEMPORAL TREND OF GROUNDWATER LEVEL IN COASTAL ODISHA

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Abstract

Groundwater is becoming more and more vulnerable due to its uncontrolled extraction, use and irregular rainfall pattern, resulting into uncertain recharge and replenishment. Thus in certain parts of the country, the groundwater level situation is gradually becoming alarming, and Odisha is no exception to that. In order to make an assessment, groundwater level trend analysis is studied in the coastal districts of Odisha affected by salinity problem. Mann Kendall trend analysis method is used to explore the trend of groundwater level using long term data (1998 to 2017) for a network of 272 locations, spread over into 4 seasons such as pre monsoon, mid monsoon, post monsoon and winter. Results indicate that during pre-monsoon period, there is increasing trend of level in 206 locations, and decreasing trend in 66 locations, in mid monsoon period there is increasing trend in 152 locations, and decreasing trend in 120 locations, in post monsoon period, there is increasing trend in 142 locations and decreasing trend in 130 locations and in winter there is increasing trend in 113 locations and decreasing trend in 159 locations. The results indicate, that the number of locations having decreasing trend of groundwater level is steadily increasing as the seasons progresses. Thus, such analysis can help the planners and managers in decision making with regard to the extent of groundwater to be extracted and used in different locations and in different seasons. Besides, it will also help in making strategies for rainwater harvesting and augmentation of groundwater recharge activities.

Keywords: *Groundwater Level, Mann Kendall trend analysis, Coastal Odisha, Spatio-Temporal analysis*

CLIMATE CHANGE AND WATER CRISIS

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Abstract

India is among the world's most water-stressed countries. According to reports, in 1950, India had 3,000–4,000 cubic meters of water per person. Today, the amount has fallen to around 1,000 cubic meters, largely due to population growth in comparison to China, which has twice the amount of water per person. Recently, the Drought Early Warning System (DEWS) report issued warning to six states which are facing acute water crisis. With the temperature level booming high in consecutive years, twenty nineteen has seen one of the driest pre-monsoon. But, what lacks is a strategic and systemic solution to address the issue at local levels. Huge corruption at implementation level, leads to water accessible only to the rich and thus initiating riots over basic water availability. The recent water riot which has unleashed in India is the signal how the issue of “water stress/crisis” is not a myth but the reality. It calls for the government and others agencies to work together towards a planned action rather than sending representatives to deliver sombre speeches to national and international forums.

Keywords: *Water Crisis, Climate Change, Joint Action*

IMPACT OF CLIMATE CHANGE ON GROUNDWATER RECHARGE AND BASE FLOW, IN THE SUB CATCHMENT OF TEKEZE BASIN, ETHIOPIA

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Abstract

The impacts of climate change are significant on both surface and groundwater resources. However, little attention has been given to the effect of climate change on groundwater resources. Therefore, the present study is concerned with the effect of climate change on groundwater recharge and base flow in Tekeze sub-catchment in Ethiopia. The future climate variables were obtained from Coordinated Regional Climate Downscaling Experiment (CORDEX) Africa program for Representative Concentration Pathways (RCPs) of RCP 2.6 and RCP 4.5 scenarios. The Mann-Kendall test and Sen's slope estimator were used for trend detection using XLSTAT software package. Further, the downscaled and bias corrected precipitation, temperature, and potential evapotranspiration were used as input to the WetSpa model to simulate future water balance changes. The results indicated a decreasing trend in annual rainfall and an increasing trend in average temperature and evapotranspiration for selected scenarios. At the catchment level, precipitation decreases by 20% for both RCP 2.6 and RCP 4.5 scenarios, and actual evapotranspiration shows 0.4% and 8.1% increment for RCP 2.6 and RCP 4.5, respectively. Consequently, the groundwater recharge decreases by 3.4% for RCP 2.6 and 1.3% for RCP 4.5. Base flow will also decrease by 1.5% and 0.55% for RCP 2.6 and RCP 4.5, respectively. The results of this study would help policymakers, scientists, government officials and local stakeholders in planning and management of the surface and groundwater resources in the Ethiopian regions.

Keywords: *Tekeze catchment, Climate change, Recharge, Base flow, Trend analysis, Wetspa*

ENTROPY-BASED INVESTIGATION INTO THE VARIABILITY OF DAILY RAINFALL OVER CENTRAL INDIA

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Abstract

Rainfall is the primary component of the hydrological cycle, describes the transfer of mass and energy from the earth to the atmosphere and vice versa. The spatiotemporal variability of rainfall has a large impact on agricultural productivity. The spatiotemporal variability of daily rainfall time series is investigated over Central India (73.5⁰E to 83.5⁰E and 18⁰N to 25⁰N) using Shannon entropy at multiple timescales. Intra-annual distribution of monthly, seasonal rainfall amounts, as well as rainy days, are analysed by using the apportionment entropy (AE) and intensity entropy (IE). Mann-Kendall test is applied to detect a significant trend in the time series of AE's and IE's. The findings from this study are : (1) Distinct spatial patterns were observed for apportionment and intensity entropies at the monthly, seasonal scale. (2) There is an increase in the variability of precipitation amount from south to north, indicating spread of the rainfall is high in the south when compared to north of Central India. (3) Regions with statistically significant trends were observed and vary from monthly to seasonal scale. Trend analysis revealed there is changing behaviour in the rainfall amount as well as rainy days, showing an increase in variability of rainfall over Central India, hence the high probability of occurrence of extreme events in near future.

Keywords: *Rainfall, Variability, Apportionment entropy, Intensity entropy, Central India, MK test*

ANALYSIS ON SPATIOTEMPORAL VARIATION OF INDIAN SUMMER MONSOON RAINFALL IN RELATION WITH EL- NIÑO SOUTHERN OSCILLATION

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Abstract

The aim of the proposed study/present study is to analyse the spatio-temporal variation of Indian Summer Monsoon Rainfall in the recent times in relation with El-Niño Southern Oscillation (ENSO) using INSAT-3D/IMD, AVHRR-OISST dataset – for computing Nino 3.4 index. The analysis carried on a regional scale over different parts of India represents the significant areas which receive intense rainfall within a short interval of time, also the long term analysis on influence of El-Nino and La-Nina trend on ISMR in quantitative context. The preliminary analysis indicates wide area of scope in understanding climatic modes and its impact on ISMR variability which plays vital role in managing the uncertainties of rainfall for effective fresh water resource management.

Keywords: *Indian summer monsoon, El-Niño Southern Oscillation, Rainfall, Spatio-temporal variation*

FLOOD FORECASTING IN RIVER SYSTEMS

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Abstract

Various models have been developed for real-time flow forecasting by using Artificial neural networks having memory or no memory. Analysis of models involving ANN having static and dynamic memory is described in the present study. Time Delay neural network TDNN, Multilayer Perceptron MLP with or without sliding window approach and Gamma Memory in multiple flows, are enlisted for flood forecasting in channel reach of Tar river basin in North Carolina. River reach characteristics govern the linkage between upstream and downstream stations. Water level and discharge at the downstream station, Greenville, and Tarboro, are forecasted by using known parameters at various upstream stations. Multiple inflows with single outflow forecasting models allow prediction of common downstream outflow depending upon the topography and river reach characteristics. Statistical criteria such as Coefficient correlation, RMSE root mean square error and coefficient of efficiency validate the model performances. Results depict that ANN having adaptable memory depth such as gamma memory is suitable best for real-time forecasting.

Keywords: *ANN Artificial Neural Network, Gamma Memory, Forecasting*

TROPICAL CYCLONE ACTIVITY IN NORTHWEST PACIFIC AND ITS RELATIONSHIP WITH SEA SURFACE TEMPERATURE

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Abstract

The strong tropical cyclone, called typhoon in China, belong to the extreme climate events, their trend of intensity and frequency is concerned with climate change. Utilizing the Best-Track Tropical Cyclone (TC) Data from the Joint Typhoon Warning Center and the NOAA Daily Sea Surface Temperature Data during 1982–2014. Spatial and temporal characteristics of northwest pacific TC activity, and its relationship with sea surface temperature (SST) are analysed. The results show: (1) TC has three distinct birthplaces: Birthplace 1 (10°-22°N, 110°-120°E), Birthplace 2 (8°-20°N, 125°-145°E), Birthplace 3 (5°-20°N, 145°-155°E), and the frequency of birthplace 2 is more than the other two. (2) TC concentrates in June-Oct of every year. General, there is the largest number of TC's occurrence in Aug, whereas the smallest number of it in Feb. In May, Nov and Dec, the number of TC increases slowly; and from June to Oct, the frequency showed a trend of slow decline. (3) The birthplace of TC often appears in the sea area which was in the south of 27°C isotherm in the center of warm pool. More than 70% of TC appears in the south of 29°C isotherm. During Jan-Mar and Nov-Dec, TC mainly appears in the sea area between 27-29°C isotherm, and during April-Oct, it mainly appears in the sea area between 28-30°C isotherm. (4) The frequency of TC has an evident inter-annual variability; 1982-1992 and 2003-2014 were Low-frequency years, and 1993-2002 was High-frequency years. From 1982-2014, the frequency characteristics of TC showed slow increase - rapid increase - decrease.

Keywords: *Tropical cyclone, Northwest pacific, SST, China*

PRECIPITATION ELASTICITY OF STREAM FLOW AND RAINFALL TRENDS OF THE THREE CLIMATIC ZONES OF MAHAWELI BASIN, SRI LANKA

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Abstract

Water resource management is progressively seeking to integrate the effects of worldwide climate change in future water supply planning. Studies across various regions have documented the sensitivity of stream flow to climate change using stream flow precipitation elasticity, defined as the ratio of stream flow to precipitation changes. The elasticity is an easy assessment of the sensitivity of long-term stream flow to long-term rainfall changes that can be used to assess the effect of climate change on region and water resources projects without any comprehensive modelling research. This study focuses on analysing the precipitation trends over the three distinct climatic zones and climate elasticity of streamflow in Mahaweli basin which spans over the wet, dry and intermediate zones. Monthly precipitation data for an extent of 30 years from 1988~2018 has been used for trend analysis and non-parametric estimation (Ep). The findings show that the precipitation elasticity of the stream flow in Mahaweli catchments selected in each zone is about 1 means 10% percent change in mean annual precipitation outcomes in a shift of 10% percent in average annual stream flow and the rainfall trend in climatic zone of Mahaweli are in-consistent and contains upward trends in dry and intermediate zone and negative trends in wet zone of the basin. The study findings imply the significance of undertaking a sub-basin scale survey for the river basins spreading over several significantly distinct climatological areas. The uncertainty in results arising from model choice can be overcome by estimating the sensitivity of stream flow to climate. Empirical elasticity offers a powerful means to test the extrapolation capacity of those hydrological models that are to be used to predict the impact of climatic changes. Farmers are advised to exercise crop rotation and grow more drought-resistant plants or early maturing crop varieties, particularly in the dry zone. Stream flow elasticity of precipitation can be extended into a two-parameter index depending on precipitation as well as temperature. This index can then be used to evaluate annual stream flow sensitivity to modifications in precipitation as well as evapotranspiration (temperature). This is helpful in both pre-disaster risk management and post-disaster rehabilitation.

Keywords: *Precipitation elasticity, Stream flow, Rainfall trend analysis, Mahawelli basin, Srilanka*

CHALLENGES AHEAD ON CLIMATE CHANGE NATIONAL ADAPTATION PLAN IN WATER RESOURCES MANAGEMENT IN IRAN

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Abstract

According to the 5th assessment report of IPCC (AR5) and recent report of the Iran's meteorological center, precipitation changes under RCP2.6 in 2030s, 2050s, 2070s and 2090s are not significant, however under RCP4.5, RCP6.0 and specially RCP8.5 precipitations will be significantly reduced relative to baseline (1986-2005). Under RCP8.5, 71% of GCM models predicted decreases in average precipitations relative to baseline. Annual changes in precipitation under RCP8.5 will be -7.5% in 2081-2100 relative to 1986-2005. The highly intense rainfall will cause the high intense flood occurrences with the large amount financial and physical/infrastructure damages. Moreover, it is estimated that the average temperature in Iran will increase by 1.5-4.5°C. Maximum increases will be 1.3, 2.6, 3.1 and 5.2° C under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, in 2090s respectively. These increases in temperature will cause more water stresses in the future. In general, the range of precipitation and temperature changes of the Iran at the end of the 21st century in two states of compliancy and the lack of compliance of the international community with the reduction of greenhouse gas emissions were between +2.5 to -7.5% and +1.3 to +5.2° C, respectively.

To facilitate the integration of climate change adaptation considerations into all relevant policies, programs and into development planning, Iran is engaging in National Adaptation Planning (NAP) process. Through the NAP process, efforts to address critical climate change-related risks and development priorities will take place in an integrated and coordinated manner, utilizing existing and future synergies. The NAP process is expected to reduce existing vulnerabilities by building adaptive capacity and resilience in water management sector and at all levels of society.

Keywords: *Vulnerability, Adaptation Strategies, Climate Change, Water Sector*

TS – 8

(PLANT-SOIL-ATMOSPHERIC CONTINUUM, SPRINGS HYDROLOGY, BASE AND ENVIRONMENT FLOWS)

Keynote Paper

AN EXPERIMENTAL INVESTIGATION OF OPEN CHANNEL PARAMETERS WITH RIGID VEGETATION

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Abstract

The vegetation in various streams (such as rivers, canals, etc.) plays a significant role in the environmental and ecological aspects. Vegetation can cause energy dissipation via drag force due to the interaction between vegetation and flow, and the dimensionless drag coefficient (Cd) is of great importance for understanding and predicting the flow behaviour in channels. A laboratory experiment conducted in a hydraulic flume for studying various hydraulic properties of the vegetated open channel under both submerged and emergent flow conditions with a parallel pattern with varying discharges and flow depths. Cylindrical rigid iron rods of height 5.0cm and diameter 4.87mm are planted in a laboratory flume with a vegetal density of 192 per unit bed area to simulate the effect of hydraulic characteristics on vegetation in open channel. The various hydraulic resistances like Vegetal drag coefficient (Cd), Manning's roughness coefficient (n), Darcy-Weisbach friction factor (f), and Chezy's coefficient (C) investigated and are found to be higher for the vegetated open channel in compare of the open channel without vegetation. These resistance factors change with flow depths and submergence ratios whereas channel without vegetation bears a constant roughness coefficient. Under the submerged flow condition, the values of Cd , n , and f , decreases with the increase of depth of flow. However, under emergent flow condition, when the depth of flow increases, values of Cd decreases while the value of n and f , is found to increase. Dimensionless numbers (Re , Fr) also increases with the increasing depth of flow.

From results, it was observed that the vegetative drag coefficient is less in the case of emergent flow in comparison to submerged flow condition. Results also explain that due to the presence of vegetation, the channel's overall efficiency decreases which leads to less supply at the end and involves more energy consumption.

Keywords: *Laboratory open channel, Rigid vegetation, Parallel pattern, Submergence ratio, Aspect ratio, Reynolds Number (Re), Froude Number (Fr)*

WATER ACCOUNTING PLUS (WA+) FRAMEWORK FOR ESTIMATING WATER PRODUCTIVITY AND LAND PRODUCTIVITY IN SUBARNAREKHA RIVER BASIN

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Abstract

Water Accounting Plus (WA+) framework has emerged as a key approach to understanding water scarcity and identifying gaps and in-efficiencies in water resources management. WA+ Framework was applied to the Subarnarekha basin to assess the total water consumptions, agricultural water consumptions (using green water and blue water concept), and estimate land productivity and water productivity (WP) for a period of 15 years, i.e., 2003-2014 for sustaining food security and making most efficient use of the shrinking water resources in the basin. The results show that the total water consumptions in the basin for the year 2013-14 are 27.1 km³/year with further partitioning of ET into Evaporation and Transpiration from different LULC. The non-beneficial consumptions in the basin are 14.1 km³/year much greater than the beneficial consumptions (12.9 km³/year). This indicates that there is a large scope for water conservation practices to be adopted in the basin to minimize non-beneficial consumptions. The overall land productivity for the cereals, i.e., mainly rainfed rice in the basin for the year 2013-14 is found to be 2325 kg/ha (varying from 979 to 2325 kg/ha for 2003-04 to 2013-2014, respectively). Similarly, overall WP in the basin for 2013-14 is found to be 0.55 kg/m³ (from 0.29 to 0.68 kg/m³ for 2003-04 to 2013-14). Results show that the yield and WP is higher in the centroid parts of the basin as compared to the other parts of the basin. The results reported herein have very much resemblance with those reported by NABARD and ICRIER (2018).

Keywords: *Water Accounting Plus, Green Water, Blue Water, Budyko, Remote Sensing, Water Productivity.*

A STUDY ON IMPROVEMENT OF WATER USE EFFICIENCY WITH REFERENCE TO KASHMIR VALLEY

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Abstract

Plant-soil-atmospheric continuum is the medium that facilitates the movement of water from soil through plants to the atmosphere by translocation of water and subsequent release into the atmosphere by evapotranspiration. Evapotranspiration is a very important and significant element of the water balance equation, and therefore, for a wide variety of hydrological analyses, which also includes groundwater recharge, its estimation becomes important. Evapotranspiration depends upon many meteorological parameters and crop characteristics. Its estimation is therefore not very straightforward. A simpler approach is to estimate reference evapotranspiration (ET_o), which is independent of the crop characteristics and only depends on the meteorological parameters. The present study has been carried out to estimate the reference evapotranspiration for three geo-hydro-meteorologically different regions of Kashmir Valley i.e. Srinagar (Central Kashmir), Kupwara(North Kashmir) and Anantnag(South Kashmir) various methods & then comparing them with the standard FAO-56 Penman-Monteith equation. For Srinagar and Kupwara stations, Hargreaves and Samani method was the most efficient method, with the highest value of the coefficient of determination ($R^2 = 0.96$ & 0.98) and least value of root mean square error (0.34 & 1.32). For Qazigund station, Priestly and Taylor was the best method with $R^2 = 0.90$ & $RMSE = 1.56$.

Keywords: *Evapotranspiration, reference evapotranspiration, soil-water relationship.*

INFLUENCE ON CROCUS SATIVUS (SAFFRON) CULTIVATION IN PRESENCE OF VARIOUS SOIL TEXTURES, WATERING CYCLES AND INTER-CORM DISTANCES

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Abstract

Crocus sativus (Saffron) is a popular and highly economical perennial stemless herb of Iridaceae family. It is widely cultivated in Iran and other countries such as India (Kashmir valley) and Greece. The luxurious growth of saffron is dependent on some essential factors which include well drained soil, a typical autumn climate and healthy corms. Kashmir valley in India with suitable climatic conditions favours its cultivation. We, possibly for the first time demonstrated successfully the tray scale cultivation of saffron. A series of experiments on germination, growth and flowering of saffron were conducted based on three objectives which includes: influence of various soils, watering cycles, and inter-corm distances. The results obtained indicated that saffron cultivation is affected in presence of soils with high water retention potential. Irregular watering cycles slowed down the germination and growth of saffron; however various inter-corm distances were not found affecting the germination, but impacted the saffron flowering.

Keywords: *Crocus sativus*, *Iridaceae*, *saffron*, *watering cycles*.

ESTIMATION OF EVAPOTRANSPIRATION FROM MEASURED METEOROLOGICAL PARAMETERS

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Abstract

Five empirical equations namely FAO-56 Penman Monteith, Hargreaves – Samani, Makkink, Turc and Priestley Taylor are utilized in the estimation of evapotranspiration for the month of May in 2018 for Trombay site in Maharashtra. Evapotranspiration from a given surface is a function of incoming solar radiation, net radiation, ground heat flux, air temperature, relative humidity and wind speed. Daily average measurements of these parameters are utilized in the empirical equations for estimation of evapotranspiration. These estimated values are compared with the measured data from pan evaporimeter installed at the site. The measured data from the pan evaporimeter are corrected using the pan coefficient K_p which in turn is also estimated using empirical equations. Average value of the pan coefficient K_p is 0.8 for the site. Average measured value of evapotranspiration is 4.7 mm/day for May 2018 whereas the average values estimated using the five empirical equations range from 3.28 mm/day to 12.69 mm/day. Among the five equations, the Turc equation with an average value of 4.8 mm/day was found to be in the best agreement with the measured values of evapotranspiration. Such studies are useful in the estimation of groundwater recharge, latent heat flux and in agriculture meteorology.

Keywords: *Evapotranspiration, lysimetric, turc equation.*

CROP YIELD OPTIMIZATION IN BHAGWANPUR DISTRIBUTARY OF THE GANDAK PROJECT, BIHAR

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Abstract

Land area management is the part of crop area management technique which is employed to aid the decision making process of farmers about judicious use of available limited land especially for small land holders. Its objective is to provide such land allocation to the farmers for different crops so that their margin of profit is maximum. The use of Fuzzy optimization gives us the proper solution of multiple objectives that need to be fulfilled simultaneously by formulation of objective functions. It has been observed that Multi objective linear programming model as compared to other linear programming models, gives the most precise output for allocation of crop area of various crops in different crop seasons. To handle the multiple criteria decision systems, in general, there are various tools available viz. the utility theory, the goal programming, the vector maximum methods, the interactive methods, and the fuzzy programming. The recent tool of fuzzy optimization can deal with the uncertainties due to vagueness in various components of the management problem (Majumdar, 2002). The fuzzy logic approach may provide a promising alternative to the existing management methods and allows incorporation of expert opinions (Panigrahi and Mujumdar, 2000). In this study an attempt has been made to optimally allocate land and water resources in a stochastic regime under a multi-crop environment for three complementary goals, viz. maximization of production, maximization of net annual return and minimization of labour cost for a deltaic command area using fuzzy optimization programming (FOP) and linear programming (LP).

Keywords: *Fuzzy optimization programming and Linear Programming.*

RESPONSE OF MACROINVERTEBRATES TO NON-AQUEOUS PHASE LIQUID (NAPL) POLLUTION

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Abstract

The discharge of industrial chemicals like heavy metals and petroleum products in to water resources is a threat to the survivorship of aquatic organisms. The water resources being widely connected are affected up to a larger spatial extent making the body unfit for usage. The discharged mixture has the potential to disturb the physiological, behavioral and even breeding performance of the macroinvertebrates by contaminating the water and ultimately affecting their water and oxygen uptake from the system. Non-aqueous phase liquids (NAPLs) being immiscible in water, form a separate layer above or below the water layer depending on the density. *Gammarus pulex* (shrimps) and *Baetis rhodani* (mayflies) are common fresh water macroinvertebrates of Europe. An exposure to NAPL pollution can have a substantial impact on their activities and survivorship. The aim of this study was to assess the response of *Gammarus* and *Baetis* to mineral oil (NAPL) exposure. The experiment was conducted in the laboratory for 24 hours under different concentrations. Shrimps showed high level of tolerance as compared to the mayflies which died due to prolonged exposure of NAPL. A trend in the floating and swimming pattern of the two species was observed with the passage of time. The overall results suggested that aquatic organisms show a quick and significant response to contaminant exposure and can potentially be used for bio-monitoring of the water bodies.

Keywords: *Aquatic macroinvertebrates, NAPLs, pollution, response*

RESPONSES OF GROUNDWATER FLOW PROPERTIES TO TIDAL WAVES IN COMPLEX COASTAL TERRAINS

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Abstract

Coastal aquifers are of interest for many years in understanding the transient interaction of tides and groundwater. Many studies have been carried out to analyse the effect of periodic tidal waves on water table fluctuation. With existing studies water table fluctuations in the two zonal aquifers of various configurations separated by horizontal or sloping bases has been addressed; however, flow properties in respective aquifers are not addressed. The present study can be served as an application of previous studies and it addresses flow properties such as flow rate at the both end of the complex coastal aquifer, volumetric exchanges of groundwater at the proximity surface and at the boundary point. In the present study, the combined effect of bed slope and tidal waves on groundwater flow properties whose base extends horizontally as well as sloping is discussed by obtaining the analytical expressions. Hydrographs representing flow rate and amount of groundwater exchanged with respect to temporal and spatial variation are plotted for various slopes, which clearly indicate the dependency of these properties on the local bed slope, tidal amplitude and tidal speed. The case of heterogeneity is discussed by considering variations in hydrological properties of the horizontal and sloping zones. In addition to this, the study focuses on dependency of groundwater hydraulic properties of sloping zone on horizontal zone. Based on the results, the outflow, inflow and steady state for groundwater in the complex aquifer systems is discussed.

Keywords: *Bed slope, complex coastal aquifer, flow rate, tidal waves, volumetric exchange.*

WATER SCARCITY, TRANS-BOUNDARY WATER AND UNABATED WATER POLLUTION

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Abstract

About 1.1 billion people worldwide lack access to water, and a total of 2.7 billion find water scarce for at least one month of the year. Inadequate sanitation is a problem for 2.4 billion people—they are exposed to diseases, such as cholera and typhoid fever, and other water-borne illnesses. Two million people, mostly children, die each year from diarrheal diseases alone. Many of the water systems that keep ecosystems thriving and feed a growing human population have become stressed. Rivers, lakes and aquifers are drying up or becoming too polluted to use. Agriculture consumes more water than any other source and wastes much of that through inefficiencies. Climate change is altering patterns of weather and water around the world, causing shortages and droughts in some areas and floods in others. Trans-boundary water management is a social, economic, and politically complex process that involves many different stakeholders and interests, usually influenced by power relations that go beyond the water sector itself, and which is often informed by the foreign and security policies of the countries that share the same water resource. In nature, water always flows to the lowest point in the landscape, be it to a lake, to a river, to the ocean, or simply recharging the groundwater. Water doesn't naturally keep within administrative boundaries; it transcends borders when it flows between regions within a country and when it flows between countries. An important concept that is often referred to in relation to trans-boundary waters is river basins.

Keywords: *Water scarcity, trans-boundary water, water pollution.*

UTILIZATION OF TAP WATER AS GREEN SOLVENT TOWARDS THE SYNTHESIS OF SUBSTITUTED QUINAZOLINES DERIVATIVES AT ROOM TEMPERATURE: A BRØNSTED ACID CATALYZED METHOD

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Abstract

Over the past few decades, water has turned up as the most versatile solvent for organic chemistry community. Most of the traditional organic methodologies depend upon it not only for its unique fluid properties and environment friendly nature but also for possessing mild reaction conditions, simplicity while undergoing reaction operations and sometimes obtaining the abrupt reactivity and selectivity of the desired products. In addition to that, chemical processes with brønsted acid catalysis have received ample attention in the field of organic research and developments. Hence, by combination of these two prominent green chemistry principles, herein, we have reported a mild synthetic route for the synthesis of quinazoline analogous. The reaction proceeds through unprecedented Tf_2NH catalyzed cyclo-condensation reaction between readily available *o*-aminobenzyl amines and aldehydes at room temperature in open air condition. With recyclability of the catalytic system up to five cycles, this green catalytic system has proven to be equally effective for the synthesis of various electron withdrawing as well as electron donating functionalities resulting in good to excellent yields under the optimized reaction condition. This important green synthetic route features as an eco-friendly, metal-free catalytic cycloaddition process, which may find applications in the synthesis of more complex bioactive quinazoline derivatives across the academic and industrial fields.

Keywords: *Ground water use, quinazoline, green synthesis, brønsted acid.*

A COMPARATIVE ASSESSMENT OF EVAPOTRANSPIRATION ESTIMATES AND ETP MODELING USING ARTIFICIAL NEURAL NETWORK

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Abstract

Evapotranspiration is one of the major components of hydrologic cycle. In this study, Potential Evapotranspiration have been calculated using the five methods PM, JHM, BCM, HM, and TWM and compared by taking PM as the standard method. The methods are ranked with an order of preference for every month. It is validated by using Kendall's co-efficient of concordance method. An alternative approach based on Artificial Neural Network (ANN) to determine the PET has been proposed and developed. The network is trained to recognize patterns of the meteorological data, calculated using Penman Method. The results of the ANN model trained by back propagation method are in good agreement with that of the Penman Method, after sufficient training.

Keywords: *Potential evapotranspiration, Penman's method, Artificial neural network*

TS – 9

(GIS AND REMOTE SENSING APPLICATION)

Keynote Paper

EVALUATION OF SURFACE WATER OCCURRENCE USING GOOGLE EARTH ENGINE DATASET AND ITS IMPACT ON GROUND WATER AND WATER RESOURCE MANAGEMENT.

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Abstract

Surface and ground water both are primary source of water supply for major population of the country and also interrelated to each other in environment cycle, the major portion is used for irrigation and industrial purposes as well as to meet domestic use. The location and persistence of both surface and ground water is affected by climate and human activity and affects climate, biological diversity and human wellbeing. At present, India has a total annual precipitation of 4000 km³, due to runoff, evaporation, and in situ use by the ecosystem, water availability for human purposes is only 1869 km³, representing just 47% of the total precipitation. Water resources developed at present amount to about 680 km³, which constitutes 61% of the utilizable potential of 1122 km³. However, it is difficult to add supply beyond this level due to heavy costs, decline in annual rainfall and due to effect of climate change. In contrast, the total demand for water is projected to reach 784–843 km³ by 2025 and 973–1180 km³ by 2050 as per government published report. If water is stored in the form of rivers and reservoir, this may help in improvement of groundwater levels as well to meet the ever increasing demand and supply gap. The more water available in surface, less water will be utilized from groundwater, which ultimately will help in increase of ground water level. Using three million Landsat satellite images change in global surface water over the past 32 years (1984-2015) at 30 m resolution is quantified and made available at Google Earth Engine. This provide the information on when water was present, where occurrence

changed, and what form changes took in terms of seasonality and persistence. India's major reservoirs are evaluated using this dataset and its impact on ground water is analysed. The results show that there are possibilities where surface water can be utilized and managed to improve the health of ground water.

Keywords: *Water occurrence, Google Earth Engine, Ground Water*

**HIGH FLUORIDE LINEAMENT (HFL) IN BICHHIYA TEHSIL, MANDLA DISTRICT,
MP, INDIA**

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Abstract

Present researchers made well distributed sampling of groundwater of the Bichhiya area. It was found that Fluoride concentration ranged from 0 to 6 mg/L in groundwater samples in basalt and the Precambrian basement aquifers. It was interesting to find that high fluoride samples display a linear pattern and hence is referred as **High Fluoride Lineament (HFL)**. The HFL lies in the Basaltic terrain and is parallel to the southern faults-system in the south of the HFL. These fault systems trend east-west in basement granulitic/gneissic terrain. Deep circulation of groundwater between gneissic/granulitic terrain and overlying basalts, facilitated by the fault has led to enrichment of Fluoride content in the study area. The present study establishes the relationship between HFL, the lithostratigraphic units and the Central Indian Tectonic Zone (CITZ). Litho-tectonic set-up establish that the source of fluoride is the basement and the fault-system made extension into the basaltic mass, probably due to post basaltic tectonic event. This study will lead to explore and identify higher Fluoride zones/cracks on the rocks which overlie the basement of granitic gneisses/granulites that are normally known to contribute to high Fluoride content in groundwater.

Keywords: *High Fluoride Lineament, CITZ, gneissic terrain*

GIS BASED LANDSLIDE SUSCEPTIBILITY MAPPING FREQUENCY RATIO APPROACH: A CASE STUDY

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Abstract

Landslide is considered a natural phenomenon in most of the hilly regions of the world but due to lack of proper planning, it causes huge economic losses and becomes a threat to human lives. So, in order to check the problems in Manipur, a north eastern border state of India, an attempt is being made to develop the landslide susceptibility map of the region using the Frequency ratio approach combining eight causative factors- topographic slope (%), elevation, curvature, aspect, Normalized difference Vegetation Index (NDVI), Land-use Land-cover (LULC), Rainfall data and soil map. Frequency ratio approach is a bi-variate statistical approach of landslide susceptibility assessment based on observed relationships between landslide distribution and landslide causative factors. Each causative factors and their sub-factors are assigned a weight according to the density of the landslides in each of the classes. The final map is obtained by summing all the weighted factors. The landslide susceptibility map is classified into 5 classes- no landslides, low, moderate, high, and very high landslides zones of susceptibility. A landslide inventory consisting of 142 landslide locations is used to validate the resulting susceptibility map. An accuracy of 75.26% has been obtained from the area under the Curve (AUC) of the prediction rate curve and 74.21% accuracy has been achieved from the Success Rate Curve for the Frequency Ratio Approach.

Keywords: *Frequency Ratio Approach, Normalized Difference Vegetation Index (NDVI), Landslide Susceptibility, Success Rate Curve, Area Under the Curve (AUC)*

**A GEOSPATIAL-AIDED HYDROLOGICAL MODEL APPROACH TO ESTIMATE
LOSS IN STORAGE CAPACITY OF A RESERVOIR: A CASE STUDY OF THE
SINGDA RESERVOIR, MANIPUR, INDIA**

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Abstract

Reservoirs are created by impounding streams carrying sediments. Sediments reduce the water quality and quantity in the reservoir which effects the management of the reservoir. The assessment of the sedimentation rate ensures sustainability of water from reservoir for various purposes. In this study, Singda reservoir catchment, which serves as the main source of drinking water to Imphal urbane and adjoining areas, is taken up considering its major concern for depleting water storage capacity. The main objective of this study is to assess the water-yield of the catchment and sedimentation taking place in the reservoir using geospatial-aided techniques in a hydrological model. SWAT is used for estimation of the runoff and sediment yield on daily time scale. Ancillary data as Toposheet, DEM, LULC, Soil map and hydrometeorological data were used. To estimate the capacity or volume of the reservoir, bathymetry of the reservoir is extracted using 3D coordinates generated from a hybrid Topomap-derived contour and DEM of the study area using SURFER. A 3D profile of the reservoir with depth elevation values was generated as the bathymetry of the reservoir. A multi temporal approach analysis has been taken up to predict the water yield and life span of the reservoir for sustainable water management for the future.

Keywords: *Reservoir, Runoff, Water Yield, Storage Capacity, Geospatial, SWAT, Bathymetry.*

A REMOTE SENSING AND GIS APPROACH TO ESTIMATE THE LOSS IN STORAGE CAPACITY OF A RESERVOIR: A CASE STUDY ON THE SINGDA RESERVOIR, MANIPUR, INDIA

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Abstract

Reservoirs are created by impounding streams carrying sediments. Sediments reduce the water quality and quantity in the reservoir which effects the management of the reservoir. The assessment of the sedimentation rate ensures sustainability of water from reservoir for various purposes. In this study, Singda reservoir catchment, Manipur, India is selected as it is the main source of potable water in Imphal, which is the capital city. Due to prevailing drinking water scarcity, this reservoir must be studied thoroughly and analyse the parameters which affects the water properties and its capacity. The main objective of this study is to assess sedimentation in this reservoir using remote sensing and GIS techniques. For the assessment, SWAT, is employed for estimation of sediment yield. Toposheet, DEM, Landuse map, Soil map and hydro-meteorological data were used. In order to estimate the capacity or volume of the reservoir, bathymetry of the reservoir is studied. The bathymetry is carried out using 3D coordinates generated from the study area using SURFER.A contour map and a 3D map of the reservoir was produced. A multi temporal approach analysis is taken up so that we can predict the life span of the reservoir for future management.

Keywords: *Sedimentation, Bathymetry, Remote Sensing, GIS, Reservoir capacity*

ASSESSMENT OF GROUNDWATER POTENTIAL ZONES IN PARTS OF NOYYAL BASIN, TAMIL NADU, INDIA USING GEOSPATIAL TECHNIQUES

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Abstract

The aim of this paper is to identify groundwater potential zones in parts of Noyyal Basin, Tamil Nadu, India using an integrated approach of Geographic Information Systems (GIS) and Remote Sensing (RS). To generate a map that demonstrates the probability occurrence of groundwater, GIS and RS were used. Hence, in order to create the groundwater potential zones map (GWPZM) of the study area, various thematic layers such as geomorphology, geology, slope, drainage and drainage density, lineament and lineament density, soil, and land use/land cover (LU/LC) were prepared and processed in a GIS environment. Suitable weights were assigned to all these thematic layers based on their relative significance to groundwater potential. By integrating all the thematic maps, the study area is categorized into four groundwater potential zones viz., 'very poor', 'good', 'moderate' and 'poor'. This study identified that only 2% of the entire study area is found to be under very good groundwater potential zone category. On the other hand, 24% and 51% of the study area falls under good to moderate groundwater potential zones respectively, whereas 23% comes under a poor category. For cross verification, different wells had been selected and the yield production of the wells within the present research area was compared with the GWPZM and was identified as realistic. This research provides the integrated use of GIS and RS are excellently performed for delineation of groundwater potential zones and the maps may perhaps useful for efficient planning and management of groundwater resources.

Keywords: *Groundwater Potential Zones, GIS, Remote Sensing, Thematic layers, Noyyal basin*

ASSESSMENT OF SOIL LOSS IN MAHE RIVER BASIN, KERALA, INDIA USING RUSLE, GIS AND REMOTE SENSING

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Abstract

Soil erosion is a major environmental threat that leads to degradation of soil, loss of nutrient rich soil, siltation in the reservoir etc. Best ecological and/or hydrological practices are essential to restrict the soil erosion rate. Availability of heavy rainfall and undulating topography of Kerala specifically signifies the importance of soil loss assessment. Revised Universal Soil Loss Equation is one of the most widely accepted methods to calculate annual soil loss. In this paper, RUSLE, Remote Sensing data and GIS tool is employed to calculate annual soil loss in Mahe River Basin, North Kerala, India. DEM, Sentinel 2, LU LC Map, Soil Map, Rainfall Data for the last 20 years are used to find out Rainfall erosivity factor (R), Soil erodibility factor (K), Slope length and steepness (LS), Crop management factor (C) and Conservation support practice factor (P) and thus Annual Soil Loss (A) in the study area. The assessment of catchment level soil loss and gradation of its severity helps to realize the criticality of the problem. The spatial erosion map can serve as smart input to the authorities to take suitable measures in an effective way to reduce the soil loss.

Keywords: *Soil loss, RUSLE, LS factor, Kerala, Mahe*

GROUNDWATER MAPPING IN LOW LAYING AREA USING GIS TECHNIQUES

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Abstract

In recent years, extreme climatic condition is witnessed in the study area (Imphal West District of Manipur State in the North East region of India; a valley/low laying area surrounded by high rise mountains) eventually leading to scarcity of usable water during dry season (winter) and water logging and flooding during monsoon season. Such unpredictable/suddenly changed situation inspires to study the scenario of groundwater capacity in the region. So, this study aims to identify the potential ground water availability (recharge potential) in the study area using remotely sensed data, Geographical Information System (GIS), ALOS-PALSAR DEM and a multi criteria decision making (MCDM) technique. The recharge potential zones were achieved by weighted overlay analysis and thematic layers of land use/land cover, geology, geomorphology, slope, drainage density, and soil and lineament density of the study area. The delineation of potential zones is identified in four categories very good, good, moderate and poor. Major part of the study area is alluvial plain consisting agricultural land and vegetation which is mostly contributing to the groundwater recharge. About 85% of the total area is found to be very good potential; 15% having moderate recharge potential and very small area less than 1% have poor recharge potential. As the study region is found to be having great ground water recharge potential, it is suggested that groundwater may be used as a source for public water supply during dry season and techniques of artificial recharge can also be adopted.

Keywords: *Groundwater mapping, multi criteria decision making, RS & GIS, Weighted Overlay Analysis, ALOS-PALSAR DEM*

SLOW AND STEADY LANDSUBSIDENCE OCCURRING IN DELHI REGION DUE GROUNDWATER DEPLETION

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Abstract

North- Western India an abode of roughly six hundred million people is the most heavily irrigated the populated place, consequently this region shows severe scarcity of waters during the summers. According to study it is found that temporal change in earth gravity field as recorded by the GRACE satellite mission (Tiwari et al. 2009) concludes that the region lost 54 km²/year. High demand for water supply poses a severe threat to change in hydrological cycle as reported by CGWB in 2006. This work is primarily focused at Delhi, where Differential Interferometric SAR technique (DInSAR) has been used to ensure the effects of surficial land subsidence due to depleting groundwater level. DInSAR has an ability to map in wider scale, almost around tens-of-kilometer combined with high precision level in fractions of centimetre. A regular monitoring of piezometer data of ground water table fluctuation for the last eleven years indicates that land subsidence is caused due to stressed aquifer conditions and low pore-water pressures in the aquifer systems. The DInSAR fringe coincides with high built up areas, both for Dwarka, Kapashera region of Delhi. Since the results of piezometric head change is exactly comparable to DInSAR based observation hence it interpretable that there is relationship between Ground water depletion and land subsidence.

Keywords: *DInSAR, predictive modelling, groundwater, depletion, subsidence*

ASSESSMENT OF GROUNDWATER QUALITY INDEX USING GEOINFORMATICS IN GURUGRAM DISTRICT, HARYANA, INDIA

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Abstract

Water Quality Index is considered as the most significant parameter to check the water for drinking purposes. It is utilized to outline a lot of water quality information into straightforward terms for answering to the board and people in general in a steady way. It reveals to us whether the general nature of water bodies forces a potential risk to different employments of water or not. The nature of groundwater especially shallow groundwater is changing because of human exercises. Water quality index (WQI) has been determined for evaluating the water nature of Gurugram area at 31 locales in pre-monsoon and post-monsoon seasons for the year 2017. So as to figure WQI, eight significant parameters in particular pH, Alkalinity (Ak), Total hardness (TH), Chloride (Cl), Total Dissolved Solids (TDS), Electrical Conductivity (EC), Nitrate (NO₃) and Fluoride (F) were utilized in light of the fact that these eight parameters contribute for deciding the drinking water quality. The figured WQI demonstrates that none of the sample in pre-monsoon and just 9% samples in post-monsoon was observed to be of 'Excellent' water class. Likewise, 13% of water samples fall in the 'good' to 'medium' water class in the pre-monsoon though 32% in post-monsoon. Then again, 87% of water samples fall in the 'Bad' to 'Very Bad' class in pre-monsoon while 58% in post-monsoon showing that the water isn't appropriate for direct utilization and require treatment. After treatment, the water can be utilized for drinking reason.

Keywords: *Water Quality Index (WQI), Geographic Information System (GIS), Gurugram District, Haryana,*

GROUNDWATER QUALITY ASSESSMENT OF VRISHABHAVATHI WATERSHED AREA, BENGALURU

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Abstract

The Vrishabhavathi watershed lies in both Bangalore urban and Ramanagara districts of Karnataka, India. The watershed stretches from South to North between the Latitudes – 12° 44' 37" to 13° 02' 31" N and Longitudes – 77° 23' 14" to 77° 34' 59" E from West to East. The rapid urban developments in the past two decades of Bangalore and Ramanagara districts have caused depletion of groundwater quantity and deterioration of quality through excessive consumption and influx of pollutants from natural and anthropogenic activities. The hydrochemistry of the groundwater was analysed in the watershed for drinking and agricultural purposes. To assess the groundwater quality, 35 groundwater samples from bore wells were collected for year 2017. Various physico-chemical parameters of groundwater were determined. The Geographical information system (GIS) was used to generate different spatial distribution maps of major chemical constituents using ArcGIS 10.1. The analytical data were used to compute parameters such as percent sodium (Na %), sodium adsorption ratio (SAR), salinity hazard, permeability index (PI) etc., to determine the quality of water for agricultural purposes. Piper trilinear diagram interpretations were made to know the chemical type of groundwater. The results indicate that, most of the groundwater samples fall under the class I and are suitable for Irrigation. From the obtained data, it can be concluded that the water quality profile was good and useful for normal irrigation agriculture.

Keywords: *Hydrochemistry, GIS, Groundwater Quality, Remote Sensing, Water Quality Index*

APPLICATION OF REMOTE SENSING AND GIS IN HYDROLOGY

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Abstract

As You know ground water is very important resource for drinking as well as irrigation purpose therefore it will remain important aspects for water resources and management .out of total water available only 2.5 percent are fresh water and out of this fresh water only 30.1 percent is in the form of ground water. 54% of India faces high to extremely high water stress. Water table is going down in almost all part of the country. Average rainfall over India is about 1120mm/year. storing only 1% of the total rainfall in India is enough to meet the country's domestic requirement of water. Total average annual precipitation over India is 4000 cubic km, ground water recharge is only 433 cubic km. If we increase quantity of ground water recharge by some better water management technique, then it will solve the problem. Remote sensing and GIS plays vital role. we can construct reservoir for ground water recharge and we also find the area which is suitable for construction of reservoir. Data collecting from GIS and remote sensing is really helpful for this. Identification of suitable sites for water harvesting made easy using geoinformatics. preliminary assessment of impact of reservoir before construction of such projects.

Keywords: *Suitable, geoinformatics, precipitation, GIS, Remote sensing*

VOLUMETRIC ANALYSIS OF BISALPUR RESERVOIR (RAJASTHAN) USING REMOTE SENSING DATA

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Abstract

Frequent and timely volumetric observations of reservoirs become necessary to observe the amount of change that has occurred in recent years. The water from these reservoirs is utilised for many day-to-day purposes like power generation and domestic as well as industrial use. Accomplishing such a task is often difficult if done using old conventional methods. Bisalpur Dam in Tonk district of Rajasthan was analysed using the geospatial techniques for water surface area, volume and its level variations. The results were calculated using multispectral satellite (MODIS) images along with Sentinel altimeter. Both these datasets were analysed using ArcGIS and BRAT. The dam water surface boundaries for each year were combined with field-observed water levels to check the accuracy of the process. The results obtained were compared with the actual values using graphs. R-value of the process came out to be 0.9598 which makes this process accurate and feasible. It also proved that the remote sensing methods of volumetric analysis are time-saving and fairly accurate. Their application should not be limited to only certain areas.

Keywords: *Modis, Volumetric Analysis, Laser Altimeter, R value*

IMPACT OF RAINFALL DISTRIBUTION IN FLOOD MODELLING OF AN UNGAUGED RIVER BASIN USING HEC-HMS - A CASE STUDY

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Abstract

Flooding, a natural disaster that causes huge damage in terms of Economy and human lives throughout the world frequently. Understanding the flooding behaviour of a catchment requires continuous measured rainfall and stream flow data. The objective of this works is to understand spatial and temporal variation of rainfall on the flooding behaviour of a catchment and its importance to the discharge estimation. Adyar River Basin, which is flowing through Chennai Metropolitan City has been chosen for this study. Two different flow events occurred in 2008 flood and 2016 cyclone have been selected for this analysis. Hydrologic Engineering Centre's-Hydrologic Modelling System (HEC-HMS) was used to model the flooding characteristics of the selected events. Different set of rainfall data have been used for 2008 and 2016 i.e. increasing number of rain gauges and daily data to hourly data. Optimization and sensitivity analysis has been carried out for the parameters to be calibrated using sum squared residual method. The model was calibrated and validated for 2016 cyclone event and 2008 flood event. The performance of this model was assessed in terms of Correlation coefficient and Nash-Sutcliffe efficiency, which is 0.78 and 0.65 for calibration, 0.98 and 0.78 for validation, respectively. The increase in number of rain gauges and using hourly data provides better simulation results. Hence this study shows, accounting the spatial and temporal variations of the rainfall occurred during the flood events can improve the performance of the model.

Keywords: *Rainfall variation, HEC-HMS, flood modelling*

CHANNEL MIGRATION OF RIVER GANGA AND WETLAND POTENTIALITY IN THE DYNAMIC FLOODPLAIN OF EASTERN INDIA: A RS-GIS – MCDM BASED APPROACH

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Abstract

The heart-beat of India, holy River Ganga is characterized with frequent shifting of its channels leading to continuous modification of its riparian areas. After crossing Rajmahal Hills, it enters into the large Bengal plain region and start depositing huge sediments in its bed. Seasonal variation of river discharge in this part along with sedimentation favours formation of river meanders, ox-bow lakes, channel cut-off etc. which later turn into floodplain riparian wetlands. This study focuses on channel migration of river Ganga using Remote Sensing- GIS based methods like historical migration zone (HMZ), erosion buffer (EB), avulsion potential zone (APZ), restricted and un-restricted migration area (RMA and UrMA) and retreating migration zone (RMZ) along with their wetland potentiality. Multi-Criteria Decision Making (MCDM) techniques like relative weightage, AHP and Fuzzy AHP have been adopted to analyse the wetland potentiality. The study is conducted in the Diara region of Malda district of West Bengal which is the home of 1.5 million people as per Census 2011 and affected by massive flood incidents due to this phenomenon. The result shows that the River is migrating at the rate of 106.61 metres per year in some parts which is quite alarming in one hand and this region is highly potential for new wetland formation on the other.

Keywords: *Diara Region, Channel Migration, Historical Migration Zone, Erosion Buffer, MCDM, Wetland Potentiality.*

ASSESSMENT OF GROUNDWATER RESOURCE POTENTIALITY AND SCOPE OF WATERSHED MANAGEMENT FOR SMALL-SCALE IRRIGATION IN DROUGHT PRONE BARIND TRACT, NW BANGLADESH: A REMOTE SENSING AND GIS-BASED APPROACH

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Abstract

Present study is carried out to study groundwater potentiality and relevancy of watersheds for conservation of runoff water for small-scale irrigation schemes using RS and GIS techniques. Decreasing rainfall trend along with increasing demand for irrigation in agro-based study area utters threat for water resource sustainability. To delineate groundwater potentiality, thematic layers like geomorphology, drainage density, rainfall, lithology, lineament density, slope and land use/land cover (LULC) have integrated in GIS environment, and has categorized mostly as 'poor to very poor' - 58% and 'moderate' - 30%. which are mostly sensitive to surface lithology. The elongated shaped watersheds with low to moderate relief and moderate to steep slope reveals a flatter peak of runoff water flow for longer duration representing good category for runoff water conservation. Here major portion of runoff water loses and not allowing sufficient infiltration to recharge the groundwater and, therefore is less potential for groundwater occurrence. The major part of watersheds is covered by cultivated land which demands basin management for water resource. Finally, present study would be useful for small-scale irrigation schemes in watersheds by constructing runoff water conservation structures; and artificial recharge of groundwater through managed Aquifer Recharge (MAR) technique in the area.

Keywords: *Groundwater potentiality, Remote sensing and GIS, Watershed Management, Drought Prone Barind Tract, Bangladesh*

ASSESSMENT FOR GEOMORPHOLOGICAL CHANGES OF CHILIKA LAGOON IN POST NARAJ BARRAGE PERIOD

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Abstract

Chilika, a shallow brackish water lagoon in Odisha state in India, adjoining to Bay of Bengal is shrinking because of its sediment surplus budget. A portion of north western bank has been transformed to large swamps and shallow mud flats, and subsequently, converted to agricultural lands. The salinity of the lagoon reduced from 22.31ppt in year 1957 to 8.5ppt in 2000. The ecology of the lagoon degraded continuously. Consequently, sediment evaluation and inflow management of the lagoon became the prime concern. An artificial opening in the barrier spit (2000), construction of Naraj barrage at head of River Kathajodi (2004), two small barrages over river Bhargovi at Gobardhanpur (1998) and Gabkund (2014) and cuts to Bay of Bengal are major structural interventions made to the hydraulic system of the lagoon as remedial measures. After construction of the Naraj barrage, four new natural tidal inlets are created in the barrier spit converting the lagoon from choked to restricted one. A detailed study regarding various geomorphological changes of lagoon, in pre and post Naraj barrage period are presented. Topographic study with the application of GIS and **Advanced Wide Field Sensor (AWiFS)** (IRS-P6) satellite imageries are considered for the various studies of geomorphological feature.

Keywords: *geomorphology, Advanced Wide Field Sensor (AWiFS) (IRS-P6), GIS*

**ASSESSMENT OF RESERVOIR CAPACITY USING GROUND BASED
DIFFERENTIAL GLOBAL POSITIONING SYSTEM FOR SUKHANA RESERVOIR,
DIST- AURANGABAD, MAHARASHTRA, INDIA**

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Abstract

Reservoir sedimentation is a serious problem caused due to soil erosion from catchment area of reservoir. For field engineers it is essential to know the exact quantum of water available in live storage zone of the reservoir for reservoir water planning purpose. The present study describes the capacity assessment of Sukhana Reservoir, using ground based Differential Global Positioning System (DGPS). The topographic survey in reservoir submergence was carried on December 2018 by Trimble R-4 base and rover instrument of L1 (1227.6 Mhz) and L2 (1575.42 Mhz) frequency. The DGPS technique combined with the GIS was used for this study. The collected raw data from both the base and rover unit was imported in Trimble Business Center (TBC) software for processing and Arc-GIS software for mapping. For the present case during field survey period water level of the reservoir was 538.65 m. The Full Reservoir Level (FRL) and Minimum Draw Down Level (MDDL) of the Dam was 542.85 m and 538.28 m respectively. The study was carried out between minimum level 538.70 m to maximum level 542.85 m. From the study it was found that due to sedimentation the study portion live storage capacity of the Sukhana Reservoir has reduced from 17.605 Mm³ to 15.28 Mm³, thus showing capacity loss of 2.235 Mm³ i.e 0.253% in a span of 52 years. The rate of siltation in study live storage portion was observed to be 1.48 Ha-m / 100 sq.km / year.

Keywords: *Assessment, Capacity, DGPS, Elevation, GIS, Survey.*

EDUCATIONAL ASPECTS OF CREATION OF PONDS AND LAKES OVER SCHIRMACHER OASIS, ANTARCTICA

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Abstract

The group at the Silver Line Prestige School, Ghaziabad, India addresses highly interesting educational aspects about the creation of deep lakes and shallow ponds over the Schirmacher Oasis, East Antarctica. The Schirmacher Oasis is a small (35 sq. km area) rocky area where the ice and snow melt during summer and this melted water along with the water from the Polar Ice get accumulated in various lakes and ponds. The lakes and ponds get created first by the receding polar glacier, which then fills the water during local summer due to melting of polar ice. During summer, snowfall during night results in the melting of ice during sunny period, this water gets deposited in depressions. This water also seeps in pores of rocks and when it freezes, its volume increases causing cracks. At night, the water in ponds freezes, this freezing causes volume to increase, thus it puts pressure on the peripheral rocks. This process of thawing leads to the expansion of ponds and over a period of time, it is seen that pond size increases. At the same time, katabatic winds cause weathering in cracks and holes in rocks. From educational point of view, we can study the presence of ponds and lakes through satellite imageries and keep a digital record, which can be matched after every decade to draw important inferences.

Keywords: *educational aspects, deep lakes, shallow ponds, Polar Ice*

MAPPING OF UNDERGROUND WATER FLOW FROM SATELLITES IMAGES

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Abstract

Satellites and aero planes draws everyone attention by having better and more advanced detailed system. Much recent advancement made by many companies like Google Earth surprised and inspired many young minds. Satellite imaginary system becomes a part of over-expectation to what a satellite can do and satellite images also meet all these expectations. The use of remotely sensed image interpretation falls in qualitative characterization of mapping of hydrological units and its specific features. Its main application includes crystalline basements, limestone's and volcanic terrains. New advancements lead to ground-water emergence in the discharge area of water flow system using multispectral imagery system. For later ground water recharge and rain water discharge will Centre attention on describing frameworks which includes vegetation, terrain mapping and its monitoring using remote sensing and hydrological GIS system. Mapping of underground water flow from satellites images have been described. In the present paper, various challenges and barrier of the application of remote sensing technology for making solution of hydrological problems, have been discussed.

Keywords: *Satellite, remote sensing, hydrology, mapping, GIS.*

LAND USE/LAND COVER CHANGES USING REMOTE SENSING AND GIS IN THE CITY OF PUSHKAR, INDIA

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Abstract

The study utilizes multi-spectral satellite data and incorporates well established landscape metrics to analyse changes in land cover and use. A small town i.e. Pushkar near Ajmer city in Rajasthan India has been selected as the town reflects unprecedented and unstructured form of urban growth. The study compares three satellite images from years 1997, 2004 and 2015. Object based Classification method with the help of quad-tree segmentation and spatial difference segmentation approaches was utilized to prepare land use and land cover maps. The study is helpful in identifying the land use change and urban growth from year 1997 to 2008 to 2015. The study can further be used for assessing the impairment of ecosystem services and functions as a result of the unplanned growth. It may also be used by the local planning and development authorities to plan land use and urban growth with minimum impacts on the ecosystem.

Keywords: *multi-spectral satellite, GIS, land cover changes*

INTEGRATED REMOTE SENSING AND GIS TECHNIQUES FOR EVALUATION OF GROUNDWATER RESOURCE

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Abstract

The urban environment quality is deteriorating day by day with the largest cities reaching saturation points and unable to cope with the increasing pressure on their infrastructure. Fresh water being one of the basic necessities for sustenance of life, the human race through the ages has striven to locate and develop it. Water, a vital source of life in its natural state is free from pollution but when man tampers the water body it loses its natural conditions. Ground water has become an essential resource over the past few decades due to the increase in its usage for drinking, irrigation and industrial uses etc. The distribution of groundwater is not uniform throughout the country. The spatio-temporal variations in rainfall and regional/local differences in geology and geomorphology have led to uneven distribution of groundwater in different regions across the country. Application of remote sensing technology in groundwater resources evaluation has been practised for about decades now. In particular, the clear response of crops to irrigation from groundwater forms a valuable means of rapidly assessing the location and extent of areas with groundwater usage. In groundwater studies much use has been made of aerospace imagery, chiefly through visual interpretations requiring photogeological experience. The present study attempts to explore the application of remote sensing and GIS in examining the ground water quality and relates it to the hydro-geomorphology; geological structure, surface water bodies, drainages and general land use/land cover. In addition to it we will also emphasis an integrated approach of remote sensing and GIS in selecting suitable sites for groundwater recharge. The integrated study helps in designing a suitable groundwater management plan for a hard rock terrain.

Keywords: *Remote Sensing, GIS, Groundwater resource evaluation, Groundwater management.*

ROLE OF REMOTE SENSING AND GIS IN HYDROLOGY

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Abstract

Remote sensing and GIS are very powerful tool to monitor natural resources such as land use pattern, climatic variations, forest cover as well as snow cover, rainfall, precipitation and water resources (surface water and ground water). Remote sensing gives the detailed information in space and time not only from accessible areas but also from inaccessible areas whereas GIS helps in storing, interpreting and retrieving the spatial data. Abilities of remote sensing technology in hydrology are to measure spatial, spectral, and temporal information and provide data on the state of the earth's surface. It provides observation of changes in hydrological states, which vary over both time and space that can be used to monitor hydrological conditions and changes. Sensors used for hydrological applications cover a broad range of electromagnetic spectrum. Both active sensors that send a pulse and measure the return pulse. It can monitor terrestrial water cycle with the launch of a great numbers of satellites, covering various applications which includes rainfall, soil moisture, flood extent, surface water level, terrestrial water storage, snow and ice, floods. This way water quantity and levels can be checked anytime with real time data and conservation strategies can be introduced with valid data that states the need of the situation.

Keywords: *remote sensing, GIS, water conservation, hydrological application.*

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**(WATERSHED DEVELOPMENT, IMPACTS OF LAND USE
PATTERN, WATER LOGGING AND DRAINAGE
NETWORK)**

**APPLICATION OF PRINCIPAL COMPONENT ANALYSIS ON GEOMORPHIC
PARAMETERS OF BERNE RIVER, RAJNAGAR BLOCK, CHHATARPUR, MP**

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Abstract

Present paper deals with a watershed on the granitic-gneissic terrain of part of Bundelkhand Craton. Granitic-gneissic terrain generally has a characteristic drainage development which is not reflected in the study area rather it has directional controls on the drainage development. The granitic terrain has intrusions of quartz reefs, emplacement of granites and dyke swarms which have found to correlate with shearing events. This fabric has controlled the drainage parameters. Hydro-geomorphological characteristics of a watershed are widely used for developing the regional hydrological models for understanding and solving various hydrological problems of surface water resources of watersheds which can be applied for various Engineering planning, river processing, sediment loss etc. In the present study GIS technique has been used to determine the geomorphological parameters of Berne River watershed which is tributary of Ken River, a part of Rajnagar block, Chhatarpur district of Madhya Pradesh. Many of the geomorphic parameters are known to be strongly correlated. The screening of such large number of interrelated variables for their underlying dimensions is best achieved by multivariate statistical techniques of the principal component analysis. Therefore, principal component loading is applied in order to get better correlation and clearly group the parameters in physically significant components.

Keywords: *Geomorphic Parameters, Principal Component Analysis, GIS*

**USE OF LINEAR PROGRAMMING MODEL TO DETERMINE OPTIMUM CROPPING
PATTERN FOR IRRIGATED AND RAINFED REGIONS OF BIDAR DISTRICT,
KARNATAKA**

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Abstract

The present study was carried out in Bidar District, to explore the possibilities of increasing net income and employment opportunities to the farmers. A linear programming model with restricted and unrestricted capital was developed and tested. It was found that the existing allocation of resources was suboptimal and there was scope to increase the income and employability through rational allocation of resources even under constrained and unconstrained capital. A sample comprising of small and large farmers was selected and data was collected through interviews and pretested schedule. In small farmers with restricted capital, the net farm returns were increased by Rs: 30576 (29%), net farm returns per hectare increased 19230 (29%) relative to existing practice while in latter, the net farm returns increased to Rs:38898 (34%), net farm returns per hectare increased to Rs:24464 (34%). In case of large farmers, the model showed net increase in farm returns of Rs: 544405 (47%), per hectare it increased to Rs: 89401 (47%) under restricted capital. Further, under unrestricted capital net farm returns increased to Rs: 1159681 (65%) and per hectare was also increased to Rs: 190432 (65%). The impact of credit on net farm returns of small and large farmers were Rs: 8,322 and Rs: 615276 respectively which shows that the model gives large amount of income and employment under relaxed capital also credit is directly proportional to farm size.

Keywords: *restricted capital, fallow, net farm returns, existing cropping pattern, labour employment*

WEITO WATERSHED SOIL DEGRADATION ASSESMENT USING REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

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Abstract

This research integrates the Revised Universal Soil Loss Equation (RUSLE) with a Geographic Information System (GIS) to quantify the potential soil erosion risk and land use land cover changes Weito watershed. Rainfall data, soil data, DEM data and satellite images were used as input data sets to generate RUSLE factor values. The meteorological data were collected from National Meteorological Service Agency (NMSA) whereas the DEM, Soil data and LU/LC were downloaded. Average annual soil losses were calculated by multiplying five factors: R; the erosivity factor, K; the soil erodibility factor; LS, the topographic factor; C, the crop management factor and P; the conservation support practice. The model result has shown an annual soil loss ranging from 0 to 210 tons ha⁻¹ and the mean annual soil loss rate is 110ton/ha/yr. The annual soil loss rate in the western and south western part of the watershed was majorly identified as high and severe and hence, requires special attentions with an immediate soil conservation practice.

Keywords: *Soil erosion, RUSLE, erosivity, erodibility, Conservation support practices*

EVALUATION OF WATER LEVEL FLUCTUATION BEHAVIOR AND QUALITATIVE ASSESSMENT OF GROUNDWATER RESOURCES NEAR MINING AREAS

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Abstract

Industrial activities in India started decades back, since then the groundwater is getting affected. Coal mining and its related industries disturb the underground water table in terms of its quantity as well as quality. The present paper discusses, in brief, the status of the quantitative and qualitative assessment in the coal mining and its nearby township areas of the Jharkhand State. In Jharkhand the major mining area is located in Bokaro and Dhanbad district. The average value of water level fluctuations of Bokaro and Dhanbad district is 6.29 mbgl and 5.21 mbgl respectively, during the pre-monsoon season and the average value of water level fluctuations is 6.29 mbgl and 3.40 mbgl respectively during the post-monsoon season. The water quality parameters of Bokaro district is slightly acidic to slightly alkaline in nature and is dominated by Ca^{2+} and Na^+ and HCO_3^- and Cl^- concentration in both the seasons. The groundwater quality of Dhanbad district is slightly acidic to alkaline in nature and it is dominated by anionic (HCO_3^- and SO_4^{2-}) and cationic (Ca^{2+} and Na^+) concentrations. The concentrations of 'Fe' has been found more than the desirable limit of Indian drinking water standard (BIS 2012) and WHO (2006) at many places. Therefore, it has been found that the groundwater management is urgently needed in these areas.

Keywords: *Groundwater, Water level fluctuations, Coal Mining, Qualitative Assessment, GIS and Groundwater management*

URBAN WATER MANAGEMENT IN VIEW OF SMART CITY DEVELOPMENT FOR DEHRADUN CITY

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Abstract

Urbanization and population growth are the main drivers of drastic land use/land cover change (LULC) which adversely effect on urban water management in the events of extreme droughts and floods. Since, storm water management is a challenging in the Dehradun city which is recently declared as smart city. Therefore, impact of LULC change on storm water in Dehradun city was assessed using Storm Water Management Model (SWMM). LULC changes (historical: 2001 to 2018 and future:2030) and urban water demand were analysed for Dehradun city. The future LULC was simulated keeping in mind various factors such as road distance, urban area distance, past LULC, DEM, etc. and quantified the future expansion of Dehradun city. The results indicated that significant increase in urban areas (73.53%) and decrease in agricultural areas (49.67%) from 2001 to 2018. With urbanization and population growth, urban water demand will increase drastically, and it may exhibit more pressure on water resources in the future which is shown with the help of Terrset software in future LULC map (2030). It is estimated that the urban area may increase up to 60% by 2030 which is beyond the holding capacity of the city. Further, the smart water management techniques using Information and Communication Technology (ICT) have been explored and suggested adaptive and intervention measures for Dehradun city.

Keywords: *LULC, Smart city, SWMM, Storm Water Management, Urban Water demand*

**CONCEPTUAL MODEL BASED ASSESSMENT OF THE STREAM AQUIFER
DYNAMICS IN THE BURHI GANDAK BASIN OF INDIA IN CONTEXT OF FUTURE
GREEN REVOLUTION**

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Abstract

The Burhi Gandak River of the eastern India has a catchment of about 12,500 square kilometre with shallow groundwater levels. It is a perennial River originating from the foothills of Himalaya and apparently does not have a glacier link. This suggests that the River flow is mostly accounted by surface runoff and the base flow. Burhi Gandak River flows through Bihar state and is a tributary of River Ganga. The River has vast fertile flood plain and mostly conventional agricultural practices have been observed in the basin. In context the proposed initiation of the green revolution in eastern part of the Ganga basin, we examined the stream aquifer dynamics in response to the increased intensity of agriculture in the Burhi Gandak basin. In a conceptual framework with a steady state calibrated regional groundwater flow model it is estimated that if the overall intensity of the groundwater abstraction in the basin increases by 25 percent, the base flow contribution to the River reduces by about 50 percent. What we suggest is a prudent land and water management for sustainability of the future increased agricultural intensity in a water ecosystem perspective.

Keywords: *Burhi Gandak River; base flow; River discharge; water management*

**LAND USE LAND COVER CHANGES FOR SUSTAINABLE WATERSHED
MANAGEMENT IN VANNATHANGARAI WATERSHED OF CAUVERY RIVER
BASIN**

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Abstract

Water is an important element of the physical environment and a valuable resource for meeting the requirements of various sectors in the country in the last few decades. Water also plays a vital role in India's economic development and in ensuring its food security. The rapid pace of agricultural development, industrialization and urbanization have resulted in the over-exploitation and contamination of groundwater resources, resulting in various adverse environmental impacts and threatening its long-term sustainability of most of the watershed. It is an urgent need to study the water resources status of the watershed of our country/state to have a sustainable development of our nation. Vannathangarai watershed has been chosen as a pilot study for the present research using modern technology and techniques. Vannathangarai watershed which is drained into Noyyal and Nallar River which is flowing through the central part of Coimbatore district. This small watershed consists of rapid urbanization, small and large scale industries which consume a huge amount of water consumption and contamination. The present study is carried out by taking the land use land cover change of the watershed. The Land use land cover change has been studied for 1990 to 2019 using remote sensing. The groundwater level of the area also been studied by taking four seasons data of each year and find out the relationship between Water quality and Water level of the watershed. Finally, the relationship between change in land use pattern and groundwater is studied.

Keywords: *Watershed, Urbanization, Water Resources Utilization Plan, Sustainable Development*

ASSESSMENT OF FERTILIZER DRIVEN FORWARD OSMOSIS MEMBRANE SYSTEM BY USING TEXTILE WASTEWATER

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Abstract

The world population is growing rapidly while the issues related to lack of clean water are affecting drinking water supplies, energy, and food production. Water is also crucial for improving the yield of agricultural land to meet the world's growing food demand. Forward osmosis (FO) is a developing innovation that guarantees low energy utilization. In this study, the performance of lab scale FO was evaluated by using textile wastewater as feed solution (FS) and concentrated fertilizer solution (KCl) as a draw solution (DS) that can be directly utilized for fertigation after dilution. The effect of pH, temperature, initial concentration of FS and DS on the performance of Fertilizer Drawn Forward Osmosis (FDFO) were studied. Water flux was found the maximum (4.7 LMH) on higher concentration (1.15 M) of DS. Also, the water flux was observed maximum on decreasing the FS temperature.

Keywords: *Forward Osmosis, textile industry, membrane filtration, desalination, fertilizer solution*

URBAN CHARACTERIZATION OF RAINFALL OVER BHOPAL CITY USING OPTICAL DISDROMETERS

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Abstract

As part of micro scale characterization of rainfall over the urban area and validation of INSAT-3D/3DR rainfall products, a network of optical disdrometer is established over Bhopal, Madhya Pradesh. The city of Bhopal falls under the central Indian region which is very significant for the monsoon related studies; a recipient of intense rainfall during peak monsoon months. The network consists nine solar-powered optical disdrometers installed over the urban area of Bhopal. A preliminary analysis of the rainfall condition over the study area for the period of July – September, 2018 is carried out. Preliminary analysis indicates vast scope for studies related to micro scale rainfall characterization and its application for the validation of satellite rainfall observations.

Keywords: *Disdrometer, Rainfall, Validation, INSAT-3D/3DR*

SYSTEMS APPROACH FOR SUSTAINABLE WATER RESOURCE MANAGEMENT

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Abstract

Experience over the last decade has demonstrated an increase in water scarcity. According to Food and Agriculture Organization (FAO), despite the global abundance of water, the heterogeneous distribution of water in space and time, which is exacerbated by economic disparities, civil unrest, and failures of institutions resulted in as high as one-fifth of the world's population lives under conditions of water scarcity. The context-specific drivers of water management to address scarcity issues, and the need for effective reallocation on need-based in the regional context, are thus increasingly important research areas. Water problems can be conceptualized as social-technical systems. Sustainable Water Resource Management (SWRM) requires creative tools such as systems thinking to size up complex situations. However, current investigations reveal that there is a lack of a general framework for water quantity assessment. This demands the acknowledgment and a better understanding of the dynamic inter-linkage and interdependence of the complex systems and sub-systems (namely physical, social, economic, ecology, environment, infrastructure, and institutional subsystems) using system dynamics technique. The aim of this paper is to develop a methodology for assessing the water resource management system and its impact on a region. It concludes with extending the knowledge to achieve sustainable water resource management at the regional scale.

Keywords: *Water resource management, System Dynamics, Sustainable Development*

**FEASIBLE GROUNDWATER MANAGEMENT AND CONSERVATION MEASURES
FOR HARD ROCK AQUIFERS: A CASE STUDY FROM MIDLANDS OF KOLLAM
DISTRICT, KERALA, INDIA**

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Abstract

Kollam district, Kerala State extending from the sea coast to Western Ghats, is one of the precarious districts in the State in terms of water availability, particularly in the hard rock aquifer system covering mainly the midland topography. The district is in “Safe category as per the level of ground water extraction reflected in 2017 ground water resource estimation with 50 % of development. Undulating topography with discontinuous aquifer systems with poor to moderate yield potential exacerbates the ground water dependency in this rural-urban area. Even though the district is drained by five rivers and its tributaries, the area faces acute scarcity of water during the summer, irrespective of normal annual rainfall of 2428 mm. This is mainly due to low storage capacity of the aquifer, incidence of high run-off during the rainy season and the release of stored water from the aquifer as base flow during non-rainy season. These are the key issues to be addressed while framing appropriate water resource development and management plans for the area. This paper highlights the suitable management options for the hard rock areas of midland and highland areas facing severe water crisis on water availability during summer. The paper also aims to evaluate the feasibility of various groundwater conservation structures and to suggest feasible management and conservation measures to overcome the supply-demand gap in the present era of sprawling population.

Keywords: *Safe category, suitable management, discontinuous aquifer*

**ASSESSMENT OF AQUIFER CHARACTERISTICS IN A TYPICAL KHONDALITIC
AQUIFER IN THE NORTHERN PARTS OF EASTERN GHATS OF INDIA**

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Abstract

Estimation and analysis of aquifer properties have been carried out in Kandivalasa river sub basin comprising of a typical Khondalitic terrain in the Vizianagaram district of Andhra Pradesh, India by conducting fourteen pumping tests in the basin. The Transmissivity values are obtained in the range of 26–304 m²/day and the Storativity values are in the range of 0.00029–0.0091. Lower Transmissivity and Storativity values are observed where the kaolinisation (highly weathered material) is more predominant at the main Kandivalasa river and vice-versa. Groundwater potential areas are identified with less fluctuation of water table. Two-Dimensional resistivity imaging has also revealed that the kaolinisation is increasing towards the stream which is responsible for well failures and reduction of Storativity all along the main stream. Based on Transmissivity distribution, eastern part of the study area is identified as high groundwater potential zone while most of the western side of the basin is having less groundwater potential zone. To delineate the litho-units of the formation and the hydraulic properties of the khondalitic aquifer, a bore well is drilled in the basin. The well logging studies are carried out in the drilled bore well. All the well logging results are well correlated with the drilling results. The fractured zones having the resistivity value of 30 Ohm-m are identified with the lateral resistivity logging and the boundaries between layers are obtained from the SP logging. The well logging investigations have revealed that the aquifer porosity is of the order of 28% in the region.

Keywords: *aquifer, SP logging, Storativity, kaolinisation*

GEOHYDROLOGICAL STUDIES OF GP-8 (GODAVARI-PURNA) WATERSHED OF AURANGABAD DISTRICT

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Abstract

River Godavari is the Major river of Aurangabad district, Purna river is its major tributary. whereas river Girija in Phulambri tahsil of Aurangabad district is the sub tributary of Purna river. The area under investigation i.e watershed GP-8 falls under the sub basin of Girija tributary. The area of the watershed found to be 27825 Ha comprising 21 number of villages. Geologically the area is covered by Deccan basalt. In all 05 number of flows have been demarcated in the watershed area between RL 02 and 05 m. In the present research work the critical field works have been carried to map these different basaltic flows. The study of basalt flows with reference to their category, thickness, lateral extent, along with Geohydrological characters such as jointing pattern, weathering condition have been carried out. The Geomorphology pertaining to drainage order drainage, drainage density, drainage pattern etc. have also been carried out. From these studies the suitable sites for water constriction structures have been recommended. The research work will be useful to the organization who under have the program of watershed development.

Keywords: *watershed GP-8, Deccan basalt, Geohydrological characters, drainage density*

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**(SOIL-WATER RESOURCE GOVERNANCE,
SUSTAINABLE WATER MANAGEMENT IN SMART
CITIES)**

Keynote Paper

**MASTERPLAN RIVERBANK FILTRATION FOR SUSTAINING WATER SUPPLY IN
INDIA**

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Abstract

Riverbank filtration (RBF) serves as an ecosystem service for human health in India because it effectively removes contaminants, especially pathogens and turbidity from water for drinking. Despite the advantages of being a sustainable natural process, an element of IWRM and a component of managed aquifer recharge, RBF is intentionally used only at some places resulting in a low portion (<0.1%) of drinking water produced thereof. There is a large potential to secure at least 5 % of India's drinking water supply by RBF. This can be achieved by an efficient combination of planning, site investigations, design, implementation and monitoring of RBF schemes, for which a master plan is needed. With the aim to encourage the use of RBF in India, the technical, hydrogeological, water quality, site-investigation, policy and awareness creation aspects have been discussed with Indian and German experts since 2014 in Dresden, Roorkee, Dehradun, Shillong, Goa and Chennai. The conclusions and recommendations from the final conference of the Indo-German research project NIRWINDU held in December 2018 in Dehradun have been summarized in to a conceptual master plan for RBF water supply in India. The development of a master plan must include scientific procedures for the identification of potential RBF sites,

including water quality investigations and also recommendations for the management and maintenance of RBF systems. To guarantee the sustainability of RBF systems, it is necessary to routinely monitor water quality for pathogens, major ions and relevant inorganic parameters. Hydrogeological investigations are necessary to characterize the surface-groundwater interaction, determine the quantity of bank filtrate that can be abstracted and its travel time. Critical aspects thereby are the parametrization of the aquifer thickness, hydraulic conductivity, riverbed clogging and geochemical investigations of the riverbed sediment and its effect on the quality of bank filtrate. Measures to implement the concept into a real master plan and associated scientific investigations to explore potential RBF sites will be highlighted based on case studies from Uttarakhand, Chennai, Mathura and Agra. An overview of the design, hydrogeology and relevant organic and microbiological water quality improvements of these RBF systems that provide a scientific basis for the master plan will be shown. Experiences from these case studies have shown that to implement a RBF master plan on the ground, the division of RBF-competency within India must be absolutely clear because the water supply practitioners need competent consulting firms in the private sector to provide planning and construction services. And the consulting firms need competent technical advisors at universities and research institutions to provide know-how and solve challenging problems encountered during the execution of work for RBF systems. The development of this competence must occur in parallel to, or shortly after, an information, education and communication (IEC) campaign, such that there is a corresponding supply for the demand that arises. More over a clear and specific policy on RBF and a body to oversee and monitor the progress of the RBF master plan in India is advantageous.

Keywords: *Riverbank filtration, aquifer recharge, RBF, NIRWINDU*

**CHALLENGES TO URBAN WATER SECURITY AND DISASTER REDUCTION IN
SOUTHEAST ASIAN CITIES**

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Abstract

As many cities in Asia are expected to continue to grow by accumulating population and assets and further expanding urban areas, securing safe water resources and minimizing water disaster risks are the most important issues for sustaining urban activities. Also, there is a strong concern that the vulnerability of cities to water shortage and disasters will increase due to likely change in the frequency and intensity of extreme weather events and significant impact in coastal regions due to sea level rise. In the presentation, based on previous case-studies conducted for large cities in Southeast Asia, we share the knowledge for water-related issues that many cities currently face, as well as the possible situations for the future, and discuss about the policies to address those issues. As an example of a chronic problem among many cities, I will introduce our recent studies on urban inundation caused by short-term intensive rainfall and focus on green infrastructure, which will become increasingly important in Asian cities, as one of the expecting measures to deal with the issue. We will discuss the expected effects of the green infrastructures in terms of securing water resources and preventing inundation under the weather and climate conditions in the target cities.

**MEETING WATER DEMANDS FROM URBAN AREAS WITHOUT CAUSING
SUBSIDENCE**

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Abstract

Explosive growths in populations in urban areas has been occurring such that in 2030, projections indicate that 50% of the world's population will live in urban areas, and by 2050, that percentage will increase to 70%. Of serious concern is the availability of water supplies for these massive urban populations. Globally, reliance upon groundwater for meeting water supply needs has grown explosively in the past 50 years but without proper planning, subsidence due to these groundwater withdrawals is causing enormous problems including, for example, exposure to increased coastal zone flooding, a consideration particularly relevant in a climate changing world. Enormous damage potential also is relevant for city infrastructure as a result of subsidence. Another global issue is how to handle the intense rainfall which is resulting in enormous flooding in these large metropolises. The historical approach to flood management of directing the water out of the urban landscape as quickly as possible is no longer acceptable. The flood waters are a resource that must be captured and used effectively. However, in the absence of large storage volumes (e.g. end-of-pipe options such as dry or wet ponds) which seldom exist in these large metropolises, of concern is how to ensure infiltration at acceptable levels to both provide sufficient water of acceptable quality as well as to avoid subsidence. This paper discusses the options of low impact development options that are being widely used now in many countries (including Canada, US and China) as a means to approach these objectives. Specific examples will be described, indicating options which are having reasonable promise of creating infiltration at substantial levels, as well as providing a reduction (not ameliorating the major floods but at least decreasing the major flooding events). Much work still needs to be done, but becoming aware of the most promising options is a good start to this world-wide problem.

Keywords: *water supplies, flood, infiltration, coastal zone*

VULNERABILITY AND RESILIENCE STRATEGY TOWARDS EMERGING URBAN WATERS CONTAMINANTS: A SOUTH-ASIAN PERSPECTIVE

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Abstract

Vulnerability assessment of urban waters in Guwahati, India, and Colombo, Sri Lanka, were carried out through analysing the concurrence of Pharmaceutical Personal Care Products (PPCPs), Antibiotic Resistance Bacteria (ARB), Viruses, Antibiotic Resistance Genes (ARGs), fecal contamination and metals in order to propose a way to achieve sustainability of water resource management. PPCPs concentrations were very low in lake/river water and high in drain samples and seem to be directly associated with raw sewage as these were not detected in the upstream or downstream of the rivers. The trend of metals was similar i.e. Cr>Ni>Mn>Zn>Cu>Pb>Co>Cd>As in both the Kelani and Brahmaputra rivers. Antibiotic resistance seems to be not correlated with the prevalence of PPCPs and *E. coli*, but anthropogenic pollution and lifestyle. Both CSIRO and MIROC model predicts more than 1.2 °C increase in average yearly temperature, whereas average yearly precipitation is likely to remain the same with some abnormalities in extremes reading on both higher and lower sides. The study recommends the formulation of a resilient framework that ensures the participation of every possible stakeholder by defining their specific role in the implementation process. The gap between people living the different types of settlement needs to stratify according to their capability and needs which will further confine to the decision making for environmental planning. The social aspects should be studied before the planning process, and thus must include people with varied expertise.

Keywords: *Emerging contaminant, Vulnerability, Resilience, PPCPs, ARB, ARG*

**DEVELOPMENT OF INTEGRATED ASSESSMENT FRAMEWORK FOR
GROUNDWATER MANAGEMENT IN THE CONTEXT OF URBAN LANDUSE
PLANNING**

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Abstract

India receives 4000 BCM of precipitation annually, out of which the available water accounts for 1869 BCM. Out of total available water, the utilizable water from surface and ground water resources are 690 BCM and 433 BCM respectively. As per Central Water Commission, the per capita water availability has decreased from 5176 cum in 1951 to 1544 cum in 2011. With consistently growing population and rapid urbanization (31.6% in 2011 census), by the year 2050 the estimated water availability will be reduced to 1000 cubic meters per capita per year. This will lead to ‘Water Stressed’ condition as defined by Falkenmark Index. As per the CGWB year book 2016-17, the overall stage of ground water development has already been reached to 62%. The stage of ground water development is very high in the states like Delhi, Haryana, Punjab and Rajasthan, where it is more than 100%, which implies that in these states the consumption is more than recharge. At present 50% of urban water requirements is being met from groundwater resources. The NITI Aayog report on composite water management index (2018) says that 21 cities including Delhi, Bengaluru, Chennai and Hyderabad will run-out of groundwater by 2020. In urban areas the status of groundwater becomes more complex because of the dynamics of various Landuses and Infrastructure developments. Thus the “Development of Integrated Assessment Framework for Groundwater Management in the context of Urban Landuse Planning” is much required for the water sensitive urbanization in India to achieve the targets of SDG-6.

Keywords: *Groundwater Management, Landuse Planning, Urbanization, Assessment Framework, SDG-6*

DESIGN OF STORM WATER DRAINAGE SYSTEM FOR AN URBAN AREA - A CASE STUDY

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Abstract

Storm water is a matter of great concern as it affects the environment in various ways. The hydrologic response of an urban area changes when catchment becomes increasingly impervious due to urbanisation, causing storm water runoff volumes and velocities to increase while base groundwater flows decrease. This on one hand adversely affects the ground water recharge activity and on the other hand causes inundation of the inhabited areas. The present study is a case study regarding the storm water drainage scenario of the Capital City of Srinagar, Jammu and Kashmir. In recent years, the city of Srinagar has seen rapid and haphazard urbanisation without a properly planned drainage system. As a result, the City inundates frequently on account of moderate to heavy rainfalls spells. In this study an attempt has been made to suggest an appropriate drainage system for this urban area. The Rational Method was employed in design of Drainage System of the study area by dividing it into suitable number of sub-catchments. The delineation was done in ArcGIS as a result of combined effect of natural flow characteristics of the study area, urbanisation and the road network. For each sub-catchment, time of concentration was determined. The IDF curves were generated using Gumbel's distribution. The land use of every sub-catchment was also considered in the study. The feasibility and the safety of the system, thus designed, was verified by using the Storm Water Management Model (SWMM).

Keywords: *storm water, hydrologic, groundwater, urbanisation, drainage*

TOWARDS A FAIR AND EQUITABLE ALLOCATION OF CAUVERY WATERS

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Abstract

Human history is filled with instants of conflicts. Conflicts occur between people in all kinds of human relationships and in all social settings. Because of the wide range of potential differences among people, the absence of conflict usually signals the absence of meaningful interaction. But more often these conflicts are accompanied by unrest and turbulence. When the resource at stake is as indispensable as water, then the settlement must be done cautiously as disharmony may further exacerbate the situation. In the history of water conflicts, various water appropriation doctrines and mechanisms have been proposed for the purpose of conflict resolution. Evidently, the esoteric concepts of 'equity' and 'fairness' in water allocations were proposed as a preferred sharing doctrine but its translation through sound objective methods has been the difficulty. Past investigators have not succeeded in their attempts to develop an objective framework to define 'equitable apportionment' in real world water conflicts and this failure has been attributed to the largely perceptive nature of these concepts. This present work attempts to address these and related issues with reference to the dispute over sharing of water resources of Cauvery basin in India between the states of Kerala, Tamil Nadu and Karnataka. Objectivity has been kept in mind while deciding the factors for the apportionment so that 'equity' and 'fairness' can be translated into practical concepts.

Keywords: *fairness, equity, equitable apportionment, Cauvery basin*

INTEGRATED WATER RESOURCE MANAGEMENT

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Abstract

Water is a finite natural resource. The development and progress of the Country is fully dependent on it. The demand of the water is geometrically increasing with time in view of unabated growth in population. Rapid urbanization, industrialization and improved standard of living. Excessive and imprudent use of water is posing wide-spread threat to ecosystem. Moreover, the quality of both the components of surface and groundwater is declining and leading to lesser availability of potable water. The distribution of water resource is uneven over a large part of the Country. The water resources are under stress and the problem is caused by poor governance and becomes environmental challenges. In some parts of the area, law and order problem, in some area losing of manpower of due sparing of the man to collect the water from a long distance and in some areas children cannot go to school. The proper planning, development and management of scarce resources and its judicious equitable and sustainable management has become a challenging problem to the Country. The Integrated Water Resources of surface and groundwater management should be in (micro level) the form of watershed and even over-exploited areas it should be in mini or micro level. The need of the hour for integrated water resources development and possible use of these resources by different stakeholders, water industries of various sectors. It is now widely recognized that the individual source single or multipurpose cannot be undertake with optimum benefit unless there is at least a broad outline of plan for future, resource for coordinate and harmonious development. The multi-disciplinary methodology is adopted for the preparation of plans. Difficulties faced and solutions are briefly stated. For better understanding, a case study with all the relevant facts and figures are presented in the text.

Keywords: *Water Resources, Natural Resources, Ecosystem, Integrated Development, Environmental Challenges, Law and Order, Poor Governance and Multi-disciplinary*

IMPACTS OF HYDRO-METEOROLOGICAL DATA QUALITY ON WATER RESOURCES PLANNING

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Abstract

Water resources development and management heavily depend on hydro-meteorological data. Some manual or machine errors may exist in the stream flow observation that we collect from different organizations. Thus, performing meteorological and streamflow observations quality assessment before using it for our required purposes is a crucial step. The main objective of this research is to identify the impacts of hydro-meteorological data quality on water resources planning in Weito Watershed. The data quality assessment was done by using Grubbs T-test for the outlying observation. Almost all the assessment result was seen to be good. However, the data collected from the survey, literature reviews, our multiple physical observations, and interview made for elders in the local community has shown otherwise. The plot of mean monthly flow against areal rainfall, estimation of D-days average minimum flow, abrupt changes in flow magnitude and comparison of Weito watershed with other similar basins resulted with an expected value. Therefore, before using this data for decision making, we strictly recommend the stakeholders, research institutions and governmental organizations to check the quality of these data.

Keywords: *Data Quality, Water resources planning, Weito Watershed, Ethiopia*

IMPACT OF GREEN INDIA MISSION ON AFFORESTATION IN STATES ACROSS INDIA

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Abstract

Green India Mission (GIM) is one of the prominent schemes that have been launched under the National Action Plan on Climate Change (NAPCC). The primary focus of this mission is to not only enhance greenery across all states in the country, but also to achieve betterment of the existing green cover. Since the quantity and quality of green cover are both important from the perspective of climate change, quantity of rainfall, control of floods and so on, it is important to study the impact of GIM. GIM further strives to enhance carbon sequestration, hydrological condition, livelihood of people in the form of reducing air pollution, fodder and other forest products. The objective of our study is two-fold. We have collected data on the amount of fund released under GIM to different states across years and the afforestation cover achieved in various states in similar time frame. We have analysed the mentioned data using data analytics tools and tried to study the impact of release funds on the afforestation achieved. Our study further tries to display and forecast the trend in afforestation achieved. Secondly, our paper also analyses the sentiments and word of mouth of people and the impact of GIM on their lives.

Keywords: *National Action Plan on Climate Change, GIM, afforestation, carbon sequestration*

SPATIAL AND TEMPORAL VARIATION OF URANIUM AND ITS SUITABILITY FOR DOMESTIC USE IN NORTHERN KARNATAKA, INDIA

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Abstract

Uranium is a naturally occurring radionuclide that can cause radiological hazards if present in drinking water. Since groundwater caters to the needs of most of the rural and urban population in India, it is important to analyze the concentration of Uranium in groundwater. The objective of this study is to study the occurrence and distribution of uranium in groundwater in a uranium mineralized region in Northern Karnataka, India. Groundwater samples were regularly monitored for uranium concentration in 47 wells from September 2013 to May 2019. A total of 500 water samples were collected, and the water samples were analyzed for Uranium concentration using Quantalase Laser Fluorimeter. The concentration of uranium in groundwater ranged from 0.24 ppb to 302 ppb with a mean of 24.45 ppb. The suitability of wells for drinking were determined using the USEPA set limit of 30 ppb. Groundwater is suitable for drinking in all the locations except in Hattigudur and Doranhalli villages. Uranium concentration in groundwater changes depending on lithology, degree of weathering and rainfall recharge. This study is useful in assessing the risk due to the presence of the uranium in drinking water in a rural village where groundwater is the major source of drinking water.

Keywords: *Uranium, Groundwater, Geology, Granitic rock, Drinking water, Gogi, India*

FROM POLLUTER PAYS TO POLLUTION PREVENTION: LESSONS LEARNT FROM SOUTH AMERICA

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Abstract

The polluter pays principle holds that the party responsible for producing pollution is responsible for paying for the damage done to the environment due to the pollution. In environmental law, the polluter pays principle does not refer to fault. Rather, it favours a curative approach concerned with repairing environmental damage. Albeit, this approach is widely practised in environmental litigations, however, this approach is concerned more with environmental economics than the law of pollution prevention. Keeping this hypothesis in view, this paper seeks to examine the current pollution control policies of India and argues that mere polluter pays principle would be a fiasco until and unless the preventive or prohibitive concept is embedded in the environmental jurisprudence. Drawing heavy influence from the South American practice, particularly the Ecuadorian model of *Derechos de la Naturaleza*, this paper suggests for incorporation of *Rights of Nature* as the guiding principle of pollution prevention in the Indian environmental defence paradigm that would not only provide an *Ante-Mortem* preventive legal protection to common water bodies from pollution, but also offer a substantive legal framework to protect millions of people who are dependent on such water bodies for their livelihoods.

Keywords: *Polluter Pays, Pollution Prevention, Rights of Nature, India*

WATER ISSUES FOR BHUBANESWAR, INDIA: ‘THE SMART CITY NO 1, TODAY AND TOMORROW’

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Abstract

The designated as smart city No-1 of the country, Bhubaneswar, the capital city of Odisha state carries glorious historical significance as the ‘Temple city’ with abundance of old heritages. This has undergone rapid urbanization during last two decades with huge influx of population without development of matching infrastructures including roads, surface drainages, water supply and sewerage system etc. With present covered area of 422sqkm and an estimated population of 9.4 Lakhs, water sources in and around Bhubaneswar are under constant stress. Provision of safe drinking water to the is one of the serious urban problems faced today. The need of the city is a permanent solution through a search for water sources or creation of water bodies. This is not just for providing urban drinking water, but also for recharging urban groundwater regime, recreational, religious, industrial and other environmental conservation. The paper focuses exclusively on water issues related to various geo-environmental problems such as: Large scale land conversion due to urbanization, unplanned development along marginal locations / valleys, drainage congestions, reduction in surface water spread of wetlands, drying of natural streams, mixing of untreated sewage with natural drainage, rapid growth around heritage water bodies and water logging in monsoon months etc.

Keywords: *Smart City No I, Bhubaneswar, Urbanization, Geo-environmental problems Water Issues*

MEASURES ADOPTED TO MITIGATE WATER SCARCITY IN AURANGABAD DISTRICT OF MAHARASHTRA

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Abstract

Aurangabad district is facing the worst ever water scarcity in the last few decades. The demand for water has increased many fold for drinking as well as agriculture due to rise in population. This year the annual rainfall was 53% of the total normal rainfall in the district. There has been deficit rainfall since last five years in the district which has led to depletion of groundwater levels by 2-3 meters as recorded in the observation wells by G.S.D.A. The condition has worsened so much that there was no surface or groundwater source available up to a distance of 50 kms even to fill up the water tankers in many talukas. The rural population had to be supplied drinking water from more than 1100 tankers. Zilla Parishad Aurangabad with the of district Collector has taken many measures to mitigate the water scarcity in the district. Temporary Pipe Water Supply Scheme (T.P.W.S.) 22 No's of temporary pipe water supply scheme were taken in the various parts of the district. Pipelines from distant sources were laid down immediately to supply drinking water since the water sources got exhausted due deficit rainfall and over exploitation of water. One major temporary pipe water supply scheme was executed from Gandheswar Medium Irrigation Project which was filled to capacity. 23 Kms Pipeline was laid down within a month's time and water was released in the existing water treatment plant (W.T.P.) in the Yesgaon Minor Irrigation Project which remained dry this season. This is an existing scheme augmented by the pipeline. Ten tankers were stopped immediately and many villages cater the need for drinking water by giving distribution lines on way from this pipe line.

Keywords: *water scarcity, annual rainfall, Water Supply*

GREEN INFRASTRUCTURE PLANNING ON CAMPUS: A CASE STUDY OF INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

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Abstract

Indian sub-continent with its dense population, mega cities and huge dependence on monsoon, breeds a huge stress on the water resources of the country. Most cities in India like Mumbai, Delhi, Shimla, Chennai, Indore, Bangalore are all facing the threat of water crisis. With a projection that, more than 50% of the population is expected to be living in urban areas by 2030, it is only logical to assume that the issue of water crisis also is scheduled to multiply in years to come. With declination, reclamation, overuse of water resources, the future may be worse than expected. In this background, rainwater harvesting is increasingly being valued as the most sustainable and efficient solution to water crisis, especially the urban water crisis. The current rainwater harvesting solutions practiced in India, are mainly storage units with limited usage and benefits. In spite of promoting rainwater harvesting, its applications and usage through various government policies and engineering solutions, its implementation on the ground are still minimum. A huge gap exists between the potential of rain water harvesting and the current accomplishments. Rainwater harvesting is the best solution to ensure year round water supply to the mega cities, as well as to the agriculture and maintain ecological flows in the water system. Also, rainwater harvesting is the most viable option to reclaim declining water bodies and ensure a sustainable solution. In this background, the study attempts to explore feasibility of rainwater harvesting through green infrastructure for the urban catchment of Indian Institute of Technology Roorkee. The study attempts to analyze 10 compounded catchments within the campus and also design green infrastructure solutions in accordance with the site conditions. The study uses SCS-CN methodology to compute the runoff of the catchments by developing excel spreadsheets. The study computes the runoff using the developed spreadsheets, using a rainfall of 10-year period. The solutions of green infrastructure explore options such as Bio-swales, rain garden, infiltration strips, permeable pavements, retention basins, detention basins, etc., The purpose of the study was to analyze the feasibility to achieve zero runoff for each of the compounded area of the IITR campus for a maximum of 10-year rainfall. The study also attempts to explain the secondary benefits of green infrastructure development. The purpose of the study is to develop simple models to replicate such work for complex urban and semi-urban settings (catchments). When put in practice, these techniques developed ensures easy design, construction and development of green infrastructure

solutions with suitability to suit specific requirements of distinctive urban centers. When developed in full scale, across the country, Green Infrastructure (GI) may act as hope to renew the ground water resources and ensure a water supply of year round.

**TREND SURFACE ANALYSIS OF RAINFALL VARIABILITY FOR SUSTAINABLE
GROUND WATER MANAGEMENT IN COIMBATORE DISTRICT OF TAMIL NADU –
A GEO-SPATIAL APPROACH**

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Abstract

Water is the vital resource essential for the survival of mankind. Rapid increase in population, urbanization, agricultural expansion and industrialization leads to higher levels of human demand. As water demand increases, issues on water availability and demand become critical. This makes the management of water resources include assessing, managing and planning a complex task. Groundwater level is an important parameter to understand the existing groundwater potential of an area. Rainfall comprises an important component of the water cycle and is the prime source of groundwater recharge. In recent decades, the exploitation of groundwater has increased greatly particularly for agricultural purpose, because large parts of the country have little access to rainfall due to frequent failures of monsoon. Thus the increasing population and their dependence on groundwater for irrigation are further inducing heavy stress on groundwater resources, leading to the decline of groundwater levels in this region. The present study has been carried out in Coimbatore district of Tamil Nadu to find out the Groundwater level fluctuation for about 30 years from 1987 to 2017. Similarly, the rainfall pattern and the seasonal variability have been well studied for the 30 years period. The seasonal groundwater fluctuation and the seasonal variability will be correlated using SPSS software. The water requirement for agriculture, industry and the urbanization have been separately calculated and mapped. The overall water demand has been compared with the available groundwater in the region. Finally, the groundwater action plan for the region has been arrived based on the rainfall variability of the study area. The spatial groundwater action plan will be more useful for the administrator to allocate the groundwater resources for their Sectoral Planning very effectively.

Keywords: *Rainfall variability, groundwater fluctuation, urbanization, action plan, Sectoral Planning*

WATERSHED DEVELOPMENT AND SUSTAINABLE WATER MANAGEMENT IN SMART CITIES

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Abstract

Natural resources play a very important role in this world about 96% of energy comes from these resources which we utilise in large amount but in last few decades amount of natural resources reduces by half and left only less in amount. So it become important to protect the natural resources and utilise it in a sustainable manner for this watershed management is designed. Usually, A watershed is a geographic area from where water flows across the land and drains into a common body of water, whether a stream, river, lake, or ocean. Mostly the water is either rainwater or storm water which runs off while the quality and quantity of storm water is affected by all the alterations to the land mining, agriculture, roadways, urban development, and the activities of people within a watershed. It is important because the overall surface water is ultimately drains into the other water bodies which may affect the health of living organisms if the quality of this surface water is bad to consume. So it is important to check the downstream impact while developing and implementing water quality protection and restoration act. It is a concept that denotes judicious, conservation and regeneration use of both natural and human resources within a watershed area. It is a functional unit of dynamic, natural and intricate established by physical relationship, social communication and action which include planners and implementing agencies to consider all inputs, processes and outputs systematically. Watershed development approaches is based on appropriate empowerment and the community to come together for participating in planning, initiation and execution of location specific watershed development activities, by the holistic development of the watershed it can be easy to tackle environmental degradation effectively. Smart cities like New York, Dubai etc., have a smart water management system composed of a core set of integrated smart technologies capable of performing a variety of water management tasks.

Keywords: *Watershed, sustainable management, smart cities*

URBAN WATER SUPPLY AND DEMAND ANALYSIS OF HALABA KULITO TOWN, SNNPRS ETHIOPIA

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Abstract

Potable water supply to satisfy the current tragically rising water demand is the basic requirement for the community. The high water demand over limited access to water supply indicates that there is a gap between water supply and demand. Halaba Kulito town has undergone through various social and economic development. The town is also the main administrative state for Halaba special woreda and business and training centre for Zones and special woredas in SNNPRS and Oromia. Rapid population growth and urbanization confronting Halaba Kulito town has called for the expansion and improvement of basic water supply service to give proper and timely response to urban water demand. This study work examined the gap between water supply and demand, its challenges and dynamics in Halaba Kulito town. The existing water supply distribution system design was analysed using Engineering Software EPANET-2 and to check the water is potable or not the water quality test was analysed for Physico chemical and bacteriological and compared with WHO water quality standards and analysed using descriptive statistical technique, SPSS 20, ANOVA and explanation building. Result revealed that Halaba Kulito town water supply service doesn't meet the current water demand of the town it covers about 75% of the town water demand but the potential for water supply sources is sufficient for the next five years if the working hours of pumps is increased to 10hrs which is the specification working hour in the design. But additional water sources needed from 2019 to future and the quality is about 37.5% percent of the samples reveal that E. coli (Fecal coliform) concentrations are more than the WHO recommendation. In addition to this, under estimation of population growth and socio-economic change and uneven distribution of water for the public aggravated the problem. The gap between water supply and demand can be narrowed through supply management, demand oriented supply, distribution system maintaining, searching additional water sources, participating different actors, mobilizing financial resources, and improving organizational structure with skilled personnel and equipping it with material facilities.

Keywords: *Water supply, water demand, production, distribution, EPANET coverage, Quality, Halaba Kulito*

RECURRENT WATER CRISES AND MANAGEMENT ISSUES IN INDIA

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Abstract

India is facing recurrent water crises in last two decades and distressing population in terms of water scarcity and at times with exacerbate fresh water sources due to floods. Vagaries of rainfall attributes intensification of such situations. Management options being explored and practiced emphasis for artificial recharge to ground water, rain water conservation, increasing water use efficiency, water regulations etc. by various agencies. However, the situation is becoming more and worse every year in many parts of the Country. There is a need to adapt water conservation and recharge practices, in view of specifically identified management strategies, for each agro-climatic zones. Special attentions are required for Aquifer dispositions, Basin Characteristics and utilisation trends in such agro-climatic zones. Intensive involvement of politicians, administrators, technologist, scientists and last but not the least with community is required. Basin/watershed/micro watershed wise water resources planning is one of the result oriented approach. This will help in inter basin links and diversion of water for irrigation or drinking purposes for deficit areas. Bench Marking of Rural water and Urban water supply will provide inventory of water sources, quality, details of users, efficiency of water supply, O& M cost etc. Irrigation schemes are also required to be bench marked for improving the irrigation efficiency. Efforts needs to be made to fill the gap of IPC and IPU for surface water schemes. Optimal utilisation of ground water resources computerization of water supply TW data is essential which will allow to monitor over development of ground water resources.

Ground water being the most promising and utilized resources in the country, is being neglected by most of the State in Country. Baring few, there are no fully functional ground water departments in most of the States. Even states rich in ground water needs them for future ground water resources management. Optimization of ground water monitoring network will provide the true depiction of ground water scenario in the Country. They will also facilitae identification and need of water regulation and intensity of adoption of water conservation practices. Evaporation suppression from water bodies, which is presently to the tune of 1.5-2.5 m per annum, needs special attention. Adoption of available techniques can help in to reduce it to evaporation losses by 50-60%. Time has come that State should look forward for “Ground Water Centric Policy” with appropriate

regulatory mechanism, encompassing irrigation sector as well, which, as of now is out of any ground water regulatory mechanism.

Keywords: *water scarcity, agro-climatic zones, rainfall, ground water*

BRAINSTORMING SESSION ABOUT ONGOING NAQUIM (NATIONAL AQUIFER MAPPING PROGRAM)

Keynote Paper

APPROPRIATE AND FUNCTIONAL AQUIFER MAPPING FOR METICULOUS GROUNDWATER MANAGEMENT

Shakeel Ahmed

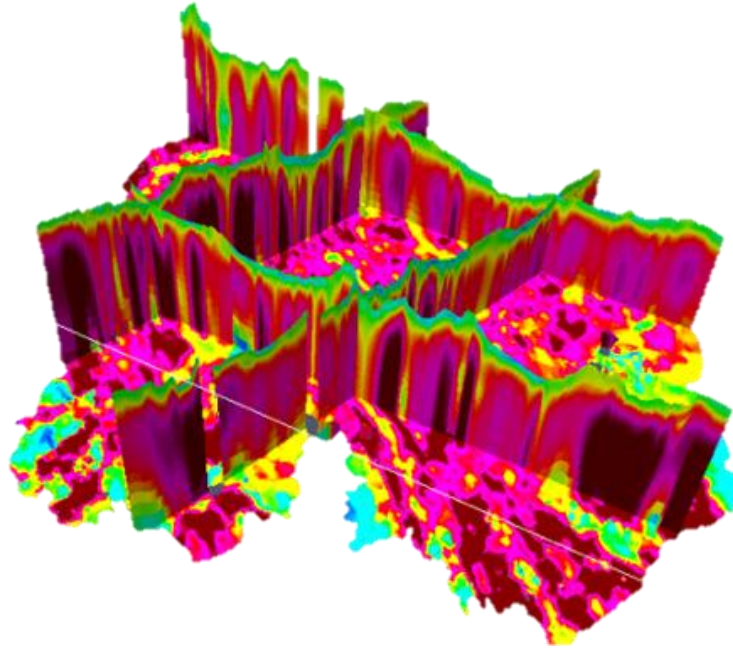
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Abstract

Groundwater has been important component of water cycle but due to recent developments of population, industry and agriculture, more stress is put on groundwater. As a result, the balance between availability and demand has been disturbed and has become negative threatening the sustainability very severely. Two major issues are prominent in this case (1) the well-established Climate change has reduced the groundwater recharge and hence the availability and (2) being a hidden resource, it is very difficult to assess its availability precisely. With these limitations, the groundwater planning and management fails miserably.

The demand can be and has been assessed with reasonable degree of accuracy. However, availability is highly variable and depends on a number of factors mainly the measurement on the ground e.g., hydrogeological and hydrological properties. Again with the constraints of time and cost as well as accessibility, the available data are sparse and scarce and it is not possible to capture the parameter's variability. The most common investigations for groundwater development and assessment are geological and geophysical. The space observations are either sketchy or provide very shallow information. At the same time the near surface is geologically highly variable and heterogeneous and very limited information from the classical approaches lead to ambiguous and uncertain interpretation. However, with the advancement of technology and expertise, it is possible to scan the sub-surface on a very detailed scale to capture parameter's variability to a greater extent in a non-invasive and rapid way.



A 3D resistivity variation obtained from Heliborne TEM investigation

The high resolution geophysical investigation employing Transient Electromagnetic and Magnetic surveys using helicopter has been in practice recently and has provided very promising results for Aquifer Mapping.

Aquifer Mapping has been now possible and is the only tool that can provide enhanced and accurate knowledge of the aquifer system and help estimating the availability. The resolute aquifer mapping and management has following steps.

1. Geophysical mapping i.e. scanning the sub-surface with very high density data up to a reasonable depth (With the new technology, up to 500 meter below the surface).
2. Translation of geophysical parameters with its constrained interpretation by removing all possible noises and errors/biases to hydrogeological parameter and preparation of 3D aquifer maps with lithological variations.
3. Hydrogeological inputs to conceptualize the dynamics system and its functioning, simulating the process of flow and contaminant transport.

4. Prepare Groundwater balance by estimating all possible fluxes operating on a decisive scale (much smaller than the modelled one) and prepare the management model or Decision Support Tool by adjusting the demand judiciously.

With the above approaches, sustainable groundwater management is possible.

A pilot study called AQUIM was made by the CSIR-NGRI, Hyderabad taking six representative aquifer formations and produced very encouraging and exceptional results. The results of such a mapping provided complete geoscientific knowledge on the groundwater system and helps in an efficient mapping of this vital resource. It is time now to discuss and compare the results obtained in different studies and design improvements both in data acquisition and interpretations. At the same time its applications are encouraging and getting multiplied in various other domains making it multifarious.

It is therefore proposed to hold a brain-storming session to discuss the progress in this direction, advantages of such approaches, its versatile applications and future planning to solve the groundwater crisis in the country.

**NATIONAL AQUIFER MAPPING PROGRAMME- A QUEST FOR SUSTAINABLE
MANAGEMENT OF GROUND WATER RESOURCES IN INDIA**

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Abstract

Ground water played a critical role in India's journey from the state of external dependency in meeting the food grains requirements at the time of independence to self-sufficiency today. However presently unplanned and reckless exploitation of aquifers is gravitating India towards a water disaster. The latest estimates of groundwater resources indicate that 17% of the assessment units (blocks/talukas etc) are over-exploited (OE). The OE areas invaded all aquifer typologies; from prolific soft rocks aquifer system in Punjab, Haryana and Western UP to complex heterogeneous aquifer systems in arid areas of Rajasthan and Gujarat to low-potential hard rock aquifers in Karnataka, Tamil Nadu, Telengana and Maharashtra.

Groundwater resource mapping (often referred to as Aquifer Mapping) creates a holistic understanding of aquifers. Since the formation of Central Ground Water Board (CGWB) in 1972, the primary objective of the surveys were to delineate potential areas for groundwater exploitation and recommending maximum possible extraction to the user Depts. Presently, many places are rampant with overexploitation, creating adverse impact on livelihood, environment and ecology. It is now essential that we understand the need for sustaining the groundwater resource. Sustainable measures, their framing and adaptation requires a wide swath understanding of aquifers, viz., their geometry and hydraulic properties, resource availability, hydrochemical processes and contamination susceptibility, capability to artificial recharge of different aquifers, inter-aquifer behavior in case of multi aquifer system, response to extraction and recharge and many more.

The 12th Plan Working Group on Groundwater Management of the erstwhile Planning Commission (now Niti Aayog) was engaged in a detailed consultation in this regard. On the basis of their recommendation, the ambitious National Aquifer Mapping and Management Programme (NAQUIM) has been launched in 2012 (initiated in 2014) with CGWB as the executing Department. The programme aims to cover ~ 25 million km² area, delineated as hydrogeologically mappable.

Various Government Departments, Academic and Research Institutes like IITs, IISc, NGRI, NIH, PRL are roped in at various levels. The outputs are validated, discussed and checked at different stages and finally cleared by a committee of independent interdisciplinary experts. The outputs and

reports are presented in State Level Coordination Committee chaired by the Principal Secretary of the Water Resources Department, formed for each States and UTs. Till March 2019, 8.67 lakh sq. km. area has been covered.

The benefit of NAQUIM can be harvested by a number of programmes/schemes launched by the various Central Government Ministries like, Rural Development (MoRD), Jalshakti Mantarlaya, Agriculture and Farmer Welfare, Environment Forest and Climate Change, Urban Development etc. Similarly, various State Government schemes on water conservation and recharge can also considerably improve benefits and outcomes. The proposed Inter-linking of Rivers is envisaging transfer of huge volume of water from surplus to deficit areas. This will also render an opportunity to recharge the depleted aquifers lying in between. The focused areas of recharge in such case can be the palaeochannel deposits delineated under NAQUIM.

One of the major objective of NAQUIM is to promote participatory groundwater management. The major part of this objective is to be achieved by empowering the communities with a seamless flow of information and understanding of the local aquifers. It is also imperative to undertake case studies in different aquifer types to demonstrate the assessment of sustainable groundwater resources and sharing it within communities through properly designed wells, irrigation practices and adopting artificial recharge through a process of consultation.

POSTER SESSION

ASSESSING CHALLENGES OF POTABLE WATER SUPPLY AND DEMAND

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Abstract

The social and economic importance of provision of potable water supply is widely recognized. Water supply projects have impacts on people's lives, which extend far beyond the expected improvements to health and reduction in time spent to collect water. In Ethiopia rural water coverage has increased at promising rates since 1990. Thus, this research is an attempt in this direction. From the findings of the study, it can be concluded that the water supply in the study area, Farta Woreda, is far less adequate due to multiple reasons. The study elicited the main reasons why water supply systems have become inadequate in the area. The Woreda technicians or experts are few in number and thus are not able to provide technical support in all sites of the woreda's water supply schemes. Moreover, the institutional, technical, material and financial support to the Woreda water bureau was found to be very weak, which highly deter the capacity of the bureau. This weak institutional capacity was due to shortage of skilled manpower. Building financial capacity for a well-organized and equipped Woreda office requires partnership among the regional state, local to decisions related to development of water supply is great. From the study it has been found that the participation of local people during project initiation and development phases was significant. The willingness of the society to participate in and contribute to the development and management of water supply projects was found to be promising for further project planning and implementation in the area.

Keywords: *Potable water supply, Water Demand, sustainability, Rural water supply, Ethiopia*

EVALUATION OF (NON)-CARCINOGENIC RISK THROUGH ORAL AND DERMAL EXPOSURE OF ARSENIC IN THE GROUNDWATER: AGE AND GENDER VULNERABILITY IN GANGETIC PLAINS

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Abstract

The high concentration of Arsenic in Holocene quaternary alluvium aquifers of Mid-Gangetic Plain (MGP) makes a vast population vulnerable to cancer risk. Dermal exposure of Arsenic carries equal vulnerability as oral ingestion. Our study based on 171 groundwater samples collected across the Darbhanga district in Bihar during the pre-monsoon (April 2011), monsoon (July 2011) and post-monsoon (January 2012) season show that spatially the central Darbhanga has the highest Arsenic Hazard Quotient (HQ) with the order as $HQ_{\text{children}} > HQ_{\text{male}} > HQ_{\text{female}}$. In terms of Cancer Risk (CR) the order is $CR_{\text{children}} > CR_{\text{male}} > CR_{\text{female}}$. It was found that the Chronic Daily Intake (CDI) in children ($0.001 - 0.0015 \text{ mg.kg}^{-1}.\text{day}^{-1}$) through oral ingestion is 2 to 3 times higher than adults ($< 0.0005 \text{ mg.kg}^{-1}.\text{day}^{-1}$). The problem becomes more serious when we see high Cancer Incidence (CI) zones coinciding with high population density zones.

Keywords: *Arsenic; Vulnerability; MGP; Cancer Risk; HRI*

EXPLORING SARASWATI RIVER PALAEO-CHANNELS USING ELECTRICAL RESISTIVITY METHODS IN PARTS OF KURUKSHETRA DISTRICT, HARYANA

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Abstract

Electrical Resistivity Tomography (ERT) survey was conducted along and across the possible Saraswati River palaeo-channels at 14 sites and Vertical Electrical Sounding (VES) survey was carried out at 8 sites in Garhi Roran village of Pehowa block and Indbari village of Thanesar block in Kurukshetra district. The ERT data were inverted into true resistivity model section using the RES2DINV software and the VES data with the 1X1D software. The inverted model was correlated with the available lithological information for various lithological units. The ERT results indicate broadly three distinct lithological units up to the explored depth of 20m. Top unit up to the depth of ~6 m, bgl is interpreted as a top soil mixed with silty clay/ sand. The resistivity value of this unit varies from 10-90 Ω -m. Second layer shows resistivity range of 90-200 Ω -m and extended up to the depth of ~10-12 m, bgl. This is composed of sand admixed with clay. Third layer indicates a lithological unit having a large resistivity range of 200-1200 Ω -m extends up to a depth of 20m, which indicates the presence of dry sand. The VES results have explored up to 123m, bgl with the 5-6 geo-electrical layers. The conductive layer with the resistivity range of 18-34 Ω -m is encountered at an average depth of 52 m, bgl which indicates the possible pathways of paleo-channels. Further, a detailed study is required to establish the findings.

Keywords: *ERT and VES Surveys, Saraswati River, Kurukshetra.*

DEVELOPMENT OF PAPER BASED CHEMOSENSOR FOR THE SELECTIVE DETECTION OF CADMIUM IONS USING COUMARIN-CHALCONE HYBRID

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Abstract

The development of chemical sensor was much attention in modern research communities to design single organic molecules which can be potential ability to sense various metal ions by utilizing diverse analytical technique. Therefore, in the present study a chalcone-based chemical sensor, (*E*)-4-hydroxy-3-(3-(4-methoxyphenyl)-acryloyl)-2*H*-chromen-2-one **1a**, was synthesized, characterized and developed for selective and sensitive recognition of Cd²⁺ in mixed aqueous-organic media and paper strips over other competing metal ions. In presence of Cd²⁺, **1a** showed the incredible color change from yellow to colorless. Stoichiometry of the sensor with Cd²⁺ ions was found to be 1:1 with the corresponding association constants as $1.79 \times 10^6 \text{ M}^{-1}$. The limit of Cd²⁺ by **1a** is 58.4 nM. The test strips were prepared by immersing strips into a CH₃CN solution of **1a** followed by dried in atmospheric air. The **1a** containing test strips were utilized to sense Cd²⁺ ions by immersing test strips in to the solutions of Cd²⁺ ions for few sec and then the obvious color change from yellow to colorless was observed. The results clearly indicate that the synthesized coumarin-chalcone hybrid could be used as an excellent chemosensor for Cd²⁺ detection in environmental samples.

Keywords: *Cadmium, chemical sensor, paper strip*

SUBMARINE GROUNDWATER DISCHARGE THROUGH THE UNCONFINED COASTAL AQUIFER OF SOUTH WEST COAST, INDIA

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Abstract

Submarine groundwater discharge is fluid flow across land ocean interface regardless of its composition and driving force. The aim of the present study is to understand the groundwater discharge flux through the unconfined coastal aquifers of Kozhikode, SW India, influence of geology in the fluid flow and its role in coastal aquifer management. Radon and salinity acts as a good tracer of submarine groundwater discharge to distinguish as well as detect the presence of terrestrial and re-circulated marine submarine groundwater discharge (SGD). On the light of understanding of the lithological layers and freshwater saltwater dynamism through resistivity tomographs in three identified locations (Site A, B and C) of SGD in Kozhikode we measured radon and salinity in groundwater as well as coastal water. This helped in understanding the potential aquifer and the amount of groundwater discharged through these aquifers. In the Northern segment of study area, the wells are fed from both shallow sandy layers (coastal alluvium) and deep lateritic and weathered/fractured rock (crystalline aquifers) whereas wells in Southern part are fed from shallow sandy layers (coastal alluvium). Time series measurement of radon in coastal water at three locations (Site A-Gotheeswaram, Site B-Puthyappa and Site C- Kappad) of Kozhikode, SW India shows discharge in Kozhikode coast varies in the ranges of 0.91-56.3 cm/day, 3.2-43cm/day and 2.5-208cm/day at Site A-Gotheeswaram, Site B-Puthyappa and Site C- Kappad respectively. More studies on nutrient flux estimation and stable isotopic studies are planned to understand the impacts of SGD in SW coast of India.

Keywords: *Radon, Submarine Groundwater Discharge, coastal aquifer, South West Coast of India, Kozhikode, Kerala*

**A COMPARISON OF SATURATED HYDRAULIC CONDUCTIVITIES DETERMINED
BY USING FIELD (IN-SITU) MEASUREMENT TECHNIQUES IN AN ALLUVIAL SOIL
OF SOT RIVER BASIN, INDIA**

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Abstract

Qualitatively, Saturated Hydraulic Conductivity (K_s) is defined as an ability of a soil to conduct water under saturation condition. Hydro-geologically, Saturated Hydraulic Conductivity is one of the most important key parameter for modelling water flow and transport related phenomena in soils. It depends mainly on the soil textures and structures. Several methods have been proposed for determining the values of K_s but results from different measuring method vary under different field conditions. In this article we compare K_s -values estimated using two most common field (in situ) measurement techniques. These two techniques are (1) Guelf Permeameter and (2) Double Ring Infiltrometer. The field experiments were conducted at different locations in an alluvial soil of Sot River Basin for measuring the Saturated Hydraulic Conductivity. This article also presents the suitability, efficiency, accuracy and ease of measurement techniques in an alluvial soil.

Keywords: *Saturated Hydraulic Conductivity, Guelf Permeameter, Double Ring Infiltrometer, Alluvial Soil*

BIOREMEDIATION OF HEXAVALENT CHROMIUM FROM POLLUTED GROUNDWATER

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Abstract

Chromium, though having innumerable applications in processes such as tanning animal hides, plating, inhibition of corrosion and products such as textile dyes, refractory bricks and ceramic glazes, it is turning into a pollutant rather than a potent raw material due to improper disposal of effluents from these industries. Chromium has several detrimental effects on animal and human life when it reaches the man in a biomagnified form. Thus, in order to combat such issues, this research aims at the bioremediation of hexavalent chromium from contaminated water. In this research, *Canna indica*, commonly known as Indian shots was chosen as the bioaccumulator. Plant specimens were cultured hydroponically in contaminated water and the rate of chromium degradation with respect to time was studied. In the second approach, zerovalent iron nanoparticles (NZVI) were prepared in the laboratory and subjected to batch experiments in which the rate of uptake of chromium from potassium dichromate solution was analysed. The results showed that 57% of hexavalent chromium was removed in bioremediation. Though adsorption showed a higher rate of chromium uptake, it is concluded that bioremediation has a greater efficiency of decontamination since it is eco-friendly and does not leave a residual chemical footprint in addition to the existing contamination.

Keywords: *Bioremediation, Bioaccumulation, Biomagnification, Adsorption, Nanoparticles*

UTILIZATION OF BIOCHARS AS PERMEABLE REACTIVE BARRIER (PRB) MATERIAL FOR SUSTAINABLE GROUNDWATER TREATMENT

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Abstract

More than 200 million people covering 21 states in India are suffering due to Arsenic and Fluoride problem. PRB is one of the groundwater remediating method for aliphatic hydrocarbons and metals. PRBs have already shown promising results for industrial effluent in developed countries, where they were tested for over a span of 10 to 15 years. The same should be tested for remediating groundwater in developing countries like India, where groundwater treatment technologies are still not fully explored. PRB capability in treating Geogenic and anthropogenic contaminants in groundwater under natural hydraulic gradient will be tested under natural hydraulics condition in a simulated aquifer model. We have tested rice Straw biochar which has shown significant results for the Arsenic remediation in the concentration of 10, 30, 50, 80 and 100 $\mu\text{g/L}$ as a potential PRB material. At optimum adsorbent dose of 0.2g /100 ml, the removal rate of 72% was achieved. We also tested Silane treated Sand for same concentrations and removal rate of 42% was achieved. Both the experiment results followed Pseudo-First Order Kinetics and Langmuir Isotherms models. We now will test the composite of two (Biochar and Silane Treated Sand) as sequential PRB material for further simulated aquifer models at lab scale.

Keywords: *Biochar, Langmuir, PRB, Silane Treated Sand*

POTENTIAL OF PMP1 STRAIN IN THE BIODEGRADATION OF ORGANOPHOSPHATE PESTICIDES AND PRODUCTION OF SOME EXTRACELLULAR ENZYMES

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Abstract

Organophosphate pesticides (OPP) play a significant role in pest control technology due to their higher effectiveness and lower environmental persistence. However, they have simultaneously also posed a threat to the environs due to their toxic nature and persistence in the food chain as their residual concentration have been found in soil, water, agronomic crops and human fluids. Therefore, the present study emphasizes on the development of a bacterial process for the removal of extensively used Phorate and Methyl Parathion pesticides by means of biodegradation. Total 13 different bacterial strains were isolated from pesticide contaminated fields, out of which only one strain named as PMP1 showed higher degradation and was identified based on morphological, microscopic and biochemical characteristics via Bergey's Manual of Determinative Bacteriology. Isolate PMP1 showed the highest degradation of Phorate, reducing the pesticide up to 45.2% and Methyl Parathion, reducing the pesticide up to 39.5% within a week. Which designates that PMP1 strain can be a valuable candidate for bioremediation of pesticide-contaminated sites. Under in vitro conditions, strains were also examined for the production of extracellular enzymes. The PMP1 isolate showed an ability to produce some extracellular enzymes, which could have an industrial application.

Keywords: *Organophosphate, persistence, biodegradation, extracellular enzyme.*

NEW TECHNOLOGIES OF WATER TREATMENT: A STUDY

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Abstract

Over the years, simplified water treatment has become available to our homes. This is so we have our own water purification techniques to protect our families. We have seen different types of water treatment technologies, each having its own advantages and disadvantages. A multi-functional water filtration membrane developed in Singapore has opened up a way to destroy the microbes and other contaminants without any biofouling. Another device, Life straw having 2 filters, a membrane and charcoal filter. These two elements take care of purifying through the water while it is being sucked upwards. Similarly, a photocatalytic water purification technology removes arsenic and bacteria has to be focused. Acoustics Nanotube Technology to eliminate contaminants in water to make it potable, making it one of NASA's contributions to water purification technologies is also to be highlighted. Interestingly, Colorado company has developed a water purification system that can purify up to 5,000 gallons of water daily with just a battery that runs on renewable energy. The TATA group designed a TATA swatch, a low-cost device able to purify the 3-4 liters of water every hour. Euglena biofiltration system mimics the action of Euglena in purifying water. Nanophotocatalytic activity involving Sunlight, nanomaterial, graphene has done a marvelous work in water purification. Another technology explains the purification is done through a biological process using ceramic filtration membrane and a final cleaning by carbon and ozone. All these technologies will be focussed in the paper.

Keywords: *Water purification, nanotechnology, filtration, biofoul, sunlight, ceramic, lifestraw.*

ESTIMATION OF SOIL WATER RETENTION CHARACTERISTICS OF A UNIQUE ARTIFICIAL RECHARGE SYSTEM LOCATED IN LAPORIYA, RAJASTHAN

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Abstract

The availability of water in the state of Rajasthan, predominantly an arid to semi-arid region, is a huge challenge. Though many MAR structures are located in the state, Lapodiya village in Rajasthan has implemented a unique way of managing water scarcity by facilitating recharge of rainwater and overland flow through construction of “Chauka system”. The Chauka system consists of a series of channels and rectangular pits fringed by about two-foot high bunds in a chequer board pattern over few kilometres wherein rain water collects and meanders down the natural slope of the land. In this study, the soil water retention properties in the Chauka system have been assessed. Soils from surface horizon and substratum were obtained and their textural properties were obtained through particle size distribution. The surface horizon and substratum soils were classified as loamy sand and sandy soil, respectively. Further, soil physical parameters viz. bulk density, particle density, void ratio and porosity were obtained. The soil water retention characteristics of both soils were obtained through two methods viz. i. particle size distribution (psd) derived parameters fitted to Arya-Paris model and ii. Pressure plate experiments. Both the datasets are fitted to van Genuchten model and the results are compared. The root mean square errors in the psd-derived suction head were 0.062m and 0.033m for surface horizon and substratum soils, respectively. The results indicate that soil water retention properties derived from particle size distribution can serve as a good approximation wherein experimental data has been lacking.

Keywords: *Soil Water Retention Characteristics, Groundwater Recharge, Rajasthan*

NUMERICAL INVESTIGATION OF MICROBIAL TRANSPORT IN A SATURATED RESERVOIR SYSTEM

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Abstract

In the present study an attempt has been made to numerically investigate the transport process of microbes coupled with fluid flow in a saturated and homogeneous reservoir system. The bulk movement of microbes from one point to another inside the reservoir is governed by the advection process which is driven by mean fluid velocity. The existing velocity and concentration gradients of microbes at different points within the reservoir govern the dispersive transport of the microbes. Hence, both of these phenomena, advection and dispersion, are included in the present numerical model for the investigation of microbial transport. Fully implicit first order upwind finite difference scheme is used to solve the advective transport of microbes and central difference spatial discretization with Crank-Nicholson method of temporal discretization is used to solve the dispersive transport of microbes. For a constant continuous source of microbes, the data are obtained for simulation time of 10 days and reservoir length of 20 meters. Verification data show that the present numerical solution matches very well with the analytical solution provided by Ogata and Banks (1961). It is also observed that the resultant concentration profile is characterized by hyperbolic dominant, advective nature of microbial transport inside the reservoir.

Keywords: *Microbial Transport, Saturated Reservoir, advective nature*

CLIMATE CHANGE IMPACTS ON SUB-SURFACE WATER RESOURCES IN MANIPUR INDIAN–HIMALAYAN REGION

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Abstract

Under the climate change risk management framework in IPCC-AR5, vulnerability is taken as an internal property of a system independent of the exposure. The impacts of climate change can be taken as the result of interaction of climate change dynamics with exposure and vulnerability of the communities and its system. In lieu of the importance of regional climate change impacts in the Indian Himalayan region (IHR), an assessment of ecosystem, bio-physical and socio-economic systems of the state of Manipur at village level has been taken up for the project study using common framework of SDC-IHCAP and IPCC-2014. Geomorphologically and environmentally, Manipur is characterized by hilly terrains with susceptibility to seismic activity, soil erosion, landslides and denudation, while inheriting rich biodiversity and adequate water resources, which has been recently undergoing rapid degradation. The study focuses towards efficient management of sub-surface water resources by recharging aquifers, rejuvenation of springsheds and improvement of stream-basin health under various time scales of climate change scenarios generated using downscaled–GCMs and RCMs. The purpose of this study was also to reinforce the targeted activities under previous SAPCC with a target for 2030. The projected outcomes indicated that there is an increment of 263 sq. km of forest area i.e. 1.18 % forest cover of the state with total carbon stock of 143.091 million tonnes which is 2.02% of the total forest carbon stock of the country. If the same rate of growth and conservation continues Manipur will have a carbon sink of 148.204 MT in 2030.

Keywords: *Climate Change, Dynamics, Indian Himalayan Region, Framework, Assessment, Sub-Surface, Water Resources, Gcms And Rcms, Management, Aquifers, Springsheds, Carbon Stock*

CONTEMPORARY RATE OF CHEMICAL DENUDATION IN MELTWATER EMERGING FROM GANGOTRI GLACIER, CENTRAL HIMALAYA, INDIA

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Abstract

River Ganga originates from a doorway of Gangotri glacier. The water stored in the form of snow and ice plays an important role in regulating the hydrological cycle. The aim of this study is to analyse the major ion chemistry with a view to assess the contribution of active glaciers to the high chemical denudation rate (CDR) in the Gangotri Glacier of Uttarakhand Himalayas. 72 samples were collected in the post-monsoon season at three locations - Glacier snout, Bhojwasa and Gangotri in the year 2018. This study presents the concentration of major ions (e.g. Na⁺, K⁺, Mg²⁺, Ca²⁺, SO₄²⁻, NO₃⁻, HCO₃⁻ etc.) and in-situ measurement parameters, pH & EC. The pH of the samples varies from 6.38 to 8.25. EC varies from 11.0 to 222 μS/cm. The order of concentration of anions in sampling period was SO₄²⁻ > HCO₃⁻ > NO₃⁻ > Cl⁻ > F⁻ whereas cations were in the order Ca²⁺ > Mg²⁺ > Na⁺ > K⁺. Calcium and sulphate are the two major constituents of meltwater, constituting approximately 80% and 64% of the total anions and cations respectively in the study period. The geochemical modelling indicated that dissolved ion chemistry of Gangotri Glacier is generally controlled by carbonate weathering with little contribution of silicate weathering. C-Ratio of meltwater of all sites shows that pyrite oxidation is a major proton producing reaction and sulphide oxidation and carbonation coupled reactions control the solute acquisition process in the Gangotri Glacier. (Na⁺+K⁺ vs. Cl⁻) plot suggested relatively small contribution from atmospheric input to the meltwater.

Keywords: *Ganga, Central Himalaya, Uttarakhand, Hydrological cycle, Glacier snout, Bhojwasa and Gangotri*

WATER CONSERVATION USING VETIVER GRASS

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Abstract

Soil erosion persists on agricultural lands in Uttar Pradesh. To erosive land degradation requires soil conservation measures that are cheap, replicable and sustainable. The use of vetiver grass (*Vetiveria zizanioides*) has offered such prospects in a wide range of climatic environments. Although the grass grows in Gorakhpur, its potential for soil and water conservation and improved crop yield has not been realized. A study was conducted at the Madan Mohan Malaviya University of Technology for three developing seasons to evaluate: The effectiveness of vetiver grass on soil and water loss, Soil moisture retention, and Crop yields. Results demonstrated that first vetiver strip on the incline collected 98% more soil than lower vetiver strips in the primary year. Vetiver strips expanded yields by 11.1% and 20.6%, separately and expanded soil dampness stockpiling by a scope of 1.9% to 50.1% at different soil depth. Maize yield expanded by half. Soil misfortune and spillover water were 70% and 130% higher on nonvetiver plots than vetiver plots. Nitrogen use effectiveness was upgraded by about 40%.

Keywords: *Vetiver grass, soil erosion, Uttar Pradesh.*

EFFECT AND PRODUCTIVITY OF MICROBIAL BIO-FERTILIZERS ON MUNGBEAN VIGNA RADIATA (L, WILCZEK)

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Abstract

The decades of often excessive use of chemical fertilizers to boost the agrarian output has deteriorated the soil health in the country. Greener measures such as organic and bio fertilizers are being seen as sustainable measures to ensure the yield and at the same time improve the soil health. In the current study, we utilized six bacteria based bio fertilizers on green gram (*Vignus radiata* L.) to test their effectiveness in increasing the yield and improving the soil health compared to chemical fertilizers. The study was conducted in plots of 2X2 meters (in triplicates) and measured various parameters on growth and yield including shoot length, biomass and pH (before sowing and after harvesting of crop). Seed and field were treated with microbial inoculants (alone and consortia), vermicompost, and chemical fertilizers. Appropriate controls were maintained. Significant improvement in growth, crop yield and soil quality was obtained with the bio fertilizers tested. The yield was compared to the national average yield of mungbean. Consortium bio fertilizer (*Rhizobium* spp., *P. putida* and *F.aurantia* spp.) showed 41.71% (662.5 kg/hectare) more yield compared to the national average (468 kg/hectare). Surprisingly, individual inoculants *F. aurantia* spp. (potassium mobilizer) also showed a modest increase of 14.43% (535 kg/hectare) yield, possibly due to the role of potassium in fruiting. The yield was significantly above that of controls ($P < 0.0001$). Our results indicate that greener measures such as bio fertilizers could aid in meeting the fertilizer demand, while ensuring a sustainable way to improve soil health. The study is being replicated on a larger scale currently.

Keywords: *Bio fertilizer, Mungbean, Microbial Inoculants, Vermicompost.*

MICROPLASTICS IN WATERBODIES AND ITS IMPACT ON ENVIRONMENT

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Abstract

Plastic tainting of marine water is a mounting and unavoidable environmental concern. It is all pervasive as it can be seen in waters bodies and harmful for ecosystem exist there. Litter sized plastic pieces i.e., microplastics < 5mm can be found in high densities in waters and residue and are affecting living beings in an assortment of ways. Examination of freshwater and marine water samples have revealed that excess concentration of microplastic are in high abundance. The presence of an undegradable substance in the fresh space which is rich in variety of species, cause a major mechanical threat as well as chemical pollution. The health impact of microplastic towards human and aquatic beings are symbiotic in nature. The microplastic acts as a carrier of unwanted harmful toxins to the water system, overtime they impart the effects on the species around, which eventually enters into the human food chain. The consumption of such microplastic fed species, result in forming issues such as chronic effects for ingestion, abrasion and cancer along with several other complications for the aquatic species and humans. The plastic gradually settles on the coasts and banks of the water body due to the tides on the surface of water body. As time passes by the deposition settles on the banks and get submerged into the sand. The method obtained to study the contamination of the plastic waste is by collection on the sample from the sites, FTIR analysis and correlation of the data with respect to the optical reflectance model formed using GIS remote sensing. Drawing upon freshwater and marine water research, this paper will deal with the issue of microplastic in freshwater frameworks to condense ebb and flow understanding. The paper will also seek to fill the learning gaps with respect to the same and propose future research needs. This paper proposes that freshwater frameworks resembles the marine water framework in terms of the sorts of powers that vehicle microplastics (for example surface flows); commonness of microplastics (for example numerically bottomless and pervasive); the methodologies utilized for location, recognizable proof and evaluation (for example thickness detachment, filtration, sieving and infrared spectroscopy); and the potential effects (for example physical harm to creatures that ingest them, synthetic exchange of toxicants).

Keywords: *Microplastics, Marine, Fresh water, Health Impacts, pollution, river bank pollution*

CHANGE DETECTION IN NAUKUCHIATAL LAKE OF UTTARAKHAND USING LANDSAT IMAGERY

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Abstract

Water bodies are important in earth for all form of life. Identification and mapping of water bodies can be useful in various ways, which include estimation of availability of water, agriculture planning, change detection and so on. In this study remote sensing technique has been used to detect change in water spread area of Naukuchiatal Lake. Naukuchiatal Lake is situated in Nainital District of Uttarakhand. To detect the change in water spread area of studied lakes Landsat series data of 17-year gap i.e. 2001-2018 has been used. In year 2001, Landsat-7 imagery and in year 2018 Landsat-8 imagery has been used for this study. The change in water spread area has been observed in summer and winter season. Water ratio Index (WRI) was investigated for the unsupervised extraction of surface water from Landsat data. A model has been developed in QGIS software to calculate negative or positive change in water spread area. The results show that decrease in water surface area of Naukuchiatal Lake in both, summer season and winter season. In summer season the area of lake decreased by 5.97% and in winter season area of lake decreased by 3.5% for studied 17-year period. The result can be helpful in reclaiming and restoration of lake area. Also this type of study can be used for change detection of other water bodies, mapping of surface water due to flood.

Keywords: *Remote Sensing, Landsat, WRI, Naukuchiatal Lake, QGIS*

ENVIRONMENTAL MONITORING OF UMIAM LAKE BASED ON REMOTE SENSING PARAMETERS, MEGHALAYA

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Abstract

This study reports an environmental monitoring of Umiyam lake in Meghalaya by water quality algorithms using data of Landsat 5 and Landsat 8 of Landsat series. Remote sensing techniques was used to monitor water quality parameters (i.e. temperature, surface algae and turbidity) for assessing temporal and seasonal variation along with spatial extent of lake to see the seasonal variation in area of lake. Spatial and temporal information provided by optical and thermal sensors of satellites was used for monitoring the changes in water quality parameters. The information was obtained by utilizing sensors for the measurement of the Electromagnetic Radiation (EMR) reflected, or transmitted by the objective that is Umiyam lake. The main focus in this study is on satellite estimated reflectance of optical bands of Landsat 5 TM and Landsat 8 OLI. Different algorithms were used to measure different parameters by remote sensing that were Modified Normalised Difference Water Index (MNDWI), for delineating the spatial extent of lake, Surface Algal Bloom Index (SABI) for estimation of surface algae and Normalised Difference Turbidity Index (NDTI) for estimation of turbidity in lake. In this study, the capability of a LANDSAT 5 Thematic Mapper and Thermal Infrared Sensor (TIRS) and also of LANDSAT 8 Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) sensors is used to assess the physical water quality parameters.

Keywords: *Landsat, TM, OLI, TIRS, MNDWI, Temperature, SABI, NDTI.*

ENVIRONMENTAL MONITORING OF MUKAM LAKE

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Abstract

This study reports an environmental monitoring of Umiam lake in Meghalaya by water quality algorithms using data of Landsat 5 and Landsat 8 of Landsat series. Remote sensing techniques was used to monitor water quality parameters (i.e. temperature, surface algae and turbidity) for assessing temporal and seasonal variation along with spatial extent of lake to see the seasonal variation in area of lake. Spatial and temporal information provided by optical and thermal sensors of satellites was used for monitoring the changes in water quality parameters. The information was obtained by utilizing sensors for the measurement of the Electromagnetic Radiation (EMR) reflected, or transmitted by the objective that is Umiam lake. The main focus in this study is on satellite estimated reflectance of optical bands of Landsat 5 TM and Landsat 8 OLI. Different algorithms were used to measure different parameters by remote sensing that were Modified Normalised Difference Water Index (MNDWI), for delineating the spatial extent of lake, Surface Algal Bloom Index (SABI) for estimation of surface algae and Normalised Difference Turbidity Index (NDTI) for estimation of turbidity in lake. In this study, the capability of a LANDSAT 5 Thematic Mapper and Thermal Infrared Sensor (TIRS) and also of LANDSAT 8 Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) sensors is used to assess the physical water quality parameter.

Keywords: *Landsat, TIRS, TM, OLI, NDTI, MNDWI, Temperature, SABI*

CHARACTERIZATION OF ARSENIC POLLUTION IN ALLUVIAL AQUIFERS OF THE NATIONAL CAPITAL TERRITORY (NCT) DELHI

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Abstract

The problem of arsenic (As) pollution in groundwater system in the Indo-Gangetic plains of the Indian Subcontinent has been well documented. However, most of these studies highlight the fact that this menace of arsenic is mostly restricted in the eastern parts of the India in the relatively younger alluvium of the Ganga basin. It is for the first time this research indicates Arsenic pollution in groundwater of the older alluvial plains and Yamuna floodplains of Delhi. We find higher concentration of As in older alluvium of Delhi. Further the negative correlation of Arsenic with NO₃, rules out anthropogenic pollution through sewerage. Rather positive correlation with Mg, Ca and Cl indicates sediments groundwater interaction as source of Arsenic in water. Although there are several theories for Arsenic pollution in the Indo-Gangetic plains, however the presence of anomalous arsenic concentration in the older alluvium of the National Capital Territory (NCT) Delhi challenges the generalization of arsenic pollution process. The study presented in the article tries to assess and characterize the presence of arsenic and its relation with other contaminant in the system.

Keywords: *Arsenic; Delhi; Pollution; Older alluvium*

SOIL WATER POLLUTION: SOURCES, VULNERABILITY AND ENVIRONMENTAL IMPACTS

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Abstract

Scientists say that soil pollution is basically related to the damage of the top soil while others say that it is related to the inner soil, well at the end it is affecting soil and causing soil pollution. Sometimes soil pollution can contribute to the pollution of water. It does affect water when the polluted soil leaches into the groundwater, and ultimately heading into the wells and other drinking water sources. In the past few years', soil pollution has gradually become a major challenge that we need to overcome for establishing a healthy environment. One of the most important sources of soil pollution is *domestic and municipal wastes*, the growing quantity of domestic and municipal wastes containing household garbage, a variety of plastic items etc. are destroying the important nutrients of soil like nitrogen, phosphorus and potassium. The total quantity of solid wastes is large and increasing day by day. This paper describes how the waste varies from one country to another one and how it is related with the public health. *Plastic* these days is also a major threat as it is disposed in the soil and does not get decomposed and further prohibits the growth of plants and if eaten by animals lead to death. The disposal of *industrial and mining wastes* is one of the major sources of soil pollution by toxic chemicals. It has been reported that about 50 per cent of raw materials ultimately become waste products in industry and about 15 per cent of it is toxic. The paper also explores how an industry affects the soil and water and the mechanism involved in it. The excreta of humans, animals and birds are also a source of soil pollution by *biological agents*. In the developing countries, intestinal parasites constitute the most serious soil pollution problems. Faulty sanitation, waste water and wrong methods of agriculture also induce soil pollution. Finally, the paper explores the groups and methods how the pathogenic organisms pollute our land resources. One more cause of soil pollution is *Acid rain* which damages the basic properties of the soil. The polluted soil becomes acidic in nature. It has a negative effect on plants and animals. Therefore, the paper outlined the sources of pollution of soil water and the current status especially in developing countries.

UNDERSTANDING NATURAL AND ANTHROPOGENIC FACTORS RESPONSIBLE FOR GLOBAL WARMING

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Abstract

Global warming due to accelerated emission of greenhouse gases to our atmosphere by burning fossil fuels has taken effect in the world over the last century. The gases that have an influence on the atmosphere are water vapour, carbon dioxide, dinitrogen-oxide, and methane. Important factors responsible for the global warming of our planet earth are but not limited to the followings: 1) Solar radiation, 2) Volcanic eruption, and 3) Orbital vibration. The solar radiation reaching to the Earth and is get emitted back in the space. This energy is carried to different parts of the globe by way of winds, ocean currents and other mechanisms, thereby, impacting their climatic conditions. Similarly, volcano eruption is quite common on the Earth which contributes to climatic change. Life on the Earth itself contributes to the changes in its climate. The process of carbon emission by humans is one of the reasons that lead to changes in the climate. Emission of carbon due to fossil fuel combustion, burning of industrial wastes and vehicular pollution further add to this process of global warming. Variation in the Earth's orbit causes a change in the seasonal distribution of sunlight received on it. This variation results in Milankovitch cycles that impact the climate adversely. The repercussions of climate change are taking place in form of 1) Forest cover change, 2) Impact on water resources and 3) Wildlife changes. Forests serve as home for numerous species of animals and plants and maintain the ecological balance on the Earth. However, changes in the climate have led to extinction of forests in many regions. Likewise, hydrologic cycle of our planet has been disturbed significantly due to climate change. The rainfall pattern has become erratic thereby causing extreme conditions such as drought and flood. It has also caused rapid melting of glaciers. Thus climatic changes have become a threat for the survival of various wild species. A number of species of wild animals and plants have gone down and many are on the verge of extinction. According to the National Oceanic and Atmospheric Administration, 2010 and 2005 has been the warmest years on record. The earth could warm by an additional 7.2 ° F during the 21st century if we fail to reduce emissions from burning fossil fuels. The rising of temperature will also have great effects on the earth's climate patterns and on all living things.

Keywords: *Global warming, Climate change, Fossil fuels, Hydrologic cycle*

CRATER HIGHLANDS WATER TO THE RIFT FLOOR: INSIGHTS FROM A MULTI-METHOD APPROACH

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Crater Highlands, in a chain of volcanoes located in the Eastern Rift zone, in Northern Tanzania; are separated from the rift floor by escarpments formed tectonically after the volcanic stage, and are considered to be recharge zones for the rift floor aquifer. Surface and groundwater resources are located on the Crater Highlands (inside and/ outside of the Craters walls) and on the rift floor; and are of different quality and used for different purposes (domestic and non-domestic purposes).

The main source of freshwater in the area is groundwater and its exploitation will continue to increase sharply due to the rapid increase of the population and tourism industry; which in turn is putting pressure on water quality and quantity. On the other hand, climate change intertwined with severe and persistence aridity has been reported in this part of Tanzania; which might hinder groundwater recharge mechanisms, increase water demand and increase stress on freshwater availability in the area.

With this study a multi methods approach (Environmental isotopes, hydrochemistry, and modeling) is being used for understanding the origin of groundwater in the area, estimation of runoff and the mechanism of groundwater recharge in Crater Highlands. The present study will contribute to a better economic and sustainable management of available water resource in the area.

Keywords: *groundwater recharge, origin and runoff*

COMMUNITY BASED WATER RESOURCES MANAGEMENT IN SEMI ARID AND DROUGHT PRONE REGION

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Abstract

The World Health Organization report states that around one in eight of the world populations do not have access to safe water and adequate sanitation, which is nearly two fifths of the world population. Water is essential commodity and critical for a society's development. It plays a seminal role not only in sustainable development but also in reducing poverty. Poor need access to water for their survival and to further their livelihoods and water inaccessibility limits opportunities for them to develop their potential. In this present study attempts are made to investigate water resources management in a semi arid drought prone region through the community participation. Planning for drought mitigation in the study area community local knowledge were used and necessary water harvesting plan for execution were prepared using S&T tools.

After the execution of the water harvesting plan groundwater levels were monitored. It was observed that groundwater level has been increased and agricultural productivity gone up. Thus by this study it is established that peoples participation and localized Integrated Water Resources Management (IWRM) program is highly beneficial in resolving the water problems in semi arid drought prone region.

Keywords: Community-Based, IWRM, Traditional Water Resources Management, Groundwater Monitoring.

8th International Groundwater Conference (IGWC-2019)

SUSTAINABLE MANAGEMENT OF SOIL-WATER RESOURCES

October 21-24, 2019, Roorkee, India

Editors: Brijesh Kumar Yadav and Gopal Krishan

Soil and groundwater are the major resources for safeguarding agriculture and fresh water demands. Developing solutions for conservation and sustainable management of these natural resources can play a crucial role to meet water and food demands of our growing population. The IGWC series provide a wonderful platform for researchers, academicians, water managers, industrialists and technocrats to discuss and present their vision on soil and groundwater management under varying environmental conditions. This 8th conference in IGWC series will provide an opportunity to the participants to exchange their ideas, identify grey areas and explore new approaches to solve the problems of these resources under one roof. This event will also create interest amongst the young scholars about various facets of subsurface hydrology and its application for the welfare of the society at large.

The abstracts of keynote and research papers presented during the International Groundwater Conference held during October 21-24, 2019, in IIT Roorkee, Uttarakhand, India, are provided in this conference volume.

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