INC-IAH NATIONAL SEMINAR 2022
on "Recent approaches in Groundwater Development & Management in Semi/Arid region of India with a focus on Rajasthan"

IN ASSOCIATION WITH
Indian National Chapter of International Association of Hydrogeologists (INC-IAH)
Rajasthan Institute of Engineering & Technology (RIET), Jaipur
Ground Water Department, Govt. of Rajasthan

Venue: Rajasthan Institute of Engineering and Technology, Jaipur Bhankrota
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Chairman’s Message

Dear Friends and Colleagues,

Greetings from RIET Jaipur.

It gives me immense pleasure to pen down this introductory message for the INC-IAH National Seminar, 2022 to be held at RIET Jaipur on 24th December, 2022. INC-IAH National Seminar, 2022 is the flagship and definitive event of INC-IAH, being one of the most prestigious and popular seminars in India, which attracts delegates from all across the country. I am confident beyond doubt that when our hundreds of delegates come together, hand in hand, in the spirit of our Society, we will be extremely fortunate to have the opportunity to learn and share knowledge in the best of the academic environment. The theme this time for INC-IAH National Seminar 2022 is “Recent approaches on ground water development and management in semi-arid region of India with a focus on Rajasthan”. Thanks to the scientific committee, we are about to have an enriching national level academic program in the form of orations, plenaries, award papers and invited talks from leading academic figures in the field. As of now, we have more than 50 papers and 20 posters which have been accepted. I am sure that these abstracts published here will be thought-provoking and stimulate rich academic discourse and future research ideas. Even with the given challenges, I expect that INC-IAH National Seminar 2022 will emerge as a rich academic treat for all.

On the behalf of the team RIET, as well as on a personal note, I take this opportunity to thank each and every one who has been instrumental in organizing this seminar, from all members of the INC-IAH, GWD to the Patrons and Advisors and the Local Organizing Committee, for offering in their heart and soul for the grand success.

With Regards

[Signature]

Prof. A.S. Ponia
Chairman, RIET
Campus Jaipur
Chief Engineer, GWD, Message

Dear Friends and Colleagues,
Greetings from GWD, Rajasthan.

Ground water is scarce natural resource and has emerged as the backbone of our State to solve water problem from year 1956. This Department is a pioneer institute of ground water management in the country. In addition to providing ground water to the State for drinking, agriculture, industry and other water needs, the Department stated preliminary ground water survey in year 1967, semi-detailed survey in year 1971, and detailed hydrogeological investigation in year 1977, and was completed in year 2001. Since year 1984, the Department, as per the guidelines of GOI and CGWB, the GWD conducts Ground Water Assessment every three years. The Department has a network of 2500 pizometers, where ground water monitoring is carried as per guidelines of GOI from time to time. The Department has helped the State in solving drinking water problem of the State and in worst famine of 1968-69 solved problem to a great extent and got great appreciation. Drinking water problem to Jodhpur city was solved when in year 1970-71, main source Jowai Dam district Pali failed by constructing tubewells in Mathania-Tinwari area. Guinea Worm Eradication Program in Southern Rajasthan hard rock area of Dungarpur- Banswara Districts was solved in year 1973-78. GWD has helped agriculture sector of state through Cluster Tubewell Scheme in districts Jodhpur, Nagaur Jalore and Pali from 1972-79. The Department worked with IGNP Command Area Development for ground water management. The Departmen constructed relief wells in Mahi Dam area to solve big problems. For Saraswati Project, the Department constructed relief wells, task of Core Drilling Rigs, but completed without those rigs and with only rotary rigs. Artificial Recharge work done with funds from CGWG in year 2001 and worked with new concept of recharge shaft without pipe assembly.

Now Department is doing appreciable work under Atal Bhoo Jal Yojna.

Surajbhan Singh
Chief Engineer, GWD
Dear Colleagues and Friends

At the outset, I extend my heartfelt greetings to everyone for a merry Christmas very happy, healthy, peaceful and prosperous New Year 2023. I wish for your well-being and hope that you welcome the year 2023 in good spirits with your family and friends. I also extend very warm welcome to you, your friends and your family members to the INC IAH National Seminar on “Recent Approaches in Groundwater Development & Management in Semi/Arid regions of India with Focus on Rajasthan” being organized by Indian Chapter of International Association of Hydrogeologists (INC-I AH) jointly with Rajasthan Institute of Engineering & Technology and Groundwater department, Govt. of Rajasthan.

Groundwater is the largest and most sought after resources for meeting the ever-growing demand of water in India. It also offers a climate resilient resource and backbone to combat drought situations. Groundwater is multidisciplinary subject wherein academician, scientists technocrats professional and practitioners from various discipline and all walk of life constituting groundwater community are engaged in understanding its behavior and its management to make this resource sustainable. With increasing importance of groundwater, the role of groundwater community has enhanced significantly. International Association of Hydrogeologists (IAH) today is largest organization of Groundwater Community with more than 4000 members from 132 countries engaged in finding solution to issue of over exploitation and contamination of this valuable resource so that this planet survives and thrives. There are around 200 members (INC-I AH) of this organization from India. INC IAH actively playing its role and pursuing the vision and mission of IAH at national level. INC IAH believes challenges to the sustainability of groundwater use in the country can only be addressed through collective action integrating collective wisdom. Therefore one of the key activities of INC IAH is promoting exchange of ideas and research findings for the benefit of all.

Under the present scenario, INC-I AH platform may prove panacea of all such problems challenging the availability of quality freshwater by putting efforts in promoting research and academics in groundwater domain and inviting the researchers and practitioners engaged in cutting edge research solutions for a fruitful interaction and deliberation. I wish INC-I AH become a vibrant platform for undertaking research through meaningful collaboration at individual and at institutional level. I am quite hopeful that in the coming time, INC IAH may be in a position to support summer/ winter Schools, boot camps, and Hydrogeological weakened, as activities needed to strengthen INC-I AH among young hydrogeologists. As we all are aware, lectures by INC-I AH experts as well as by experts from the envisaged partner organizations/ institutions, both from India and abroad, have already been initiated. Quarterly INC IAH e-Newsletter are regularly made available to all concerned. Next issue of E-journal would be released during the seminar on 24th December. Announcement inviting application for the INC IAH Annual scientific awards will be made soon. Special Awards for short Video reel by school students are going to be yearly event. Field Internship provision for strengthening the skill of young students and researcher with the support of the established professionals is another important initiatives going to be undertaken by INC IAH from coming year.

It is a matter of great pleasure and satisfaction that INC IAH is organizing the Seminar at Jaipur in partnership with the above named esteemed institutions and it is expected that deliberation during the seminar would pave the way forward for the impactful management of groundwater resources towards its sustainability particularly in arid semi-arid region of the country. I on behalf of INCA IAH convey my sincere thanks to our partner institutions, to all scientific contributors and delegates to the seminar and to all volunteers who worked very hard to make the event a highly memorable one. My apology to those to whom I am not able thanks individually here but all knows about them as this Seminar could not have taken shape without their sincere indulgence and total commitment. My salute to them.

Jai Hind

(A.K.Sinha)
Vice Chancellor, Chhatrapati Shivaji Maharaj University and
President, Indian National Chapter of International Association of Hydrogeologists
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1. An innovative technique of Artificial Ground Water Recharge in Alluvial Formation – A Case study from Neemrana area, Alwar Dist, Rajasthan, India

SM Kanwar,
Former Chief Engineer, Groundwater Department, Rajasthan, India & Former Expert Member, Drinking water & Sanitation Council, Govt of India

Abstract

Our dependency on the groundwater has increased many fold. In arid and semiarid region where it is main source of drinking water. Groundwater has also become the main stay of our food production and is highly valuable resource to adapt with the consequences of warming climate. However, its sustainability has become questionable owing to its overuse in agriculture, Industrial and domestic sector. Globally its level is depleting. The artificial way of recharging groundwater is considered as a means to address the challenges of groundwater level depletion and its adverse consequences, Various techniques of groundwater recharge is being practiced in consolidated and unconsolidated geological formation. Undoubtedly many of these techniques used are beyond the pocket of marginal farmers and petty entrepreneurs. This paper deals with an innovative measure of artificial recharge of groundwater in Alluvial formation where recharge shaft was developed without using pipe assembly.

The technique based on the premise of developing recharge shaft without pipe Assembly preferably in Alluvial formation. Twentyfive such recharge shaft were developed. One of this structure was tested by CGWB and CGWB found the cost of such structures to be about 30% and recharge efficiency is about 800% higher. of structures with pipe assembly, Subsequently after the approval of CGWA m a DPR was submitted which was accepted by CGWA and on its basis 91 recharge shafts without pipe assembly were constructed in nearby villages and 38 recharge shafts without pipe assembly were constructed in twp plots of Heromoto Corp, Neemrana in industrial area under my technical supervision. Considering life of recharge structures as 20 years, per cubic meter recharge cost in these recharge shaft was found Rs.1.0 per cubic meter in water bodies in near byvillages and Rs.10.75 per cubic meter
in recharge shafts in two plots of Heromoto Corp.

The technique was not employed anywhere in the world so far and same technique may be replicated in all alluvial area for economically and efficiently developing the recharge structure for the recharge of the groundwater

Keywords: artificial recharge, groundwater, Alluvial formation, Recharge structure
2. Strategies for Sustainable Water Management in India

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Abstract

Everyone appreciates that water security is an important issue for India. However, water management has been an unsustainable path in the country for centuries. Water security has progressively deteriorated over the years for many reasons. As population, urbanization and industrialization have increased, more water is needed for production of food as well as generation of electricity for supply to urban areas in ever-increasing amounts. While Central and State Governments always focused on increasing water supply to meet higher demands, no serious effort has ever been made to manage the efficiencies of water uses in domestic, agricultural and industrial sectors can be significantly improved through better management practices, including the use of economic instruments, adoption of new technologies and instilling greater concern for conservation among all Indians to value, preserve and protect water. In addition to water availability problem, India is also facing an even more serious issue of water quality. Decades of neglect have affected all water bodies in and around urban centres, which are now seriously polluted. Accordingly, all water bodies, including rivers, lakes and aquifers, within and near urban centres are now heavily contaminated with all types of pollutants. The situation is getting progressively worse as appropriate and timely actions by the administration are still unsatisfactory.

While India’s water future currently looks bleak, there is no reason why it should be so. The country has enough expertise to solve its water problems with access to technology and investment funds to ensure a sustainable water future. To address the issues, various strategies discussed in the paper at great length include (i) Closing the huge IPC-IPU gap is a “low hanging fruit” which can be picked by investing in CAD works, ERM projects, and irrigation management reforms (ii) Aggressive Promotion and incentivization of sprinkler and drip irrigation on a
massive scale in general and in over-exploited and critical areas, in particular, can be the most important demand side management strategy to over consumption(iii)Managed Aquifer Recharge, intelligent management of the energy-irrigation nexus and participatory groundwater management offers a major opportunity for water-secure and resilient India. (iv)MAR is the most economic, most benign, most resilient, and most socially acceptable solution, but has not been due importance in the past out of lack of awareness, inadequate knowledge of aquifers, immature perception of risk, and inadequate policies for integrated water management, including linking MAR with demand management.(v)Mandating progressively increased use of recycled/treated wastewater. This has huge potential for substitution of fresh groundwater used in Industrial, domestic (non potable) and agriculture sectors.(vi) Encouraging the Use of brackish/saline water for selected agricultural crops in western and north-western India, where huge unutilised potential exists.(vii)In the country conjunctive management of rain, surface water, treated wastewater and groundwater is the big hitherto under-exploited opportunity for supply-side management and (viii)Enabling Legislation for sustainable water management and Institutions for water governance needs to be established in the states for enforcing effective governance.
3. Delineation of Flowing Groundwater Channel Using Electrical Tomography in Limestone Terrain of Bundelkhand Region, India

Subhsh C. Singh
Ex Central Ground Water Board, Govt. of India
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Abstract
Assessment of groundwater resources in limestone terrain is quite challenging due to wide variations in its hydrogeological characteristics. There are some advanced geophysical techniques that are being used in groundwater exploration, development and management in such geological formations. Many parts of Bundelkhand region of India having limestone formations, along with granite rock, are facing acute shortages of water to meet their minimal demands for agricultural, domestic, and industrial sectors. The study area, some part of Bada Malhera and Bakshwaha blocks of Chhatarpur district, Madhya Pradesh, is occupied with Bijawer limestone and Bundelkhand granitic formation. Caverns in limestone and fractures in granites are forming complex paths for groundwater movement in the multi-aquifer system. Appraisals of groundwater availability have been done through the integration of hydrogeological and geophysical investigations. The prime objective of the investigation includes determining the geological controls on the behavior of limestone cavities and delineating limestone cavities and fracture system holding enormous groundwater resources. The study utilizes a wide range of approaches including hydrogeological mapping, surface geophysics comprised of Vertical Electrical Sounding (VES) and Earth Resistivity Imaging (ERI), satellite image analysis, borehole drilling and analysis of groundwater quality of aquifer systems. Twenty resistivity imaging profiles have been conducted at 20 locations in 17 villages covering an area of about 250 km². The results of the investigation have indicated a very good logical match between the 2-D resistivity tomograms and lithology of boreholes. It has been noticed that the air-filled cavities have very high (near-infinite) electrical resistance compared to the wet limestone having a resistivity in the range of 1000 ohm-m and they have produced readily recognizable anomalies. The hard and compact limestone, dry limestone cavities and hard compact granite have indicated very high overlapping resistivity values. The investigation
enables us to link the depths and orientation of caverns/fracture, the interconnectivity of caverns/fractures, and length of caverns/fractures with the availability of groundwater.

During the study an extensive 300 m long southwest (430 m amsl) northwest (100 m amsl) dipping lineament between Chhatarpur (MP) and Prayag (UP) has been noticed on Google Earth which is infested with limestone formation. It is found that large numbers of water pools and caves/caverns exist along this giant lineament. Some of the famous pools like Bhimkund (Chhatarpur), Pandav Cave/fall (Panna), Gupt Godavari (Chitrakoot) etc are having huge unseen flowing groundwater. It is also reported that the water discharge of Ken River crossing this lineament loses a considerable amount of its discharge. It is found that many boreholes drilled on this lineament are yielding huge yields after encountering the cavernous limestone. Based on the results and observations of the study it is assumed that a deep water channel is flowing through limestone formation beneath the lineament. To carry forward the strong prevailing myths, the study postulates that the invisible Saraswati River at Prayag is a subterranean groundwater flow that originates from the Bundelkhand region of Madhya Pradesh and follows the deep limestone cavities/caverns and finally converges to River Yamuna and Ganga at Prayag. The paper emphasizes the need for further integrated geoscientific studies toward this hypothesis. The study also suggests that the presence of several big limestone cavities in Bara Malehara block of Chhatarpur district in Madhya Pradesh can be developed for Geo Tourism sites.
4. An Insight From Isotopic Data to Understand Salinity Mechanism in the Aquifers of Semi-arid Regions of the North-west, India

Gopal Krishan  
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Abstract

The North-west region of India has become a centre point for groundwater researchers due to the rapid decline in groundwater levels and degradation of water quality due to groundwater contaminations. In addition to these, there are issues of high groundwater salinity in arid and semi-arid regions where the rate of evaporation is more than the precipitation. Groundwater plays a critical role in these regions due to uncertain and low precipitation. Understanding the hydrological process will be crucial in efficiently managing and sustainably developing scarce water resources in these regions. Various approaches are there to understand these processes but the tracer technique being the result of the environmental effect or the interaction between water and medium can be reliable. In the present study, a comprehensive database of isotope measurements and hydro-geochemical parameters in the semi-arid regions of Punjab and Haryana states was compiled, which was generated under different projects to clarify the isotope signatures and understand the salinity mechanism. The local meteoric water line (LMWL) was derived from the stable isotopic rain values for Mewat as: $\delta D = 7.5 \delta^{18}O + 0.48$ ($R^2 = 0.94, n = 6$), for Punjab as: $\delta D = 7.9 \delta^{18}O + 5.5$ ($R^2 = 0.96, n = 322$) then the processes were tracked by comparing the isotopic characteristics of the waters. The shallow isotope values for groundwater (shallow depth $< 60$ m) for Mewat and Punjab were $\delta D = 5.6 \delta^{18}O -10.34$ ($R^2 = 0.89, n = 80$), for Punjab as: $\delta D = 6.1 \delta^{18}O -6.2$ ($R^2 = 0.95, n = 325$). The results show the evaporation process taking place before reaching the water to aquifers. In addition, ionic ratios indicated that chemical weathering control the initial salinity, and evaporation becomes the main contributing factor in increasing the salinity to higher levels. This study is very useful in understanding the salinity mechanisms in semi-arid regions of northwest India and for planning management measures. In the future, the long-term monitoring and observations of isotopic and ionic
composition of groundwater need to be strengthened to explore the hydrologic process and the evolution of groundwater salinity in the semi-arid regions of northwest India.

Keywords: Semi-arid regions, northwest India, Isotopes characterization, groundwater salinity
5. Geospatial Technology for Sustainable Water Resource Management: Indian Perspective

Prof. (Dr.) B. S. Chaudhary
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Abstract

The globe is facing great pressure on water resources availability due to enhanced pressure by continuous increase in population, urbanization, industrialization, and climatic change. Global distribution of fresh water resources is skewed and uneven which makes it more pertinent to conserve, preserve, recycle and reuse the water in prudent manner. Geospatial technology provides a handy tool for mapping and management of water resources on sustainable basis. Geospatial technology is the integrated use of Remote Sensing (RS), Geographical Information Systems (GIS), Global Positioning System (GPS) and Information & Communication Technology (ICT) and helps in generating baseline information for the effective and optimal utilization of water resources. This aids better decision making for planners and decision makers based on sound techno-economic feasible consideration. The effective planning for water resources mapping and management at district level can be made if the base information is generated on 1:50,000 scale by using satellite data and other ancillary information along with ground truth. India experiences an average precipitation of 117 cm per year which makes about 1,720 cubic metres of fresh water per person. However its spatial and temporal distribution makes it highly uneven and calls for strong water conservation measures. Haryana state is covered by Yamuna, the Ghaggar and internal basins which are parts of Ganges and Indus system. The natural slopes of northern and southern Haryana make almost a latitudinal depression along Sirsa-Fatehabad-Hisar-Jind-Rohtak-Delhi axis. Saucer shaped physiography of the state is resulting into many problems related to water resources management in the area. This results into flooding, water logging, and salinity in the central portion of the state whereas continuous decline of water table in fresh water areas in north and south portion of the state. There is an average decline of .33 meters per year over last decade. This calls for integrated study of water resources in the state for its optimal utilization.
Water resource development plan maps focusing both on groundwater and surface water resource action plans in parts of Haryana state, India have been prepared using Geospatial technology. Remote Sensing Satellite IRS 1C LISS III data have been used in the present study. Visual Image Interpretation and Digital Image Processing have used with limited field checks. Hydrogeomorphological maps showing various groundwater prospect zones depicting groundwater worthy features have been prepared. This information has been supplemented with the available inputs from existing sources about the depth to water level and groundwater quality etc. The other maps such as land use/ land cover, geomorphology, drainage/ canal network and soils etc have also been consulted for preparing water resources action plan. The maps thus prepared depict different units for further groundwater prospecting. The surface water resources action plan maps have been prepared by integrating geomorphology, slope, drainage, soils maps and various sites have been suggested for site specific water resources conservation measures such check dams/ gully plugging, earthen dams etc. These are of utmost importance for groundwater amelioration, surface water conservation and optimal utilization of land resources in the watershed.

Key Words: Sustainable Water Resources Management, Geospatial Technology, Satellite Data, Groundwater Prospects, Indian Perspective,
6. Groundwater Resource Management in Thar Desert of Western Rajasthan, India

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ABSTRACT
The arid and semi-arid dry land of western Rajasthan is well known for incidence of chronic
droughts, existence of the world fame Thar Desert and acute water scarcity. Erratic and low
average annual rainfall varies from <150mm to 450mm along with high potential evapo-
transpiration rates. The area is mainly drained by ephemeral Luni river along with Ghaggar river
and inland Kantli river. However, major part of the desert is devoid of any drainage system.
Geology is mainly represented by Delhi Super-group of rocks, Marwar Super-group of rocks,
Igneous Intrusives, Bap Boulder Beds, Mesozoic Formations, Tertiary Sandstone and Quaternary
Formations. Unconsolidated Alluvium, Borunda Limestone, Lathi Sandstone and Nagaur-Palana
Sandstones are the potential aquifers. Water level varies from water logging conditions/shallow
water levels in Indira Gandhi Nahar Pariyojana (IGNP) canal command areas to over 140m (50m
to 80m in major parts). Quality of groundwater varies from fresh to highly saline/brine generally
having high concentrations of fluoride and nitrate along with industrial pollution at places.
Groundwater drought situation has been developed in the major parts due to its over-exploitation
mainly for extensive groundwater irrigation (84 blocks are under overexploited category out of
total 120 blocks as on year 2020). Government of Rajasthan has taken remedial steps like
mandatory rooftop rainwater harvesting for new houses in urban & semi-urban areas having plot
area of >300m². Central Ground Water Authority has notified 22 blocks in western Rajasthan to
tcontrol/regulate groundwater overexploitation. Hon’ble National Green Tribunal is suitably
issuing directions especially for combating industrial water pollution. Future effective water
management strategies needs to incorporate both supply side as well as demand side
management components of water conservation, augmentation and regulations, all based on
micro-scientific studies. Gravity of seriousness calls for implementation of large scale artificial
recharge schemes. Deep and declining water levels creates ample scope of gradual recharging of potential aquifers of the estimated magnitude of 71,000MCM utilizing surplus water in IGNP during monsoon period, monsoon rainwater and harvesting surplus floodwater available in the northwest India, which otherwise presently flowing into neighboring country. Need of the hour is to make rainwater harvesting mandatory for all buildings & village farms. There is need for adopting remedial measures including mandatory micro-irrigation, growing water efficient crops & conjunctive use of surface-groundwater in canal command areas of IGNP etc. The quality issues may be suitably addressed by developing cost effective desalination (using solar energy) & de-fluoridation techniques/devices and also mandatory recycle/reuse of industrial/sewerage/other gray & black waters. The regulatory measures should include formulation & enforcement of Rajasthan Ground Water Legislation, constitution of State Level & District Level Ground Water Authorities, Rajasthan Groundwater Policy, Mass Awareness/Capacity building (including establishment of a Water University/Institute of Arid Hydrogeology), notification of all overexploited blocks and polluted& water logged areas, especial status for water to arid & Semi-arid areas for granting especial financial assistance etc. Integrated participatory groundwater management will ensure catering of safe drinking water, enhanced irrigation/agro-industries(food security),drought resistance, sustainable development, transforming dry lands in to green fields, combating adverse impacts of global climate change, overall improvement of socio-economic fabric & ecosystem in Thar Desert.

Key Words: Arid, aquifer, artificial recharge, drought, drainage, desert, evapotranspiration
7. Nation Wise Rainwater Management Program

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Abstract

Groundwater depletion is a major problem across regions in the world and also in India. This has consequences in terms of disruptions in the hydrological cycle, food and water security, geopolitical conflicts between transboundary water resource sharing authorities, etc. Nation-wise Rainwater Management Program presents a notable solution to combat global groundwater depletion and to empower communities to improve their water security. The solution, in addition, can contribute to combating climate change and in the lowering of greenhouse gas emissions. The program is focused on providing solutions for almost all geographies of the planet to address Groundwater and Surface Water issues with development of low-cost structures and devices with "CONTAMINATION AVOIDANCE ABILITIES" along with generating High end Revenues for the Nation (Govt of India) through licensing, royalties and other diplomatic tools. In this presentation, we first introduce the interventions made by Shree Someshwar Education Trust to combat groundwater depletion in Surat, a district in Gujarat state in India by implementing total rainwater management. Secondly, we discuss the impact the Rainwater Management program is having on our study area. We lastly argue that such intervention can be replicated across various regions globally to empower localities to improve their water management practices and to combat groundwater depletion.

Keywords: rainwatermanagement, groundwater, watersecurity, climatechange

Themes: TechnologytransferandinnovativesolutionstoGroundwaterandclimatechange, Impacts, Hazards, risks, and effective adaptation to climate change
8. Causes and Implications of Groundwater Depletion in India

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Abstract

Groundwater is very important because it plays a vital role in various purposes like food security, water availability, and economic growth of more than 1.3 billion people in India. Most of the part of our country i.e. India notwithstanding the development of irrigation schemes based on groundwater, surface water remains a primary source of irrigation. The food production rapidly increases in India it contributed due to Green revolution in the 1970s with the help of development of groundwater based irrigation, which resulted in an expansion of irrigated area and a rapid rise in the number of diesel and electric pumps. A large part of area which are affected by rain was converted to irrigated agriculture leading to growing multiple crops in a year with increased crop yields. Due to the expansion in groundwater-based irrigation helped fulfilled the rising food demands of a large population of India, it was resulted in several environmental implications. Groundwater depletion has now become one of the most prominent challenges in India for food and water security. Both in-situ and satellite-based observations indicate a rapid decline in groundwater storage in north India. In India, both natural and anthropogenic factors cause groundwater depletion. The primary driver of groundwater depletion is Groundwater pumping for irrigation, which can further affect food and water security as well in India under climate change. Both in-situ and satellite-based measurements have issues and uncertainty. In India sustainable management of groundwater is important for tackling growing challenges related to water availability. Here we discuss the challenges and opportunities related to the measurements and modelling of groundwater, groundwater recharge, cropping systems and irrigation efficiency.

Keywords: Groundwater, Groundwater depletion, irrigation, Groundwater recharge, Groundwater pumping.
9. Lake Rejuvenation in peri-urban area: A case study of Udayapura Lake in Bengaluru, Karnataka

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Abstract

Waterbodies and lakes are integral part of the river basins, especially in Karnataka. They are the most productive ecosystems linking land and water resources and providing environmental sustainability. The Bengaluru city is being sprawled in radial directions causing urbanization of naturally existed riverine ecosystem. Due to urbanization, the natural stream network endowed being distorted in turn causing imbalance in natural distribution of surface and ground water and further causing pollution, flash floods, scarcity of water in spite of good rains. The lakes have lost their ecological functionalities and have become more like storage of pollutants as seen on the site. At the same time, changes in the land use land cover of the catchment area has influenced water yield and water quality of the lakes. Untreated pollutants from both domestic wastewater and industrial effluents are being dumped along with the solid waste into the lakes from the upstream in the catchment area, which is making the lakes pollution stressed along with being water stressed. Several attempts are being made to revive the natural system by various agencies. In spite of several programs being executed, the problem exists and the conditions are worsening day by day. Hence, it is imperative to study and analyse the causative factors and propose the plan of action for rejuvenation of the same. The present study is a pilot exercise expected to provide a model for rejuvenation of peri-urban watersheds in similar terrains elsewhere.

The study area is a catchment area of the Udayapura lake, that is located in the watershed of Suvarnamukhi river, which takes its origin from Bannerghatta hill range in the south eastern part corner of Bengaluru city. To study causative factors, plan of action was prepared by delineating mini watershed boundaries in the uppermost part of Suvarnamukhi sub basin, preparing thematic maps of land use land cover, soil texture, soil slope, administrative boundaries, and drainage network using Remote Sensing and GIS tools. Point sources of pollutants were also mapped by
taking a traverse across the Miniwatershed along the natural stream network to trace the intensity of the pollution, locating suitable sites for pollution treatment, locating suitable sites for rainwater harvesting. 38 different locations were selected to assess the condition of pollution. Water samples were collected from 15 different locations distributed along the catchment, both upstream & downstream. All the samples were sent to laboratory for further physicochemical analysis. The analytical report depicted wide variety of deterioration. This is attributed to large quantities of wastes both from municipal and industrial effluent, which is the key finding. Based on which, mainly three actions are suggested. First is to clean the upstream lakes named Talaghattapura lake, Roerich estate lake and Kuppareddykere. Second is to communicate to all the stakeholders and third is to adopt most suitable treatment for cleansing of polluted water flowing to Udayapura lake.

Keywords: lake rejuvenation, Radha Kunj Lake, Suvarnamukhi river rejuvenation, Peri-Urban watershed
10. Role of Groundwater Community Participation and Regulatory Measures for Sustainable Groundwater Reservoir of Rajasthan, India

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ABSTRACT

Groundwater is a major source of water, but over a few years, the water level is highly likely to go down due to overexploitation and a lack of artificial recharge. Through regulation and governance, the groundwater community's participation is now required as a viable mitigation strategy for balancing the supply and demand of the groundwater reservoir.

The State of Rajasthan is the largest state in the country, covering an area of 3.42 lakh square kilometres, which is more than 10% of the total geographical area of the country. The State of Rajasthan is one of the driest states in the country, and the total surface water resources in the state are only about 1% of the total surface water resources of the country. Some studies were carried out based on secondary information as well as a few primary data sets collected during field studies. It was observed that the water level below the ground surface goes down very far, almost more than 50 meters. As a case study, we present here part of Alwar city (Ramgarh block) as an MI industrial area. The average annual rainfall in this region is less than 500–600 mm. According to the CGWB report, the groundwater has been declining by 25 cm per year to 2 m per year.

For this assessment, we collected selected water level data from few villages surrounding the MI industrial area during pre-monsoon and post-monsoon for case study. As per observation, the water levels are very low due to various uses of water. The collected data indicates that water levels from 55 to 122 m go down. There is fluctuation 0.5 m to 2 as rise or fall. It is observed that demand is higher than supply. According to the concept of governance and regulatory
measures, a geological and hydrogeological survey reveals that the topography, soil, aquifer, and geomorphological features are suitable for water conservation through rainwater harvesting and artificial recharge. GIS techniques will be used to analyse the various parameters that are responsible for the decline of groundwater level, such as structural geology, slope, aquifer, lineament density, rainfall, soil characteristics, etc.

Based on present situation, it was observed industrial growth is dependence on groundwater, that user has taken form of unsustainable over extraction, which lowering the water level and adversely impacting on drinking water security. Hence recharge is must at the same rate as discharge. Groundwater community will be analysed the necessity to construct different types of water conservation structures measures with Jal Shakti Notification 24th Sept. 2020 (CGWA guideline), State Water Policy, Govt. of Rajasthan, 2010 and State Groundwater Department directions 7th Dec. 2020. This study is concluded, industrial cluster will be form association with common fund under CSR and developing the ground water management and development within watershed along with local government agencies, gram panchayat, NGO if available, farmers and SHG group of womens.

Keywords: Groundwater, Community, Governance, Regulation, Hydrogeology.
11. Utilizing Food Based Waste Biomass as a Sustainable Platform for Water Indemnification

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ABSTRACT

Lately, cost effective and proficient adsorbents derived from waste biomass are strongly in demand due to their extraordinary capabilities and abundant availability in nature. Cellulosenanofibres (CNFs) derived from waste bio-masses are considered as one of the major breakthroughs in the category of biodegradable nanostructured adsorbents. Food based waste biomass being cheap and easily accessible has driven a huge interest in transforming the waste biomass into much valuable solid state adsorbents with tailorable selectivities for the isolation of harmful contaminants from water. Cellulose is a fascinating bio based material of almost inexhaustible quantity but faces major obstacles due to its water sensitivity and low relative strength. Improvement of these physical properties can be achieved by functionalization of cellulose using various inorganic moieties aiming at the production of stable cellulose based derivatives with increased adsorption capacity. These functionalized cellulose based nanomaterials offer wide applicability in removal of various harmful contaminants from water.

Keywords: Wastewater, Biomass, Cellulosenanofibers, Waterpollution.
12. Source of High Fluoride Concentration in Groundwater in Different Rock Formations of Rajasthan State

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Geologically, the state of Rajasthan is covered by the oldest Archean metamorphic rocks like Bhilwara Super group, Aravalli Super group, Delhi Super group, Vindhyan Super group, quaternary alluvial formations and aeolian sands.

In the eastern side of the state, the Vindhyan Super group rock formations exists, there are Aravalli Mountain ranges, trending in NE-SW direction, which is almost in the middle of Rajasthan state which are made up of Bhilwara group, Aravalli group and Delhi group of rocks.

To the west of Aravalli hill ranges, late Proterozoic to early Paleozoic Marwar Super group of marine sedimentary rocks exist. High concentration of fluoride in groundwater is observed in the hard rocks of Bhilwara, Aravalli and Delhi group of rocks which are part of Aravalli hill ranges.

In Rajasthan, in almost all the districts, groundwater is contaminated with high fluoride concentration. In western Rajasthan high fluoride concentration in groundwater is observed in marine sedimentary formations of Marwar group of rocks in Nagaur, Jodhpur and Churu districts. Besides Marwar group of formations, high fluoride in groundwater is also noticed in the Quaternary alluvium, Tertiary sandstones, and Mesozoic formations (particularly Lathi sandstone of Jurassic age) in Barmi, Jaisalmer and Bikaner districts.

In few districts like Kota, Bundi, Karauli, Dausa, and Jhunjhunu districts, fluoride concentration is not severe compared to the other districts.

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Abstract

Worldwide changes in climate conditions increase variability in precipitation leads to longer periods of droughts and floods, and directly affects availability and dependency on groundwater. Due to overexploitation of vital fresh water supplies, numerous people across India facing a serious threat to their livelihoods and food security. The alarming circumstances of water scarcity in Indian regions have recently received attention of government for sustainable ecosystem and to fulfill fresh water needs by focusing on future climate issues, water pollution and changes in available water resources. The present research provides a comprehensive view of the linkage between groundwater, climate change, and anthropogenic activities, with a focus on the India’s most water scarcity region Rajasthan. The substantial previous studies addressing the impacts of climate on groundwater through natural and human-instigated processes are reviewed. The condition of available groundwater quality in Rajasthan with respect to various contaminants is also discussed in particular zones. The study also reveals government previous state water policies, action taken to tackle water scarcity, technology adopted and future action plans in terms of demand and supply for efficient ground water management. The strength, weaknesses, opportunities and threat analysis on the most pretentious zones of Rajasthan provides more insights for the policy makers, researchers and academician for future research. Based on the previous studies, the sustainable practices implemented for optimum consumption of groundwater for different purposes and the possible groundwater-based adaptation strategies for climate change are also enunciated.

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Abstract

The present paper explains the experiences of implementation of participatory groundwater management (PGWM) processes in Atal BhujalYojna (ABhY) in Kachchh district of Gujarat. There is total five blocks considered for implementation of ABhY in district. Arid Communities and Technologies (ACT) is implementing ABhY in four out of five blocks as District Implementation Partner (DIP). ACT is one of the pioneer voluntary organizations has perused PGWM in many part of country and gained also helped to carve out road map for PGWM with various milestones such as (01) groundwater data collection and defining aquifer characteristics at village level; (02) use of geohydrological science for creation of water security plans for village; (03) implementation of supply side interventions; (04) implementation of demand side interventions and (05) setting up of village level groundwater management and governance mechanism. Grassroot level capacity building of respective stakeholders of a particular stage is the heart of entire PGWM processes. ACT made to types of attempts for inclusion of her ground experiences in implementation of ABhY in project blocks i.e., Mandvi, Anjar and Bhachau in total about 75 GPs. In initial stages in three blocks ACT has customized water security planning processes including capacity building activities according to guideline of ABhY. While in second attempt, adopted design@scale approach i.e., utilized experiences has been converted into community centric and BhujalJankar as Community Resource Persons controlled WSP processes by using Participatory Digital Attestation (PDA) - digital platform for capturing real time data and for holding capacity building activities at a scale. Designing of the capacity building on digital platform has included processes like, task and content development, holding virtual and guided training, designing a monitoring dashboard to monitor task performance by participants, compiling artifacts and data for final water security plan document. The entire process has involved about 65 CRPs, 04 cluster coordinators in block level, 02 PDA managers,
and 11 trainers. Implementation PGWM during Pre and during ABhY stages have three major learning one, involvement of community was time taking processes without use of digital technology but of course it was very in-depth process and scale was question mark, implementation ABhY with DIP centric process is able to reach scale but the community ownership was a question mark while use of digital platform for capacity building of community and planning gives the answers of both the questions i.e., implementation scale with penetration of knowledge among community and community owned process. In addition to this all the data and decision-making tools remains with community and records of such capable human resources with authenticity can be utilized for successive development project.

Key words: Participatory Groundwater Management, Community Centric Planning, Digital Platform, BhujalJankar, Design@Scale approach
15. Groundwater Recharge

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Abstract

Artificial recharge of groundwater is accomplished by placing surface water in basins, furrows, ditches, or different centers wherein it infiltrates into the soil and actions downward to recharge aquifers. A synthetic recharge is increasing used for short- or a lengthy-term underground garages, where it has several blessings over floor storage, and in water reuse. artificial recharge requires permeable surface soils, in which these are not available, trenches or shafts in the unsaturated sector can be used, or water can be at once injected into aquifers via wells. To design a machine for artificial recharge of groundwater, infiltration rates of the soil have to be determined and the unsaturated area between land floor and the aquifer ought to be checked for good enough permeability and lack of polluted regions. The aquifer should be sufficiently transmissive to keep away from excessive buildup of groundwater mounds. know-how of those conditions calls for area investigations and, if no deadly flaws are detected, check basins to predict machine overall performance.

Keywords: Artificial recharge, Water reuse, Natural, Groundwater recharge, Aquifers
16. Perspective on Groundwater Development & Management in Rajasthan

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Abstract

Ever-increasing demands for water from domestic, irrigation as well as industrial sectors have created a water crisis worldwide. Unfortunately, Rajasthan is the most water deficit state of our country, where each drop of water is as precious as a diamond. Increased demographic pressure and societal advancement result in an acute water shortage for drinking, agriculture and industrial purposes. Rajasthan is the largest state of India covering 10.4% of the total area of the entire nation. On the other hand, the State is having only 1.15% of the total water resources of the country to cater the needs for about 5.5% of the nation’s population. Ground water is the only dependent source in larger part of the state except in a few district areas, where canal water or surface sources are also available. Deeper water levels and inferior quality of ground water (highly saline, enriched with high nitrate and fluoride) followed by periodic occurrence of droughts and famines further deteriorate the situation putting tremendous pressure on limited available freshwater aquifers. Though the state is endowed with a lot of good cultivable land but inadequate rainfall and lack of water resources from other sources hamper good agriculture production. Industrial development also greatly suffers for the want of water at suitable locations. As result of an increase in hydrochemical parameters, lives of human beings, flora and faunas have been adversely affected which in turn has affected their socio-economic status. Therefore, for sustainable development proper management efforts must be made viz. maximum utilization of rainwater by reviving and strengthening traditional water harvesting structures, proper soil conservation measures by afforestation, watershed development, artificial recharge of groundwater, Dry farming, drip, and sprinkler irrigation techniques have to popularize to minimize the use of water for irrigation, installation of reverse osmosis plants, Defluoridation plants and above all it is exigence to educate and create mass awareness amongst consumers of water for its judicious use.

Keywords: Demographic pressure, acute water shortage, highly saline, periodic occurrence, maximum utilization, rain water
17. A Case Study - Rain Water Harvesting

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Abstract

Water scarcity is a serious problem throughout the world for both urban and rural communities. Rainwater harvesting is defined as the process of augmenting the natural infiltration of rainwater or surface water into the ground by some artificial methods. In rooftop harvesting, the roof becomes the catchment and the rainwater is collected from the roof of the house/building it can either be stored in a tank or diverted to a recharge pit etc. This method is less expensive and very effective and if implemented properly helps in augmenting the groundwater level of the area. The methods of rooftop rainwater harvesting are recharge pit, recharge trenches, storage tanks, abandoned dug wells, bore well. The present study tells us 2, 87, 536 liters of water harvested per year in four numbers of underground storage tanks. 
Keywords: Catchment, drain pipe, filter, storage, tank
18. Correlation and Regression Analysis- An important tool for ground water quality assessment

Swati Saxena & A. K. Sinha

Abstract:
The present review deals with the significance of statistical analysis in ground water quality monitoring. Systematic study of correlation and regression among water quality parameters proves itself important in assessment of actual water quality of a particular area and also quantify relative relationship of various pollutants which in turn is very useful for implementation of various water quality management programs. The parameters having significant and moderately correlation coefficients exhibits linear relationship between them and one parameter can be easily predicted on the basis of another. Scatter plots and applied regression model evaluate genuine relevance and utility of these relationships.

Key Words: Ground Water, Statistical Analysis, Correlation coefficient, Regression equation, Water Quality Assessment.
19. Sustainability of Ground Water in Barmer, Rajasthan

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Abstract
Demand of groundwater in Barmer area is increasing day by day for drinking and irrigation purposes therefore need detailed hydrogeological investigation. Barmer district is located between 24° 58' to 26° 32'N latitudes and 70° 05' to 72°52’ E longitudes and occupies 28,387 km² area. The district having a population 2,603,751 as per census 2011. Barmer area is situated in the central part of the Thar desert and fall under extreme arid condition where annual rainfall is about 150mm. Luni is the only existing seasonal river of the area originates from Naga Hills of Ajmer district is flowing along Balotra (Barmer) and Jalore area. No surface water body exists in and around the city area. Total water requirement of the district is fulfilled by groundwater extraction and rain water harvested in Taankas (underground tanks). The geological succession of Barmer area is represented by rocks of Proterozoic to Recent age. Surface exposures of Malani Volcanic suite (750 Ma), Cretaceous-Carboniferous sedimentary formations and Recent Aeolian sands occurs in the area. Hydrogeologically, Quaternary sand largely forms semi confined to unconfined aquifer and part of vadose zone. Aquifers of semi consolidated formation of Cenozoic and Mesozoic age are unconfined to confined in nature and weathered and fractured zone identified in volcanic hard rock form poor unconfined aquifer. More than 1000 wells were identified for monitoring of water levels and quality for entire Barmer district including Barmer city. In 10 km radius of city, 85 groundwater wells are identified for urban monitoring. Groundwater level range from 20 to 150m bgl. EC value range from 1000 to 6500 µs/cm. 150 to 225m deep tube wells are constructed in the area using rotary drilling rig with circulating mud. For casing purposes, cement blank pipes and cement slotted pipes are used in place of galvanized iron castings to overcome salinity problems. However, the cutting of the slots is localized and the openings are not enough, resulting in lower well efficiency and thus requires higher energy for pumping of groundwater. Since the water levels are deep down to 100m, 20-40 horsepower submersible pumps are used.
The pump is installed at a depth of 90-
120 m. To run such higher capacity pumps need to separate transformer for each well.
Sprinkler and drip irrigation method are mainly used in study area. Main crops are Bajra,
Moong, Til and Jawar. Jeera is a cash crop of the area. Water levels and discharge of deeper
wells largely remained constant for last 20-25 year as reported by farmers through small
variation in EC can be observed.
20. Conservation of Subterranean Flow in Solving the Acute Drinking Water Crisis in Andaman and Nicobar Islands and Its Wider Applicability: Examples From the Equatorial Islands and Semi-arid Purulia District, W.B.

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Abstract
Inspite of copious rainfall, rugged topography, size, and shape of the Islands, steep slope, low in filtration capacity of the geological formations and close proximity of the hills to the sea are the reasons for low ground water potentials in the major parts of the archipelago. Simultaneously the dearth of good catchments, geological constraints, and environmental regulations, are the handicaps for surface water development. Thus, the development of Water Resources including surface and groundwater resources as also their management in the islands has been a perennial problem in the archipelago. The research and development (R&D) work in the Islands has revealed a good prospect of watershed development through conjunctive use of surface water and ground water, combined with rainwater harvesting, artificial recharge, and subsurface water conservation. There was the stupendous impact of the 26.12.04tsunami and devastating earthquake (M=9.3) in the islands on the water resources as a whole and ground water resources in particular. Studies conducted have been highly useful for the successful construction of various water resource augmentation structures. The structures include the subsurface dam, recharge shaft, check dam, collector wells, dug-cum-bore wells. The outcomes of the studies are proved applicable elsewhere for the augmentation of water availability. Case studies in A&N Islands and in the water-scarce Purulia district, West Bengal are considered to put forward the wider applicability of the water augmentation techniques in similar hydrogeological setup else where in the globe.
21. Geophysical and Hydrological Investigations for Saraswati River Palaeochannel in Kurukshetra District

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Abstract
Palaeochannels are remnants of rivers or stream channels that flowed in the past and have been currently filled or buried by younger fluvialite sediments. The palaeochannel is one of the promising features to hold a considerable amount of groundwater and acts as an underground reservoir for supplementing groundwater resources. The present study is an attempt to identify the presence of Saraswati river palaeochannel using VES, ERT, hydrogeological and geochemical studies in this part of Kurukshetra district, Haryana. Fourteen ERT surveys were conducted along and across the Sarusti Nala in Garhi Roran and Indbari villages of Kurukshetra district, Haryana for preliminary information about the course of Saraswati river palaeo-channel. The ERT results show three distinct subsurface layers up to the depth of 20 m. Highly resistive third layer gives the first clue about the presence of the palaeochannel in the study area. Vertical Electrical Sounding (VES) surveys were conducted near Garhi Roran and Indbari villages in the Kurukshetra district. The VES results delineated a palaeo-path from 15 to 50 m depth of high resistivity 170-780 Ω-m. The width of the palaeochannel in the study area is interpreted as about 10-12 km. The hydrological data analysis shows a high productive zone of good quality groundwater. Longitudinal unit conductance (S) and Transverse unit resistance (T) analysis also indicates the existence of palaeochannel in the study area.

Keywords: Saraswati River Palaeochannel, ERT and VES Survey, Kurukshetra.
22. Hydrogeophysical Study for Well Design in the Largest Onshore Oilfield of Barmer Basin in India

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Abstract

Barmer basin located in the western part of Rajasthan is the largest discovered onshore oilfield in India which requires a large volume of saline water to support oil field development. Detection of such a huge line water resource with no practical use for domestic or irrigation purposes is a big challenge. Salt water intrusion and upcoming in saline aquifers are common phenomena brought due to the flow of saline water into freshwater aquifers originally caused by groundwater due to wrong casing design of water wells which has been recognized as a major concern around the world.

This present paper describes the recommendation of the borehole design during the installation stage in order to prevent the intrusion of saltwater into the freshwater system. The objective of the study is to identify the unscientific mode of water well construction which causes saline water upconing affecting the cropping patterns and the potability of water which directly alarms the livelihood of the concerned area. The salinity of the aquifer also increases due to the wrong placement of the production screen of the water well against the desired water-bearing zone and due to the wrong use of packing material in the well annulus. Clogging of well is also a common phenomenon due to the wrong selection of slot size of screen because of which the yield of wells as well as the quality of water deteriorates. Therefore, water wells must be properly designed to ensure long life, efficiency, and economic operation.

A proper hydro geophysical study is a prerequisite for the design of water wells. The wire line geophysical allogging data delineate fresh and saline water zones. The use of geophysical logs aided by detailed lithological logs provides sequence of formation sand their area extent when correlated between wells and can identify aquifer tops and bottoms. The precise identification of
quifer top sand bottom will help place the casing and screen against desire daquifer zone as well as place the packer to separate fresh and saline zone with in abore hole. Three distinct groups of permeable granular ones separated by impermeable zone shave been identified. The spatalexten tof the aquifer has also been mapped with help of seismicre flection data. Brackish groundwater occurs at the top and becomes highly saline at the bottom with a range of 5000mg/L to 10000mg/L. This large static groundwater resource below ~350m depth has been identified as a suitable aquifer for saline water abstraction to meet the long-term saline water requirement of oilfields in Barmerbas in which is not likely to deplete the limited dynamic shallow groundwater resources. Therefore, this study is aimed at reducing the challenges encountered in groundwater exploration and exploitation in the part of Barmer basin through the use of existing borehole logs in predicting and separating the freshwater and saline water zones both vertically and laterally by estimating depth to drill, lithologic unit variation, placement of screens during borehole developed and recommending buffer zones at minimal cost in the exploitation of groundwater.

Keywords: Salt water intrusion, Well Design, Casing, Salinity, Hydrogeophysical
23. Advance Scientific Monitoring of Groundwater: A Case Study of Western Rajasthan

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Abstract

One of the most important pioneering inventions for the energy sector of India of this century is the largest onshore oil and gas field in the Barmer Basin of Western Rajasthan. The crude oil of Barmer Basin is highly viscous and requires hot water injection to maintain reservoir pressure and voidage replacement to improve oil recovery. The area being arid and consequently the scarcity of fresh water resources is a limiting factor in the economic development of the region. Therefore, the stress on the limited supply of freshwater is high and the same is not being replenished to the extent that it is being utilized. This necessitated under taking the challenging task of as aline water aquifer that has no practical use for potable purposes. Based on the detailed hydrogeophysical investigations with use of sub-surface data associated with oil field exploration and production mainly seismic, petrophysical, lithological information coupled with hydrogeological study, a 800m thick deep confined aquifer zone located 350m BGL consisting of well sorted, medium to fine grained sand separated by a geological structure from the unconfined freshwater system has been identified with salinity ranges from 5500 mg/L to 10000 mg/L.

This paper summarizes the advance scientific periodic monitoring of groundwater from dedicated monitoring wells within the unconfined freshwater and confined aquifer, Government Water Department monitoring wells and Hydrocensus wells for pre and post monsoon monitoring to effectively manage the aquifer through optimal abstraction of saline water without any adverse effect on the fresh water system. It aims at sampling and collection of groundwater from the monitoring wells and to analyze the major, minor and trace parameters twice a year during pre and post monsoon from advanced government accredited laboratory for identification of any particular threat and depth to groundwater measurements from each monitoring well from water level
recorder with telemetry to evaluate overall water level trends throughout the area. Field data is being collected at regular intervals to create a long-term regional hydrogeological database and to update existing groundwater models to improve impact assessment.

A sustainable strategy is planned as part of compliance and social responsibility with an extensive network to monitor the temporal and spatial variation in hydraulic head and salinity to determine the impact of saline water abstraction on the shallow freshwater system. The monitoring wells are screened at the top, middle, and bottom portion of the freshwater lens fitted with multi-parameter transducers to monitor aquifer pressure and electrical conductivity continuously. Thorough monitoring has aided in the development of decision support systems, which use model simulations to forecast the aquifer behavior under various temporal and spatial stresses. Numerical flow and solute transport simulation has further helped to optimize the pumping rate and inter-well spacing criteria. This study provides the opportunity to demonstrate judicious utilization of oil field data in defining the deep groundwater aquifer without creating environmental impact and any conflict with local stakeholders.

Keywords: Monitoring, Aquifer, Salinity, Barmer, Modelling
24. Integrated approach of Groundwater exploration in the Jaisalmer sub-basin of Thar Desert using Geophysical and Remote sensing methods

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Abstract

Thar desert is a unique arid ecosystem that is densely populated unlike other deserts of the world. Jaisalmer basin is rich in sand dunes and desert. Below-average moisture conditions and scanty rainfall makes it a drought-prone area. Exploration of subsurface aquifers is important to bring relief to local people who face absolute water scarcity all year round. Active and Passive remote sensing methods offer an important tool to collect important surface data for groundwater exploration. Remotely sensed data along with secondary data was used to generate a thematic map for various parameters like slope, elevation, lineament density, drainage density, and dunes mapping. Geology, geomorphology, and hydrogeology data were integrated to delineate potential zones of groundwater. The resistivity survey carried out at thirty-seven locations revealed eighteen probable sites for groundwater extraction.

Keywords: Jaisalmer basin, Remote sensing, Groundwater exploration, Resistivity survey.
25. Assessment of Physico-chemical Parameters & Uranium in Ground Water of Different Blocks Churu District in Rajasthan

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ABSTRACT

Water is not only essential for drinking but also needed for agriculture and industrial use. The Physico-chemical analysis of ground water quality of different blocks of Churu district in Rajasthan has been studied. The water samples were collected from different sites including dug wells and hand pumps in all blocks of churu district. The suitability of water for safe drinking and irrigation purposes has been studied in the area. The different parameters measured are pH, electrical conductivity, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, chloride, nitrate, fluoride, carbonate, bicarbonate & Uranium. From the observed data it has been found that few parameters were found to be above permissible limit of drinking Water like Total dissolved solids in 50.00 % samples, Fluoride in 38.89%, Nitrate in 68.52% & Total hardness in 31.48 % of samples. The study also indicates that in 25.93 % samples, uranium content exceed the acceptable limits for drinking water. Due to the high concentration of fluoride, dental fluoros is was also identified in the study area. In the Study area nitrate beyond the acceptable limit has been observed in most of blocks and the highest nitrate value has been observed to be 1350mg/L at Bobasar, Sujangarh block of Churu district. The high values of fluoride have been found in Ratangarh, Rajgarh & Sujangarh blocks in Churu district with highest value of 10mg/L at Bobasar, Sujangarh block of Churu district. The total hardness upto 2700 mg/L (highest at Bobasar, Sujangarh block) has been observed in the Churu district. From the analysis it has also been observed that some of the sites are contaminated by high uranium in few pockets of all blocks of Churu districts with highest value of 210 microgram/L (ppb) at Kolasar, Sujangarh block. Few of the remedial methods have also been discussed.

Key word; Fluoride, Uranium, Ground Water,
26. Arsenic Contamination Leading to Escalation of Health-related Issues in West Bengal, India

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like skin irritation, respiratory, cardiovascular, hematological disorders, diabetes, genotoxic etc.,
are experienced due to exposure to inorganic arsenic. In this paper, the status of arsenic toxicity
and its mitigation measures are focused so far. The imperative actio

Abstract

Arsenic is a naturally occurring component in air, water and land. It is highly toxic in its
inorganic form but organic form is less harmful as found in sea food. Inorganic arsenic is present
in the groundwater in countries like Argentina, Bangladesh, Chile, China, India, Mexico and the
USA. Its contamination is high in West Bengal also. It has been first detected in 1978 in West
Bengal. Presently, about 72 blocks in 8 districts in West Bengal are arsenic affected. This
toxicity is having adverse effect on health of the populace of West Bengal. The stratigraphic
study reveals arsenic prone aquifers occur in the southern part of West Bengal beneath the
alluvial plain. The health ailments for affected communities is providing safe drinking water,
food preparation irrigation for food crops. Community participation, educating about the
problem and innovative governmental measures will help to curb this grave problem. Under
2030 Agenda for Sustainable Development, the indicator of safely managed drinking water
services demands for access to population of safe drinking water which is free of feecal
contamination and chemical contaminants like Arsenic.

Keywords: Arsenic, toxicity, cardiovascular, stratigraphy, aquifers.
27. Fluoride Pollution in Ground Water- An Overview

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Abstract

Ninety-seven percent of the freshwater that is easily accessible worldwide comes from groundwater. The majority of rural Indians rely on groundwater for drinking. Being the surface that is more accessible, Water supplies are already in high demand, and groundwater is under increasing pressure. Groundwater has traditionally been seen as a dependable and secure source of water, shielded from contamination at the surface by geological filters that clean the water as it percolates through the soil. These contaminants are not completely absent from still ground water. Because the ground water is used for so many things, it might be contaminated. It includes harmful chemicals, soluble detergents, fertilizers, and municipal, hospital, and other waste that is both biodegradable and nonbiodegradable. The organic nitrogen compounds in the waste could cause both reversible and irreversible changes in the body. The physical characteristics of this water, such as its color, flavor, and aroma, are also altered by this waste. It causes several illnesses and health issues for people. The obvious pollution of surface water draws a lot of attention. In India, fluoride pollution of water has been recorded in 19 states, and arsenic contamination has been confirmed in at least 10 states. Groundwater is becoming more and more at risk from overdevelopment, overextraction, and pollution as a result of rising pollution levels, increasing population pressure, rising living standards, industrialization, and a lack of effective management to balance changing demands and resource use patterns.

Keywords: Groundwater, Contamination, Prevention.
28. Relationship of Piezometry with Electrical Conductivity and Chloride Distributions, Dhund Basin, District Jaipur (Rajasthan)

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Abstract:
Dhund River, a tributary of Morel River, forms a north-south elongated basin in the semi-arid terrain of District Jaipur. The northern part of the basin is hilly where topography is undulating. The altitude ranges between 270 and 653.0 m amsl which decreases towards south. The isohyets show that the rainfall increases from south to north. The average rainfall is 627.0, 587, 565, 614, 594 and 642 mm for the rain gauge stations located at Amer, Jhotwara, Sanganer, Bassi, Chaksu and Jamua Ramgarh, respectively. Granite-gneiss, quartzites and alluvium form the aquifers. Quartzites form the basement roughly in the northern - half of the basin and the southern - half of the basement is occupied by the granite gneisses. Alluvium is deposited on the basement having a maximum thickness of 99.6m. A thin veneer of Aeolian sand overlies the riverine alluvium. Groundwater occurs under phreatic conditions. Depth to Water ranges from 24.20 to 65.40 m bgl (Period: May, 2010). The well hydrographs, for the period from 2000-2010, show that there is a progressive decline in water levels ranging from 0.807 to 3.665 m/year. The flownet analysis shows that groundwater flows from NW-SE and NE – SW. The flow lines converge along Dhun River. The electrical conductivity (EC) and chloride ranges from 565 to 20070.0 micro mhos/cm and 7 to 6390.0mg/L, respectively. The EC and chloride distribution maps superimposed over the flow net map show that the piezometry has direct relationship with the EC and chloride distributions. The EC and chloride increase in the direction of groundwater flow. However, in the SE part of the basin there is an abrupt change in the EC and chloride values. Groundwater is saline here, it is manifested as salt incrustations along the inner peripheries of the dugwells. The area is free from urbanization and any industrial activity and hence the possibility of anthropogenic pollution does not exist. The spurt of this magnitude in the EC and chloride is irrefutably due to a subsurface geogenic source. This could be due to an evaporate body hidden below.
29. Comparative Assessment of Fuzzy, AHP and Integrated Fuzzy-AHP Methods for Demarcation of Groundwater Recharge Prospective Zones

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Abstract

Groundwater recharge plays a crucial function in hard rock aquifers, where occurrence, movement and availability of groundwater have restrictions. Keeping the significance of recharge areas in view, the thematic layers of relevant parameters such as landforms, lithology, land use pattern, stream density, lineament density, terrain slope, soil and rainfall were generated using GIS. The analytical hierarchical process (AHP), fuzzy logic and integrated fuzzy-AHP methods of multi-criteria decision analysis (MCDA) were used to get the weights to be assigned to various feature layers and these feature layers were merged using a geospatial tool to delineate Groundwater Recharge prospective Zones (GWRPZs). The resultant maps of AHP, fuzzy logic and integrated fuzzy-AHP methods were categories into four zones: very low, low, moderate and high. The maps were validated with the groundwater fluctuation data of 34 dug wells using the receiver operating characteristic (ROC) method, depicting an accuracy of 67.28%, 74.90% and 75.67% respectively. This study revealed that integrated AHP-fuzzy logic method has high accuracy and could be preferred over other MCDA methods in delineating groundwater recharge areas.

Keywords: AHP, fuzzy logic, GIS, groundwater recharge potential zones, ROC.
30. Monitoring the Spatio-temporal Changes in Groundwater Resources of Maharashtra State Using Grace Satellite Data

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ABSTRACT

Maharashtra state is dominantly occupied by Deccan Volcanic Basalt representing simple and compound flow units. These rocks possess secondary porosity due to weathering, fracturing and jointing imparting heterogeneity to the aquifer system vis-à-vis the availability of groundwater. The state frequently faces water scarcity issues wherein dependency on groundwater is more and therefore the characterization of this key resource is essential. Rainfall is the major source for aquifer recharge. Hence, rainfall-recharge relation has to be decoded for the groundwater storage estimation to address the scarcity issues. The monitoring, assessment and identification of groundwater has become effective due to RS-GIS techniques wherein GRACE satellite data usage is becoming a part of research studies. The present study is performed using the Total Water Storage (TWS) data of the JPL TELLUS GRACE Level-3 Monthly Land Water-Equivalent-Thickness Surface Mass Anomaly Release on NASA PODAAC Drive to understand the fluctuation of groundwater levels for every quinquennial (5 yearly) from 2011 to 2021 and its correlation with rainfall.

Keywords: Groundwater estimation, GRACE data, TWS, recharge
31. Monitoring of Spatio-temporal Changes in Groundwater Quality and Depth through GIS in Kurukshtera District, Haryana

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Abstract

The availability of groundwater is vital for overall development of society. Fast increase in human population, increasing urbanization and industrialization have caused intense stress on groundwater resources especially in developing countries. Spatio-temporal monitoring of groundwater is important for sustainable development and management of the water resources of a region. It helps in identification of critical zones and devising appropriate strategies to deal the problem. Kurukshetra is a part of Indo-Gangetic alluvial plain situated between 29° 53’00” to 30°15’02” north latitudes and 76° 26’27” to 77° 07’57” eastern latitudes comprising an area of 1684 sq. km. There is no perennial river in Kurukshetra district except few canals which play important role in irrigation. The base map has been prepared using SOI topographical sheets on 1:50,000 scale. A total of 97 observation well data was used for the years 2010, 2015 and 2020 for spatio-temporal analysis of depth to water level and groundwater quality over five year interval. Inverse Distance Weighted (IDW) technique of interpolation was applied to prepare depth to water level and fluctuation maps. The data from the year 2010 indicates that 45% area of the district has come under the depth to water level range of 30-35m. In the year 2020, 40% area of the district has reached in the range of 40-45m which is a severe decline in comparison to 2010. The results indicate that there has been a severe decline in depth to groundwater levels in the northern region of the district followed by central and southern region in last 10 years. It further indicates that the quality of groundwater falls under suitable to permissible category in the district. The integrated map of the area will show the suitability evaluation of groundwater for domestic purpose in detail.

The dominant reasons for this acute depletion of groundwater depth are excessive usage of
groundwater resources for irrigation in farming activities. The remedial measures to cope up with this critical issue include recharging of groundwater, crop diversification focusing on less water requirement crops, creation of farm ponds, sprinkle irrigation and introduction of various government schemes like MeraPani Meri Virasat etc.

Key words: GIS, Groundwater, Spatio-temporal distribution, Kurukshetra, India
32. Recharge of Underground Reservoirs by Surface Drainage and Puncture in Earth surface

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Abstract: Water is one of the most essential human needs which impact all aspects of life like agriculture, energy, health, and livelihood. The management of this resource is important to protect and promote sustainable development. It focuses to build capacity to reduce the risk through effective planning of Preparedness, Response, Recovery, and Mitigation. The conservation and management of water resources are the most basic challenges that we face today. The Indian Rivers Inter-link mainly focus on effective management of water resources in India to enhance irrigation, groundwater recharge and reduce persistent floods in some parts and water shortages in other parts of India by linking Indian rivers to a network of canals, reservoirs and lakes. The effective management of the flood can be utilized to overcome water scarcity, variability and disaster management. Both infrastructure and governance will have to be expanded to achieve this objective.

Water harvesting is used as a tool for ground water recharge since ancient times. Surplus rain water should be stop from run away. Runoff will cause flood disaster situations in low lying area’s and scarcity in the same area to where actually it belongs. Arid zones where rainfall is below average level, if anyhow the access flood water is diverted will be dual beneficial. It will reduce the flood disaster in low lying area’s and will increase natural recharge in arid zones resulting in prosperity in both I.e. flood affected area’s as well as in arid area’s increasing irrigation along with drinking water facility. Artificial recharging is traditionally adopted solution for water scarcity problem in the arid and semi-arid zones such as Middle East countries since thousands of years. Many countries of middle-east are focusing on new methods for water harvesting and artificial recharge in arid and semi-arid zones but if access flood water is diverted and spreads will more effectively recharge surface and subsurface aquifers. Subsurface reservoirs may be recharge by puncturing Earth surface (Existing or new Bore wells).
This study is conducted for diverting access flood water of Sutlej, Beass and Yamuna River towards Rajasthan (arid and semi-arid area’s) Shekhwati region. All the surface and subsurface water bodies may recharge. The performance and hydrological function of an improved water harvesting technique, referred to as the floodwater spreading system, in arid Iran.

However, this study showed that, with balanced pumping (artificial recharge), the floodwater spreading system may be an effective mean to increase surface and subsurface water resources in arid and semi-arid areas. Further more research is required to maximize the floodwater recharging. Improvement is required to manage the uncertain magnitude of inflow of flood water.

Key words: Water scarcity, water harvesting, Natural recharging, artificial recharge, floodwater spreading, subsurface aquifers, arid zone, semi-arid zone and Shekhawati.
33. Ground Water Community Participation, Governance and Regulation, Atal Bhujal Yojana

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Abstract: Groundwater is a necessity for the community including farmers, especially in areas where the rainfall is very less. After the green revolution, the irrigation system in India has encouraged irrigation agriculture initially through surface water storage dams, rather than groundwater. Numbers of Indian agricultural statistics show a significant rise in groundwater irrigated areas from 0% by tube wells in the middle of the 20th century to around 40% in the start of 21st century, while usage of open wells in irrigation has decreased from 29% to 22.5% in the same period.

This clearly shows that India’s agriculture is mainly dependent on groundwater than on surface water and there is a decrease in the use of open wells for irrigation while there is a significant increase in the use of tubewells, indicating an on-going depletion of groundwater from aquifers. Groundwater is also the main source for drinking purposes, supplying nearly 90% of rural drinking water as per DDWS report in 2009. Though the drinking water supply share is only about 7% of total water use, the groundwater extraction for agriculture purposes has started threatening drinking water supply, firstly through an overall shortage of water, and secondly through water quality deterioration.

Rajasthan gets very less rainfall compared to the other regions of India. Out of the total rainfall, a big portion is at the start of the rainy season which mainly builds the soil moisture and is also lost to evaporation because of the arid conditions. The amount infiltrating through the soil mass to add to groundwater storage is nearly 5-7% in areas underlain by hard rocks and 10-15% in alluvial areas.

There is continuous increase in groundwater draft due to increasing population, urbanisation and industrialisation. Out of 295 blocks, with 3 saline blocks, around 203 blocks the draft has exceeded the estimated replenishable resource. In 33 blocks, the stage of development has reached Critical levels in 23 blocks and semi critical levels in 29 blocks (groundwater resource estimation 2017) leaving only 37 blocks in safe category. Any further increase in the draft will deteriorate the already worsened situation of depleting water levels and/or worsening water quality in some areas.

Groundwater is the common shared resource used by lakhs of farmers in the country and is still the major drinking water source for rural water supply. It is also used for industrial purposes. Reducing water resources and continuously increasing demand of these important resources require finding, quantification and management of groundwater in such a way which stops overexploitation and resultant economic and environmental damage, and in parallel satisfying demand for water supply of competing sectors. Participatory groundwater management is envisaged to make an important step in groundwater management at ground level to enable the
society and the stakeholders to be vigil and manage the groundwater as common pool resources themselves.
It is very important to have a participatory groundwater management programme to implement sustainable groundwater management effectively, which would need a well planned effort incorporating different government departments, research institutes, PRIs, civil society organisations and the stakeholders at the village level who would lead combined sharing and use of groundwater based on a deep understanding of the storage and transmission characteristics of different aquifers.

The implementation of sustainable groundwater management is proposed through collaborative approach amongst the stakeholders mentioned above. The stakeholders would also include farmers, landless farm workers with enough representatives from SC, ST and Women categories. Consensus based decision building is the aim of the local Water Users Association. Gram Sabha is proposed to be the final decision maker in case of disputes and for setting up some basic regulatory norms under the PRI system. The programme envisaged activities towards building capacity, skills and knowledge to groundwater users.

The important way to educate the community is through an intensive capacity building of rural youth mainly, known as Bhujal Jaankars. These Jaankars are trained in their local settings through relevant knowledge and practical exercises, enabling them to perform a geo-hydrological evaluation of their area, monitor groundwater and share their findings and experiences with the people in their village.

The objective of Atal Bhujal Yojana is to demonstrate community led sustainable groundwater management mainly through convergence among various ongoing schemes with the active involvement of local community and stakeholders. It also aims at bringing about behavioural change at the community level through awareness programmes and capacity building for fostering sustainable groundwater management.

Groundwater Governance: Groundwater governance includes promoting responsible collective action to ensure control, protection and socially-sustainable utilisation of groundwater resources and aquifer systems for the benefit of mankind and dependent ecosystems. Groundwater governance has four components:
• An effective and articulate legal and regulatory framework.
• Accurate and well spread knowledge of the groundwater systems concerned, along with awareness of the sustainability challenges.
• An institutional framework with leadership, strong organisations and enough capacity, permanent stakeholder engagement, and working mechanisms to coordinate between groundwater and other sectors.
• Policies, plans, finances and incentive structures aligned with society’s goals.

Regulation: Looking at the continuous depletion of water tables in Rajasthan and increasing over-exploited blocks, in the budget honourable chief minister of Rajasthan announced to establish groundwater management and conservation authority for the better governance of groundwater regime.