



INC of IAH

Indian National Chapter of International Association of Hydrogeologists



E- News Letter

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August 2019

Vol. 6, No. 2

Messages

From Desk of the Patron



Ground water is 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. With increasing importance of ground water, the role of Hydrogeological fraternity has enhanced significantly and hence the institutions like IAH. One of the key role such institutions can play is promoting exchange of ideas and research findings for the benefit of all. INC of IAH e-News Letter is a medium by which readers would come to know about latest developments / research studies and findings in the Ground water sector. It is a matter of pride that the new editorial committee has brought out its first e-Newsletter in the shortest and apt time when Jal Shakti Abhiyan of the Government is in full swing.

I convey my warm greetings and best wishes to the newly elected committee for all future initiatives

**K C Naik, Chairman
Patron, INC-IAH**

Central Ground Water Board,
Government of India,
Ministry of Jal Shakti Department of
Water Resources,

From President's Desk



I am writing this note with a sense of pleasure, as you are all aware that in the recently held election for the new Executive Council, under the able supervision of the Election Officer Sri Ashis Chakraborty (Former Member, CGWB), myself along with Prof A.K. Sinha and Dr. Dipankar Saha won keenly contested election as President, Vice President and Secretary respectively along with a new team of executive members. At the outset, I wish to thank Sri Chakraborty profusely for the smooth conduct of this election.

This issue of the e-Newsletter, is the first one being brought out by our new editorial team. I congratulate and welcome all my colleagues in the newly constituted Executive Council (EC). Further, on behalf of the whole EC, I express my deep sense gratitude to all the members of the INC of IAH for reposing faith in our teams as per our 'Future Vision'. Yet, in this process, I do not wish to belittle the efforts made by the outgoing team under the able leadership of Dr DK Chadha, former President, INC-IAH. As per 'Future Vision' for the INC, our principal attempt would be to impart to this body a more academic orientation by steps like recognition of academic accomplishments of the younger members and by starting an Online Research Journal on regular basis. I am also thankful to the New EC for supporting the earlier decision of the outgoing EC to organize a National Conference on "Groundwater Management in Mining and Social Sectors" in Ranchi on Sept.21, 2019.

I do hope that you will find this issue of e-Newsletter informative. Nonetheless, your suggestions to improve the e-Newsletter are most welcome and are solicited in all earnestness. I, on behalf of the whole EC of INC-IAH, greet all its members on the eve of India's 73rd Independence day.

Prof. D.C.Singhal, President, INC-IAH

Editorial Box

We are delighted to present this issue of the e-news letter. The preceding editions of this newsletter were instrumental in shaping this new issue and the entire credit goes to the previous team members for their hard work which we are building upon. In this issue, we have tried to stay true to our roots and maintained a lot of what made the previous issues so successful and admired. However, borrowing from suggestions and our own experiences, we have tried to make the e-news letter more interesting. Our main aim in this issue is to involve the people of groundwater fraternity to a larger extent and we hope to achieve that. Lastly, this news letter is yours' and we would love to hear suggestions to make it more interesting. Your ideas will help us in designing the next issue. Finally we would thank all the Authors for their contributions within a very span. Finally, we wish all our fellow Indians a very happy 73rd Independence Day..

- Ranjan Sinha, Dr. Sudhanshu Sekhar, Dr. B.S.Chaudhary

EXECUTIVE COUNCIL (2019-21)

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Prof. D. C. Singhal
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Prof. A. K. Sinha
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Vice-President's Message



At the very outset I wish you all a very Happy Independence day , Happy Raksha bandhan and Happy Shrawan Purnima marked by good health, good humor as well as by some innovative and inspirative ideas and initiatives. I wanted to reach you all one to one but some unforeseen short term responsibility forced me to postpone my outreach till I got an opportunity to share my feelings with you through this first News-letter being issued by the new INC-IAH team. Being fortunate to be part of the two year cycle of INC IAH EC, I take this opportunity to greet all of you on assuming the charge of INC-IAH Vice-Presidency. It was your decision which put me in this role and I feel a deep gratitude for the trust you reposed in me and at the same time a grave responsibility which this position requires.

The newer challenges are unfolding as the INC-IAH is slowly coming to age. As a one of the premier scientific societies of the country, we are required now to support the aspiration of the growing groundwater user community not only to sustain the groundwater resources but to sustain the INC- IAH itself. Therefore we not only need to strengthen it but also to make it accessible and supportive to the community as well as to the Policy makers. Despite increase in the membership of INC-IAH during recent past, more and more professionals and students need to be brought under its aegis. As activities of the INC IAH cover almost every aspect of a hydrogeologist's life, we need to promote many such activities in all parts of the country which helps our youngsters in choosing a career of hydrogeologist.

In the coming days greater emphasis would have to be laid on transforming innovative ideas in to usable and workable outputs through research. The INC -IAH platform may become a vibrant forum for undertaking research through meaningful collaboration at various levels. I foresee organization of INC IAH supported Schools and Hydrogeological weekends, lectures by INC IAH experts activities which are needed to strengthen INC-IAH in general and our young budding hydrogeologists in particular.

Prof. A. K. Sinha

Vice –President, INC-IAH

Secretary's Column



It is extremely heartening that in its first Meeting of the newly elected INC IAH Executive Council 2019-21, the decision has been taken to strengthen and regularize the e-Newsletter. Previously also commendable efforts was taken to publish it by earlier coordinators.

The groundwater resource development and management in India is at cross road. At last, it appears that the political system and the policy makers are reckon with the importance of sustainable management of groundwater. All around discussion is going on about supply and demand side interventions so that every drop of groundwater counts and we strive hard to live within the dynamic resource as far as possible. Even the Hon'ble Prime Minister of India emphasize the wisdom and urgent need of harvesting water to rejuvenate the depleting groundwater resources.

IAH India Chapter should play a significant role in this juncture. It is the largest association of Professional Hydrogeologists on the earth. In India also the IAH has a strong foot print. The most heartening fact is that the young and budding groundwater lovers are showing interest and becoming members.

I personally request all our members to contribute in future e- Newsletter. It should be enriched with relevant information, latest happenings and also achievement of our members in the domain of groundwater. Pl contribute in plenty. Sh Ranjan Sinha is taking all efforts to publish it with able support from Dr. Sudhansu Sekhar and Prof. B S Chaudhary. This issue would come out in the month of August 2019, I therefore take this opportunity to wish you all a very happy Independence Day and also let us remember those who have given their life and everything during independence struggle.

Dr. Dipankar Saha

Secretary, INC-IAH

A Quick Glance to the Journey of Ground Water Development in India

Dr. S.P. Sinharay Member CGWB (Retd); Emeritus President, CGWS;
Chairman, fluoride task force & Convener arsenic task force, Govt. of West Bengal



Ground Water has its own role in India since pre-historical times. In pre-Independence days also, it was increasingly being important in drinking water sector. Dug Wells spread over the entire length and breadth of India gives testimony to the fact. However, its role in irrigation water supply was very limited and quite insignificant. Although tube well technology came to India at the turn of the century, due to numerous constraints it did not take shape in a big way during pre-Independence period.

With the beginning of the first Five-Year Plan, slowly tube well irrigation picked up. Statistical information available shows that the number of private tube wells has raised steadily, from 3000 in 1951 to 22,000 in 1961, 540,000 in 1971 and about 2 million by 1980. The sudden jumps in tube well figures are attributed to "Green Revolution" in Punjab-Haryana-Western Uttar Pradesh states of Northern India. The well statistics is given in Table-1.

supply of water year round.

The contributions made by Ground Water Division, Geological Survey of India, Explanatory Tube well organisation and Central Ground Water Board (Since 1972) in ground water surveys, exploration and aquifer mapping have pivotal role in supporting development and management of this vital resources by providing very crucial scientific and technological inputs. The following Table 2 gives the share in Ground Water irrigation in 1977 in different States.

State	Number of Private Tubewells	Number of Public Tubewells	Net Area Irrigated by Tubewells* (000 hectares)
Andhra Pradesh	60,000	—	112
Assam	2,000	131	NA
Bihar	1,20,000(7)	4,200(16)	560(10)
Gujarat	2,500	1,500	105
Haryana	1,85,000(11)	1,500(6)	624(11)
Himachal Pradesh	Neg	40	1
Jammu and Kashmir	2,000	81	2
Karnataka	1,000	—	1
Kerala	500	—	—
Madhya Pradesh	5,000	115	19
Maharashtra	500	—	—
Orissa	1,500	1,120	26
Punjab	4,70,000(29)	1,107(4)	1,418(25)
Rajasthan	11,000	60	41
Tamil Nadu	50,000	—	26
Uttar Pradesh	6,00,000(37)	14,709(54)	2,590(47)
West Bengal	85,000(5)	2,300(9)	NA
All-India	6,11,500	27,032	5,563

*Relates to 1973-74.
Notes: (1) Figures in brackets are percentages to All-India Total.
(2) All-India figures are inclusive of Union territories and states not listed in this table.

Year	Estimated Stock of Tubewells		Estimated Stock of Dugwells
	Private	Public	
1951	3,000	2,400	3,855,000
1961	22,000	8,890	4,542,000
1965	1,00,000	12,000	5,100,000
1969	3,60,000	14,656	6,110,000
1971	5,39,800	16,000	6,332,800
1974	1,184,800	22,012	6,939,000
1977	1,611,500	27,032	7,477,000
1978	1,744,300	29,825	7,691,700

Table 1- Tubewells and Dugwells, 1951-1978
(Source: B D Dhawan, Economic and Political Weekly Vol 14, 1979)

The significant factors behind upward trends in ground water irrigation are many, namely the temporal progress in land consolidation work, rural electrification, institutional credit facilities and economic benefits from irrigation. Tube well irrigation was proved to be distinctive from other methods modes of irrigation because of its copious and sustained

Till the early 1960s, States of Eastern India and Northern India had almost the same levels of agricultural productivity but in the late 1960s as Eastern India failed to take up the benefits of Green Revolution, gradually was lagged behind the States of Punjab, Haryana and Western Uttar Pradesh and the gap between the two parts increased. The same has been explained in Figure-1.

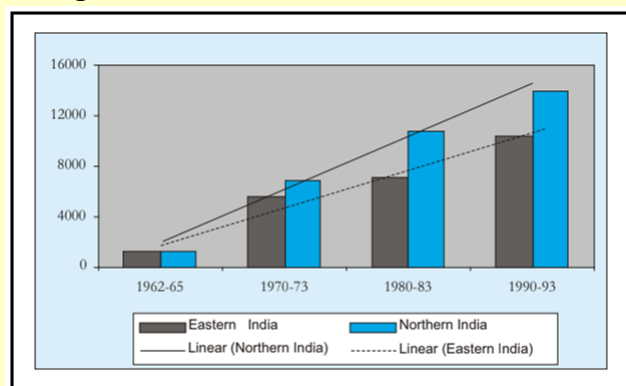


Figure-1 Agricultural Productivity (Rs/ha) in Eastern and Northern India, 1962-65 to 1990-93
(Source: Aditi Mishra, IWMI-Tata Comment, 9/2003)

However, with the emphasis given by Government of India, the States of Eastern India also are now picking up the momentum and are slowly but steadily preparing for the second Green Revolution. With the development of advanced drilling technologies for drilling in hard rock areas, bore well irrigation in hard rock areas of India, specially in Southern India also boosted up in 1970 onwards and considerable irrigation potential has been created there also. Another landmark contribution after post- Independence years is the development of groundwater irrigation in North-Eastern States, specially in Cachher district of Assam and Tripura though the concerted effects of Central Ground Water Board from late 1970s where Tipam Sandstones were proved to have moderate groundwater development potential.

Ground Water resources assessment in the country is done periodically through the joint efforts of the State Ground Water Developments and Central Ground Water Board. Previous such joint exercises were carried out in 1980, 1995, 2004, 2009, 2011 and 2013. The latest figure is available for the year 2019. The most recent assessment of annual ground water recharge has been estimated to be 432 bcm, of which extractable annual ground water recharge is 393 bcm. Upto March 2017, the total ground water resources extraction is 249 bcm ie 63% of the total annual ground water recharge.

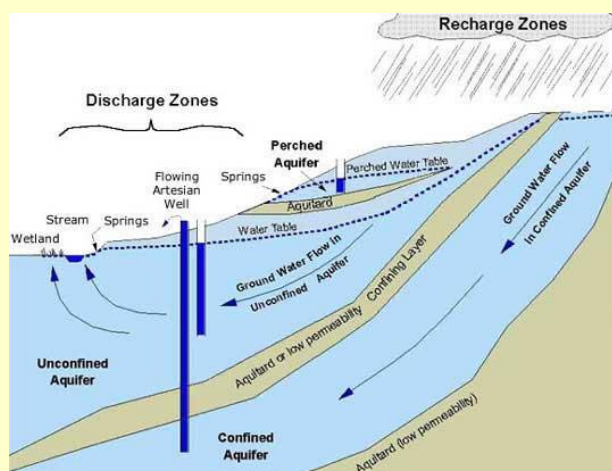
However, there are significant variations in the rate of ground water extraction in different States. Out of the total 6881 assessed units (Blocks/Mandals/Talukas/Fivkas), 1186 units (17%) have been categorised as “Over-Exploited” (extraction is more than 100% of annual recharge). Similarly, 313 units (5%) are Critical (extraction 90-100%) and 972 units are Semi-Critical (extraction 70-90%). But 4310 assessment units are “Safe” where the stage of ground water extraction is less than 70%. It has also been found that in 100 assessment

units (10%), ground water in phreatic aquifers is brackish or saline. These units have been categorised as “Saline” blocks. The “Over-exploited” blocks are confined to the States of Punjab, Haryana, Delhi and Western Uttar Pradesh.

As it happens for development of any natural resources, ground water development is also beset with a few problems like lowering of water table, deterioration of ground water quality, saline water intrusion etc. In India too, similar problems are being faced. The geogenic contamination of arsenic, fluoride, chromium etc and some anthropogenic pollution like nitrates, radio-active substances etc have been found in alarming proportions in certain areas.

The major challenges being faced by the country is the development of this precious resource sustainably. Ground water recharging through water harvesting, augmentation of water resources, chemical treatment for de-arsenification, de-fluoridation etc are some of the measures being undertaken to mitigate the problems.

Continuous scientific research on different facets of ground water resources and well conceived management planning for sustainable development can bring a sea-change in the future ground water scenario of the country.



Role of Groundwater Protection Planning In Groundwater Governance

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Introduction

Ground water use has undergone dramatic expansion throughout the world over the past 50 years, with global abstraction rates increasing from an estimated 100-150 km³ in 1950 to 950-1000 km³ in the year 2000. This type of dramatic transformation where expansive areas are now being irrigated by ground water has also been witnessed in developing countries, like India (FAO, 2005). In addition to dramatic growth in agricultural extraction rates, increased water demands are also occurring in response to rapid urban growth and to the population explosion where 55 to 60 percent of the population in India, are dependent upon groundwater extractions.

Through the construction of millions of private wells, there has been a phenomenal growth in the exploitation of groundwater in India in the last five decades (Garduno et al., 2011). As a

result, 29 % of the groundwater assessment blocks in the country are classified in semi-critical, critical, or overexploited categories with the situation deteriorating rapidly (Romani, 2006). The government has no direct control over the groundwater use of millions of private well owners, both in rural and urban areas. In part, this is due to the absence of a systematic registering of wells. Widespread groundwater pollution could render the resource useless before it is exhausted. This poses a big challenge to the agencies responsible for groundwater development and governance in the country.

Need for Groundwater Protection

There are various potential causes of quality deterioration in an aquifer and/or in a groundwater supply. These are classified by genesis and further explained in Table 1.

Table-1

Type of Problem	Underlying Cause	Contaminants of Concern
Aquifer Pollution	Inadequate protection of vulnerable aquifers against manmade discharges and leachates from urban/ industrial activities and intensification of agricultural cultivation.	Pathogens, nitrate or ammonium, chloride, sulphate, boron, arsenic, heavy metals, dissolved organic carbon, aromatic and halogenated hydrocarbons, certain pesticides.
Wellhead contamination	Inadequate well design/construction allowing direct ingress of polluted surface water or shallow ground water.	Mainly pathogens.
Saline Intrusion	Saline (and sometimes polluted) ground water induced to flow into freshwater aquifer as result of excessive abstraction.	Mainly sodium chloride, but can also include persistent manmade contamination.
Naturally occurring contamination (Geogenic)	Related to chemical evolution of ground water and solution of minerals (can be aggravated by manmade pollution and/or excessive abstraction)	Mainly soluble iron and fluoride, sometimes magnesium sulphate, arsenic, manganese, selenium, and other inorganic species.

Rationale for Pollution Risk Assessment

The above criteria guide what type of pollution risk assessment to use. The commonly adopted approach (from Foster and Hirata, 2002) employs the interaction between hazard from contaminant load and aquifer vulnerability to determine the risk of pollutants reaching the aquifer (Figure-1) . The risk can then be conceived as the interaction between:

- The aquifer pollution vulnerability resulting from the natural characteristics of both the aquifer and the strata separating it from the land surface and
- The contaminant load that is, will be or might be applied to the sub-surface as a result of human activity.

Adopting such a scheme, it is quite possible to have high contaminant load but no significant pollution risk because the aquifer's intrinsic vulnerability is low, and vice versa (Figure-2). As the intrinsic vulnerability relates only to the properties of the aquifer with its overlying layers, and not to the properties of the potential contaminants (because these are numerous and highly variable), the approach is most helpful when dealing with persistent mobile contaminants not readily susceptible to attenuation. For the purposes of developing groundwater protection and management policies, the assessments of aquifer vulnerability and contaminant load are presented in the form of a groundwater resource planning map (GRPM) Fig.3. This is derived by combining Groundwater vulnerability map (GVM) and a potentially hazardous activities (PHA) map.

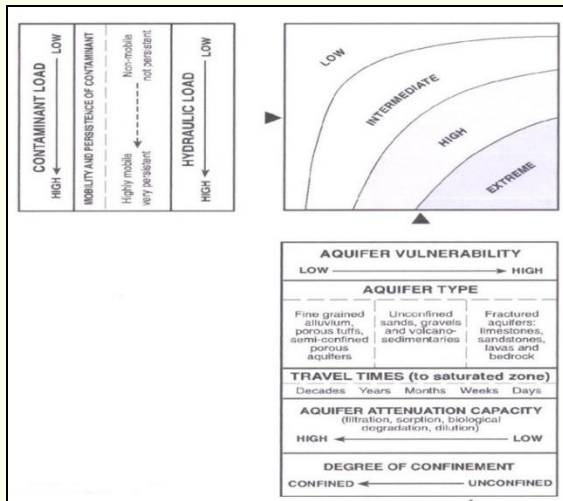


Fig. 1: Conceptual scheme of groundwater pollution risk (modified from Foster et. al.2002)

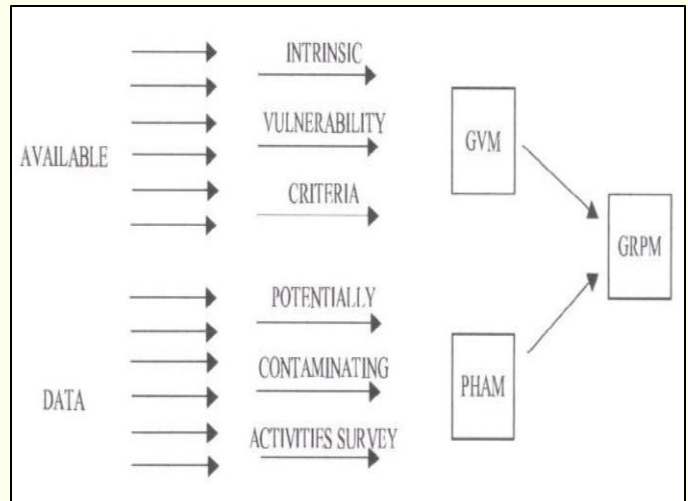


Fig. 2: Evaluation of component parts of a groundwater resource planning map (GRPM)

Case Study of Saharanpur, North India

In the present case study, impact of urbanization and industrial development on the shallow groundwater regime of Saharanpur town of Uttar Pradesh was examined where a major percentage of populace depends on shallow groundwater for drinking through hand pumps. Further, the protective capacity of the vadose zone overlying the unconfined aquifer was also estimated in terms of a geoelectrical parameter called 'total longitudinal conductance'. Lithologically, the alluvial aquifers present in the area are composed of fine to medium grained sands separated by clay-kankar horizons. A large number of private and Government owned hand pumps have been installed in the town for supplying drinking water to the residents of the town. The hazardous physiochemical and bacteriological parameters and heavy metals detected in the shallow aquifer are harmful pathogens like fecal coliforms, heavy metals like cadmium, chromium and other physicochemical constituents like nitrates and sulphate. An assessment of ground water vulnerability using the well known DRASTIC method has confirmed that the groundwater vulnerability in some central and southern localities of Saharanpur town is in medium risk zones (Drastic Index: 160 to 180). Further, using field data of 32 electrical resistivity soundings, the protective capacity of the unconfined aquifers assessed in terms of 'total longitudinal conductance' of the unsaturated sediments overlying the unconfined aquifer was found to range between 0.04 to 2 Mho in the area which indicates the generally low protective capacity of unsaturated sediments against the infiltrating effluents (Figure-4). Yet, some areas in the southeast, central, northwestern and western parts seem to have higher protective capacity (total longitudinal conductance >1.0) against infiltrating pollutants. A ground water protection planning map (Figure-3) prepared by combining the DRASTIC map and the 'potentially hazardous pollutants' map has brought out the need to install eleven new groundwater quality monitoring wells in the town at locations near the line sources and point sources of pollution (Figure-3). Such studies can be of considerable help in planning a strategy for protection of shallow groundwater resources of Saharanpur town and other cities where majority of the people depend on shallow groundwater for drinking. This approach can be readily employed by the decision makers in framing sound policies for groundwater protection and governance in the country.

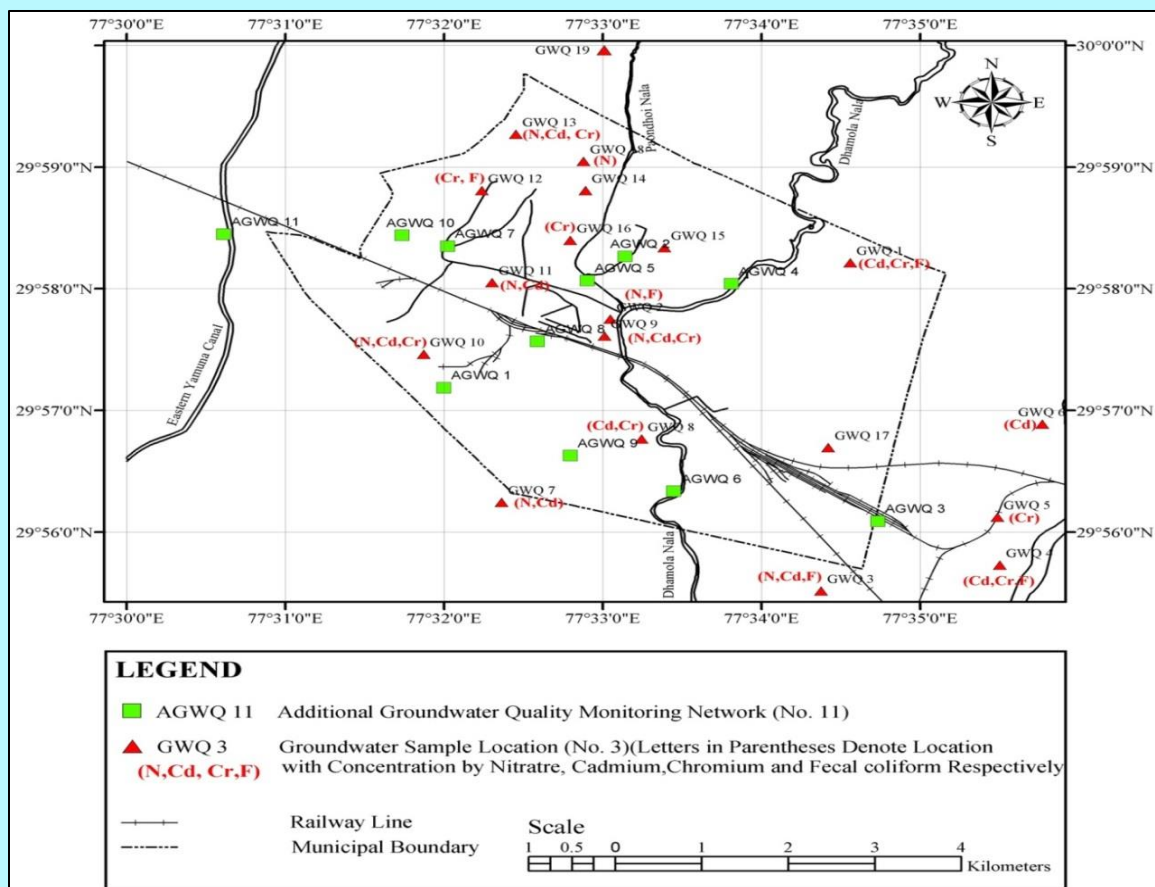


Fig.3: GRPM Map of Saharanpur town

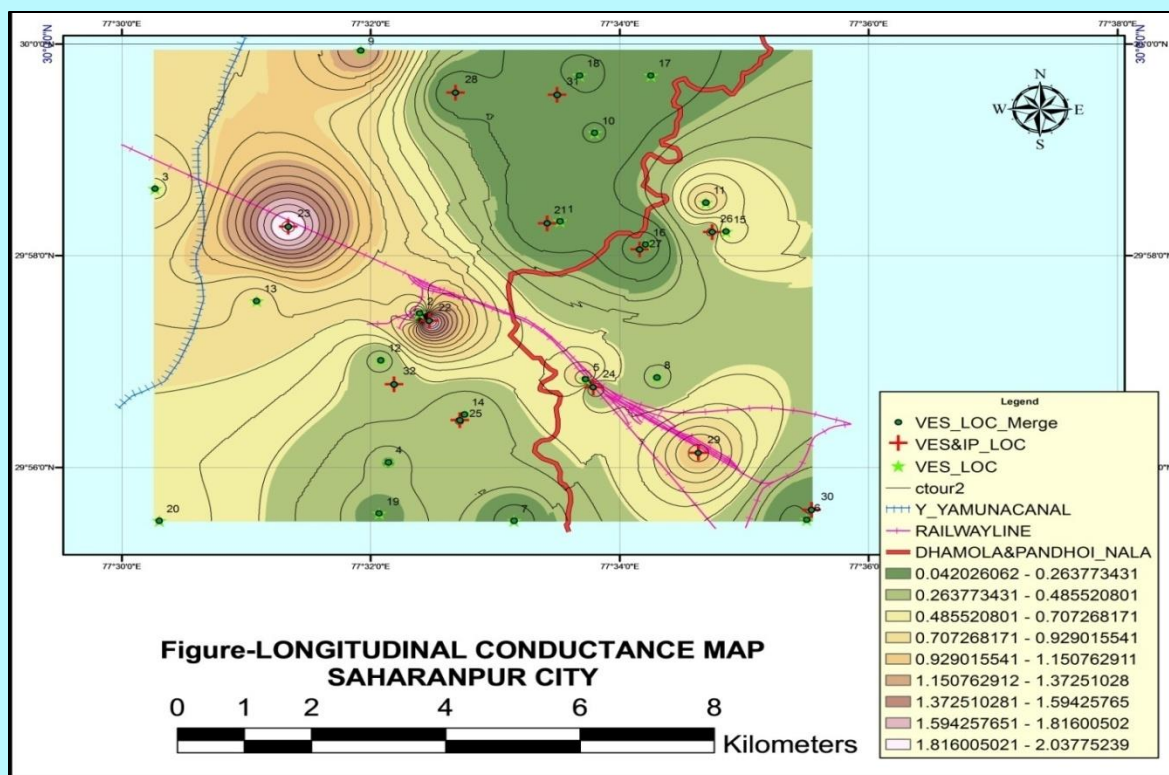


Fig. 4: Longitudinal Conductance Map of Saharanpur City

Groundwater Modelling -Tool to Predict the Behaviour of Over utilised Aquifers in Patna Urban Area

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Introduction

Patna (Patliputra) is oldest human civilisation in the world. It was the capital city of the Mauryan Empire. It is believed that it was at the time the largest city in the world. It is located at the confluence of the Ganges and Son Rivers. It might be one of reason for shifting capital. Abundance of water availability, surface as well as groundwater and low risk of flood due to location of historical city on natural levee of the river Ganga. There is also evidence of use of groundwater during the Mauryan period, the present Agam-Kuan place named after historical (Mauryan period) open well.

Entire city water supply is solely based on groundwater and it has sustained multi-fold growth of the city. It is catering needs of more than 20.49 lakhs population. General public water supply system comprises ~ 98 tube wells drilled in depth range of 150-200 m BGL and tube wells operate 15 hours a day. The total groundwater withdrawal is ~186 MLD and it is likely to reach ~ 690 MLD in 2030.

There is evidence of depletion of groundwater

resources due to heavy withdrawals within densely populated Patna Urban Area (PUA). The shifting of the Ganga and Son rivers and reduced river flow has also attributed change in groundwater flow dynamics as aquifer is actively connected to river system. There is urgent need to manage the groundwater resources and plan for conjunctive use of surface and groundwater resources for PUA water supply.

The alluvial sediment comprises clay at the top and sandy horizon below it down to the explored depth of 300 m BGL. The main aquifer is covered with 30 -50 m thick clay layers. The principal aquifer start at depth of 50 – 80 m BGL and is expected down to the depth of 300 m. The transmissivity of the deep aquifer ranges between 6000 to 16000 m²/day within the PUA. The depth to water level of phreatic aquifer ranges between 2 and 8 mBGL during pre monsoon season. The depth to water level of deep aquifer ranges between 3 and 10 mBGL. It has also been observed that water level of deep aquifer near Patna maintains the level of the river Ganges river in north and *Punpun* river in east and south.

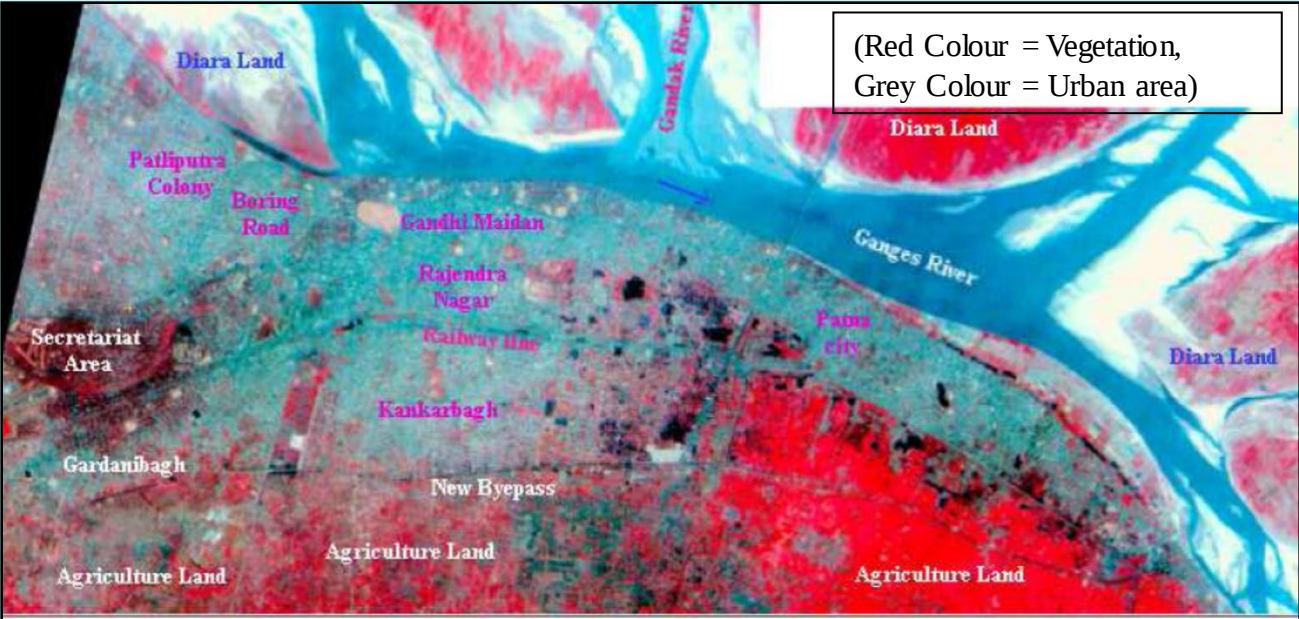


Figure 1: Satellite image of Patna Urban area and surroundings

Groundwater Model based forecast

The multi layer groundwater flow model has been developed using MODFLOW computer code to predict aquifer behaviour under different stress conditions. Model also takes care of Ganga river its interaction with aquifer which one of important aspect in explaining dynamic behaviour of aquifer. Simulated head of the deep aquifer (4th layer) at the end of 1st year and 10th years is explained in Figure-2 and 3 respectively. Model simulation has indicated that flow level of river Ganga has significant impact on the aquifer behaviour. Shifting of river near PUA has impacted aquifer behaviour. Simulated results of pumping wells have indicated that these pumping wells are

creating permanent cone of depression. Depending on the rate of withdrawal (2000 to 7000 m³/day) from the individual pumping well, radius of influence of well is varying between 100 to 200 m. Results indicated that high yield deep tube wells are interfering each other. The flow budgets of different stress period indicates that the amount of water withdrawn from the aquifer is not being supplemented. The simulated results with the existing stress condition to the aquifer system indicate 0.5 - 1 m /year decline in hydraulic head of the deep aquifer. It is appropriate to say that deep aquifer is being mined. Also land subsidence cannot be ruled as long-term consequence of over-extraction.

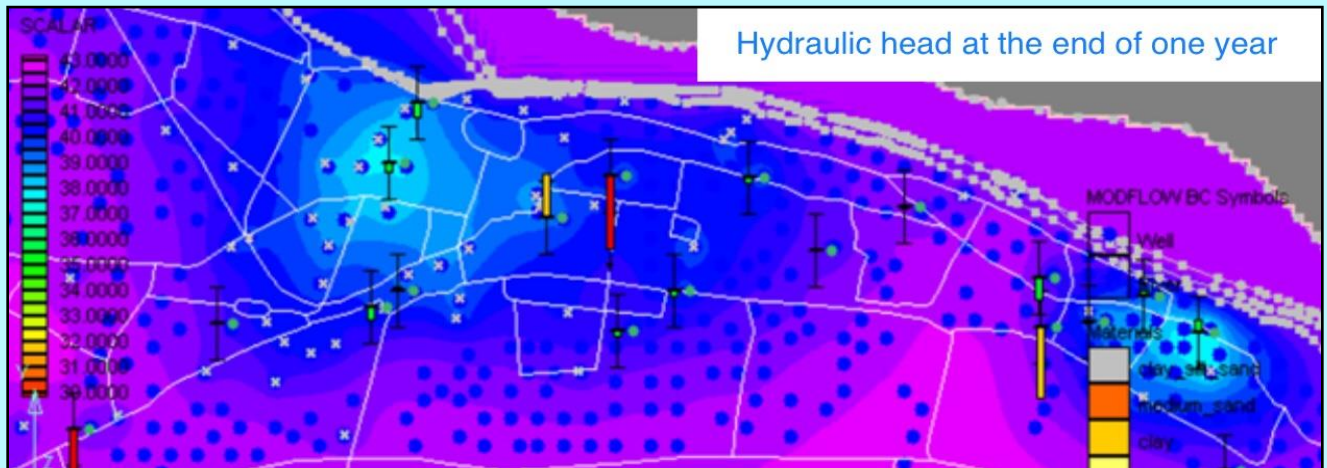


Figure 2: Simulated head of the deep aquifer (4th layer) at the end of 1st year

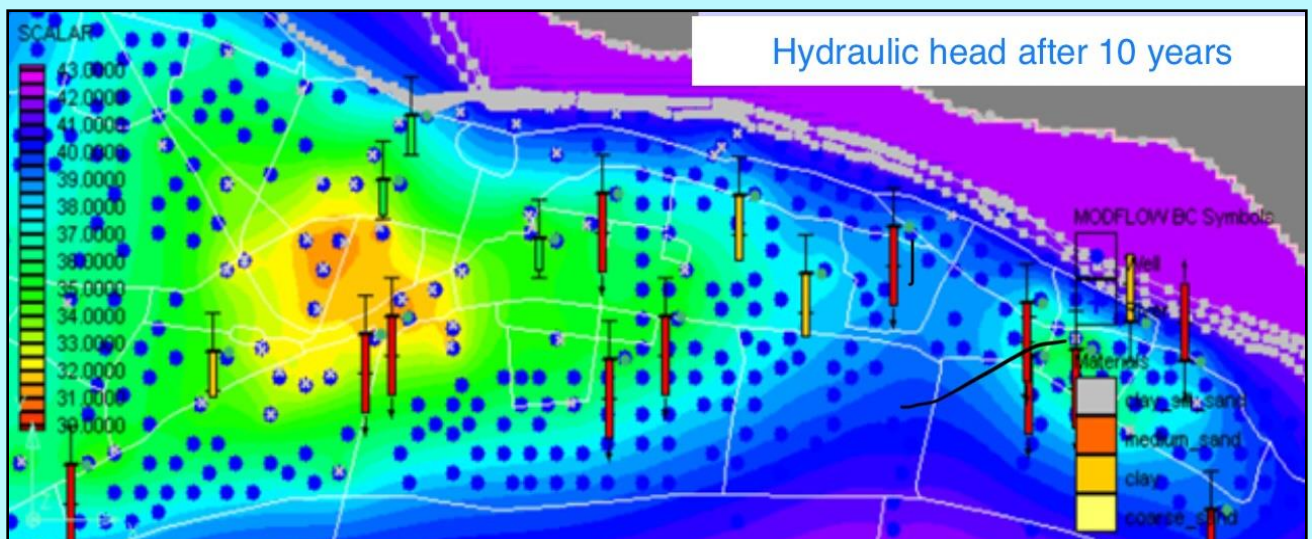


Figure 3: Simulated head of the deep aquifer (4th layer) at the end of 10th years

Opportunity to Revitalize Indian Rivers

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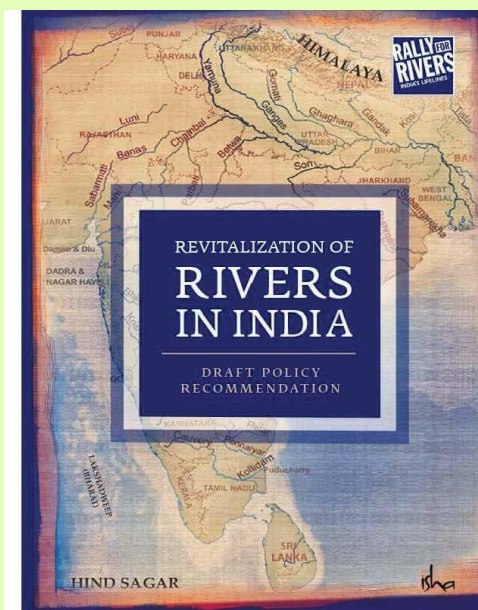


Today, there is much talk about groundwater. The Groundwater Crisis is often understood by people as a drawdown of the resource due to excessive withdrawal of the same. But it indirectly affects the river flow, surface water and ecosystems. In fact, many rivers receive most of their flow from the groundwater (base flow), particularly during the driest months. There is a dynamic relationship between climate, groundwater and surface water, which is a major dependent ecosystem.

Many of the Indian rivers are experiencing a steep decline in their flow. Recent studies show that the annual the water flux has drastically decreased (by 20% to 60%) in the rivers of the Cauvery, Godavari, Krishna and Narmada. The ecohydrological system is undergoing desertification, which raises serious questions about the current and future availability of water, as well as food security. In the last few decades, per capita water availability has gone down about 70%. Total current requirement of water for our nation is 500 km³/year and it has been estimated at about 1450 km³/year in 2050. What then is the solution to these problems?

As an advisory committee member, I am glad to share Rally for Rivers, an excellent initiative by Sadhguru (founder of *Isha Foundation*), which has garnered support across the country at the right time. The **“Revitalization of Rivers in India - Draft Policy Recommendation”** was handed over to the Honourable Prime Minister of India in 2017. This policy was accepted by the Government of India and an action plan group was formed by NITI Aayog and an advisory was sent out to all state governments on the policy guidelines, whereas 6 states signed an MOU with Isha Foundation. The policy addresses not just the technical aspects of tree plantation for river revival, but also the social, economic and management aspects for actual on-ground implementation.

The project has proposed a solution methodology to improve the groundwater level for the secure and sustainable living of agriculture communities along the banks of the major rivers. This project mainly focuses on the sustainability of surface and subsurface water in agriculture practice. Planting trees on both sides of the river is one of the main drivers to maximize the green cover. The role of trees in sustaining the hydrological system is well known. Two models are proposed, based on land ownership: agroforestry for private farmlands and afforestation with native and endemic species in public lands. The result is an economic programme with a significant ecological benefit, which can be widely adopted and can ensure economic and ecological sustainability of actions taken. The first phase is currently being implemented along the course of the Waghadi River, in the Yavatmal region of Maharashtra, with a budget of INR 415 Crores. The fruits of this initiative will become apparent in the next 5 - 10 years. The current climate is favourable and this is the right time for the hydrological community to foster ground level action across the nation.



Proterozoic Karsts of Central Indian Craton and it's Importance

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Karst morphology is a unique feature that develops due to the percolating water through soluble rocks. The central Indian craton (CIC) also known as Bastar craton, exhibits the single largest soluble calcareous rock outcrop in India. It covers about 130000km² geographical area and consists Precambrian cratonic rocks, supracrustals and isolated and thin Quaternary cover sediments. The Archean to Palaeoproterozoic supracrustals rocks of CIC are highly deformed and are metamorphosed to low to high-grade crystalline rocks, whereas the Mesoproterozoic consolidated sedimentary rocks are non metamorphic and structurally less deformed strata.

Karst morphology has been identified at various stratigraphic levels within CIC, starting from the calcareous meta-sedimentary rocks of Palaeoproterozoic Chilpi Group. The folded sequence of Chilpi Group show dipping strata and made positive elevation. The younger Chhatrela Formation of this group is having low grade metamorphic limestone in its upper part showing well developed cavernous zones in the north waster part of Rajnandgaon district around Mandeepkhol. The cave of Chhatrela limestone is having well developed cave structures like stalactite and stalagmite. Other structures like honeycomb structures and micro cavities are also present.

The argillo-calcareous rocks of Mesoproterozoic Chhattisgarh Supergroup and Indravati Group of rocks have produced karstic feature at several stratigraphic horizon. Within Indravati Basin, the Kanger Formation along the southeastern margin has produced series of limestone caves (Figure) extended in the State of Chhattisgarh and adjacent Orissa. The limestone are nearly horizontally bedded and faulted and the caves having developed cave structures like stalactite, stalagmite dripstone and cave deposits and water pools. Other structures like micro cavities and solution channels are also present. Differential weathering around stromatolitic colonies preserved in limestone can be seen.



Whereas, Machkot Member of Jagdalpur Formation is having karstic stromatolitic dolomite intercalated within the shales. The re-crystalline dolomite beds with Jagdalpur Formation due to karstification have produced prolific aquifers around Naganar-Bakawand area.

The development of karst in the rocks of Indravati Group is found most extensive followed by the rocks of Chilpi Group, where large caves of few hundred of meters have developed. However, the Chhattisgarh geological basin which occupy large area nearly 36000km² in the craton and consist of 60% of calcareous- gypsiferous strata by thickness and covers 65% geographical area of the basin do not have produced large caves except other karst forms in the basin. The Chhattisgarh basin is having both calcareous and gypsiferous karst formation. While gypsum karsts are restricted in Maniari Formation of Kharsia Group, the calcareous karsts are well developed in the Singhora, Raipur and Karsia Groups in the basin.. The largest cavernous structure that is known within the Chhattisgarh basin has been identified near Telkadih (Rajnandgaon) at the contact zone of Deodongar Member shale with Newari Member limestone, but this cave formation seems due to subsidence of limestone horizon and creation a gap between two horizons. However, at Baramkela block of Raigarh district development of 1 to 1.5m deep cavernous zone can be seen on surface. Karst landforms are well developed in these terrain but karsts generated springs are not much abundant in CIC

The karstic rocks of CIC are huge source of potable drinking water and cater 18% population of Chhattisgarh State. They also produce comparatively better soil and water prospect within the CIC which support food security. Further, karst areas of CIC are relatively densely populated and intensive anthropogenic activity area. Therefore special attention is to be given to protect the karst areas of CIC as these areas are vulnerable too. The unique Proterozoic karst terrain of CIC produce one of the oldest (1800 to 1000 Ma age) karst system of world and are still not fully explored. The limestone areas of Singhora valley which are folded and intensively faulted, calcareous rocks of Kharsia Group in Baradwar subbasin and in the northern part of Hirri need to be scanned more thoroughly for identification of large caves within the Chhattisgarh basin. Further, karst caves are excellent experimental houses for palaeo climate and other speleological studies, as well as can be developed for conservation of biodiversity and can be developed as revenue generating center for eco tourism.

Lessons from Cape Town's "Day Zero" Crisis

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Few month back we all shared then catching news on the South Africa government announcement of "day zero" or the day when all the taps would run dry, an anticipated scenario on account of low water level in its water supply reservoirs. Then, this was the topic of almost every conversation and became subject of a multitude of news articles, interviews, opinion pieces, editorials, blogs, and tweets—not just in South Africa, but all around the world. Then witnessed some noteworthy actions on parts of Government and some key jerk reactions all over. Cape Town authorities slashed its usual water supply and introduced water ration to cope up the situation. News about dwindling urban water supply, dried up gardens and people collecting shower water to flush their toilets became topics of concerns. Social media shared pictures of people queued to communal water collection points.



Cape Town government management strategy

Prior to the onset of 2017 rains, Cape Town water supply reservoirs were only 37 percent full and soon it was realized that reservoir storage is not enough to last until the next rains. In September 2017 realizing the failure of ambitious although unrealistic plan to provide additional sources of water, mostly from desalination and groundwater by June 2018, the City of Cape Town introduced stringent water use restrictions; 87 liters per person per day. The restrictions were voluntary and the city mayor personally visited consumers of excessive amounts of water. The restrictions were partially success, with water use dropping by 25 percent compared to earlier years, but not successful enough. The situation was not really improving, and in February 2018, water restrictions were further tightened to 50 liters per person per day, with punitive charges for households using more than 6,000 liters per month. The city was able to halve its overall water use, to just 500 million liters a day, and avoided 'day zero'. Then, with usual & timely winter rainfall this year saved situation, at least for a next summer and as on date, "Day Zero" is no longer considered likely to happen in 2018.

Analyzing Cape Town crisis and its mitigation strategy invariably highlights some undisputable facts. First, the regulatory measures in terms of water use restrictions worked. It is mainly due to the consistent efforts of Cape Town government to confide its citizen about day to day water resource management situation and measures required to mitigate crisis through its web link (www.capetown.gov.za Refer: pic) and reciprocated genuine societal will to save water.

All these combined efforts, by the government and the society, enabled to enforce an increase in tariffs and implement water management strategies and ultimately resulted into water use drop to the tune of 500 million liters per day—less than 50 percent of pre-drought levels. Second, it is reported that the region's agriculture came into play, with a similar level of demand reduction. Third, the City of Cape Town managed to borrow water from agricultural users in neighboring water catchment areas.

Top ways to save water at home

Fix water leaks

Monitor your water consumption

Report water issues and offences

What the City is doing to save water

Document downloads

Top ways to save water at home

Insufficient rainfall and fast declining **dam levels** have led to the current unprecedented water crisis.

Please immediately:

- Cut your water use to less than 50 litres per person, per day
- Use municipal drinking water only for essential washing, cooking and drinking purposes, and only use indoors
- Check and fix all leaks on your property ([English](#) | [Afrikaans](#) | [isiXhosa](#))
- Follow our [Household Water Usage Guidelines](#).

See our top [water-saving tips](#) to help avoid Day Zero.

- Only flush the toilet when necessary. Let the yellow mellow at home, work, school, gym, shops, etc.

Moreover, the various water augmentation schemes for tapping groundwater and utilizing desalination plants, earlier which were found difficult to scale out in the midst of the acute crisis period, mainly due to financial / administrative constraints and short time span to implement, are possible to work out now. It is envisaged that the situation would be much improved in coming period and much calmer than a couple of months ago.

Lessons from past experiences

Cape Town is not only city faced water crisis and see its water supply fail. In 2014 and 2015, parts of São Paulo in Brazil received water for only two days a week. São Paulo's drought risk was highlighted in hydrological models, but wrangling between city, state and national governments delayed action for a decade. (Simon, Romero; News Paper Article ; "Sao Paulo Water Crisis - Linked to growth, pollution & deforestation", NY Times, 16.02.2015). In 2008, Barcelona in Spain had to ship water in from Tarragona & Almeria in southern Spain & from Marseille, France. In Barcelona, a surprise 2004 election win saw winning political party stop a long-planned programme of dam development and river transfers because of a manifesto commitment to regional allies. (Kelly, Graham; News Paper Article; "Barcelona forced to import emergency water", The Guardian, 14.05.2008). . In both places political decisions exacerbated their water crises. During its decade-long 'millennium drought' in the 2000s, Australia spent billions of dollars on desalination plants because of environmental opposition to dams, and ultimately desalination increased city's vulnerabilities to

a multi-year drought. Some Indian cities, namely Rajkot in Gujarat, Latur in Maharashtra and Chennai in Tamil Nadu states also faced similar situations in past, mainly on account of not having any system models for timely action and decision making process. On contra, China is a counter-example. It has managed to keep water flowing in some of the world's largest and fastest-growing cities through responsive government planning and major infrastructure projects. These include the Three Gorges Dam, which controls flooding on the Yangtze river, and the South-North transfer, which has channeled water from the Yangtze to Beijing since 2015.

What Cape Town learned is that its problems are due in large part to a turn away from management based on science and risk assessment towards a more populist approach. Mike Muller argued, "Don't blame climate change; People and poor planning are behind most urban water shortages". It is reported that since 1980, South Africa water management uses word class system models which support real time operations of the water network as well as planning for development. For two decades, policymakers heeded the models and succeeded to meet rising demand from urban and industrial growth. Earlier, required dam building in 2000 was stalled till 2009 on local environmentalists campaign. Back in 2009, the models had already flagged a need to boost Cape Town's water supplies after 2015, but officials dismissed the recommendations. Now, Cape Town's leaders are working feverishly to build the schemes that were recommended back in 2009 for managing groundwater, reuse and surface supply. The crisis has obliged them, and others elsewhere in the country, to look more carefully at future challenges. The premier of Gauteng province, the country's inland urban hub, has convened a high-level task force to tell officials how to avoid Cape Town's experience.

Points to ponder

Have we learned anything from Cape Town's experience or are becoming engrossed with another mundane and cliché issues on social media? The most difficult task for managers of urban water supplies is to get viable and amicable decisions made in timely fashion from political leadership and its growing consensus from the stakeholders. There is no general best practice approach to accomplish this. For implementing such consensus timely

decisions, steadfast centralized system is most ideal but same time coordination between ground level institutions play a great role. Water basin do not follows administrative boundaries and its underlying hydraulic characteristics are beyond comprehension of layman. Sound management strategy requires when urban areas spread over multiple basins managed by a different agencies. Preferred approach for managing water issues in such overlapping water basin is to consider concerns of major stakeholders and the geographical areas on which they depend. As water needs grow and water systems evolve, more resources will need to be devoted to monitoring and modeling. Similarly integration of technical advice with decision making processes always benefit for timely action. Such practice facilitate administrators / bureaucrats to know who is doing the modeling and how recommendations are useful. Moreover, if these information is jargon free in user friendly format, it empowers them to act appropriately. Therefore, it is essential that groundwater scientist (Hydrogeologist) must collaborate with experts from the social sciences and humanities, notably economics, policy and law, to develop water-management tools that decision-makers and the public can understand and use. With greater involvement of other disciplines, it will be easier to ensure that appropriate social, economic and environmental criteria are used when selecting technical options, such as whether store water in a dam or to use energy for desalination or adopt which type rainwater harvesting techniques or adopt management cum regulatory measures, etc.

Finally, practitioners also need to monitor and model peoples' behaviour. The long time scales over which decisions and interventions need to happen must also be better understood. And the easy resort to simplistic solutions to 'use less water' and 'rely on natural infrastructure' must be resisted. Cities must move from crisis responses to effective management of the water that is essential to lives, livelihoods and environments. 'Day Zeros' are not inevitable.

Hydro-geophysical Traverse in Nubra Valley, Ladakh, India.

K. P. Singh & Priya Kanwar, Scientist, Central Ground Water Board, WR, Jaipur.

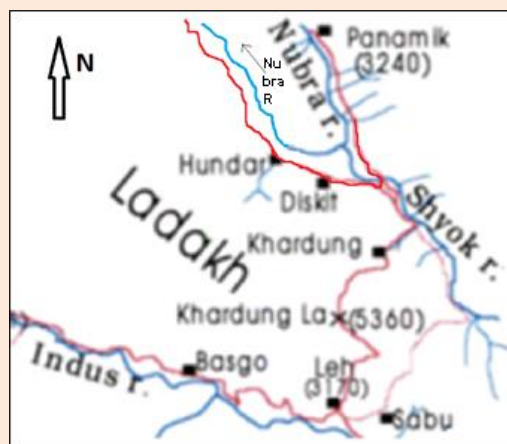
Email: kpsinghcgwb@yahoo.com



Introduction to Nubra Valley

Nubra—a tri-armed valley is formed by Nubra and Shyok Rivers. Nubra River originates from ~ 70 km long Siachen glacier, which lies north of this valley. It joins the Shyok River near Tirith village, which ultimately joins the Indus River at Keris, east of Skardu in Pakistan. The width of Nubra valley at places varies from around 800 m to 3 kms, till it leaves India. Nubra valley separates the Ladakh and Karakoram ranges. The average altitude of the valley is around 3050 m amsl. Disikit is headquarter of Nubra Tehsil and is about 150 Kms north of Leh town, the capital of Ladakh Union Territory, India. Diskitis reached after travelling on ‘one of the Highest Motorable Road in the World’ and passing through majestic Khardung La Pass (5,359 m amsl). An alternative route along the Shyok River, opened in 2008, crosses the Wari La pass from Sakti, to connect the main Nubra road via Agham and Khalsar. Diskit, is famous for ancient Monastery which was built in 1420 AD and a 35 m tall ‘Maitraye Buddha’ statue made on a hill overlooking Nubra valley. Hundar was the capital of the erstwhile Nubra kingdom in the 17th century and is home to the Chamba Gompa. Between Hundar and Diskit lie several kilometres of sand dunes where rare double-humped Bactrian camels are found which survives on seabuckthorn (Leh berry).

Nubra is a high altitude cold desert with very less precipitation and the melting snow water streams sustains life during summer. The long



and hard winter with 3 months (Dec. to Feb.) of sub-zero temperature, sets in late-October and lasts till May. The temperature goes as low as -20°C during winters. The vegetation is scant due to high aridity and low temperature, except along river beds. During the short intense summers, the snow melt water is managed judiciously by participatory management for producing wheat, barley, peas, mustard and variety of fruits and nuts, including Leh Berry, blood apples, walnuts, apricots etc. Nubra Valley is inhabited by Nubra dialect or Nubra Skat speakers, majority of whom are Buddhists. In the western or lowest altitude end of Nubra Valley near the Line of Control i.e. the Indo-Pak border, along the Shyok River, the inhabitants are local tribe, Balti of Gilgit-Baltistan, who follows their age old customs in their lifestyle and speak Balti which is just spoken and not written, and are Shia and Sufia Nurbakhshia Muslims.



Nubra Valley at Diskit and Fertile land towards Hundar



Sand Dunes at Hunder

Along the Nubra River (Diskit to Siachen), which follows the Karakoram fault, lie the villages of Sumur, Kyagar (Tigar), Tirth, Murgi, Kuri, Tiricha, Panamik, Turtuk, Sasooma etc. Samstanling monastery is between Kyagar and Sumur villages. Panamik village is famous for its hot water springs emanating from the hill just upside of road and the isolated Ensa Gompa. Other hot water spring in this valley are at Chaglung and Pulthang villages, that are confined to Karakoram Granites having tectonic contact with the overlying Shyok Volcanics. The temperature of spring water (95°C) at the source indicates that ground water is oozing out from deeper thrust zones. Villages along the north-western limb of valley are Hunder, Partapur, Thoise, Skuru, Terchay, Skampuk, Chamshen, Baigdandu etc. At Baigdandu village there is a marked presence of people with startling blue eyes, auburn hair and rosy cheeks as against the typical mongoloid features of the Ladakh is. Local lore has it that they were a Greek tribe who came in search of Jesus Christ's tomb and eventually settled here. This village is also known for the goats that gives the famous Pashmina shawls.

The springs and marshes receive apparently more than their due share of importance in the traditional Ladhaki water management system.

The springs, are predominant seepage zones

the higher altitudes, not only supply water for drinking but also irrigation in some of the parts. Hand pumps drilled by the PHE departments helps to cater the need of drinking water especially in winter seasons when surface flow decreases or freezes in the nalas. The fresh water nalas called as Lungpa in local language are other water sources. Sasooma, Tirth and the Landjung Thang are the three irrigation schemes of Irrigation department in the area. The yura or khuls draining out from the lungpa are the expertly managed man-made irrigation channels constructed by the farmers on the local level. The ground water occurs in the secondary porosity developed due to stress and tectonic disturbances acted on the hard igneous and metamorphic rocks of the area whereas the unconsolidated formations like alluvium, scree and talus formations present along the rivers and top weathered zones have the promising potentials. The depth of hand pumps and the tubewells drilled in the Nubra and Shyok valley areas are confined to unconsolidated zone of Quaternary Age. The general depth range of these structures ranges from 21.36 m to 60.00 m below ground level and the depth to water level ranges from 9 m to 34.74 m below ground level. High discharge has been encountered in wells constructed at Siachen Base Camp viz. Siachen Base Camp-II (30 litres per second).



Geophysical Investigation

Vertical Electrical Soundings (VES) with Schlumberger electrode configuration were conducted in the valley area. The maximum current electrode separation (AB) varies from 160 m to 660 m in these VES. The prime objective of the survey was to decipher the weathered thickness, depth to basement and ground water potential fracture/s at deeper depths. The resistivity sounding curves obtained in the area are multi-layered in nature and represent A, K or HA type curves. The interpreted true resistivity of the field VES curves indicates 3 to 6 sub-stratum geo-electrical layers in the depth range of 25 m bgl to 90 m bgl, indicating loose / soft formation at shallow depths and hard formation at deeper horizons.

Ladakh batholith bifurcates the single suture segment of Indus and Shyok zones. Shyok suture zone has volcano-sedimentary sequences and melange zone is exposed in Shyok-Nubra valley. Ophiolitic melanges in Shyok suture zone is exposed in the Nubra valley and comprises serpentinites, shales, limestones and basic volcanics. Other volcanic units grouped under Shyok volcanics range from tholeiitic basalt to basaltic andesites to andesites. Basic volcanics, at places green colored, grouped under Shyok volcanics are seen in contact with the acidic volcanics in Hunder Nala and also further north near the villages Sakampuk and Partapur. Continental sedimentation in Shyok suture is represented by Saltoro molasses and comprises shales, sandstones and conglomerates.

During the hydrogeological traversing near the village Khalsar, a section of around 120 - 150 m thick Pliocene-Quaternary fluvio-lacustrine sediments are exposed along the left bank of the Shyok river comprising mainly of boulders, cobbles, coarse to fine sand and clay. Similarly, near the village of Tirit which is south east of the Shyok-Nubra confluence, along the right bank of the Shyok River, a thick sediments of around 20 m are exposed.

They are composed of thinly-bedded clay and silt and fine-to medium-grained sand, conglomerates and breccias. Also, a 20 m thick flat layered horizon of mudstone, sandstone, conglomerate and breccia is seen. This horizon is cut by a clastic dyke which is also composed of mud, sand and conglomerate. The dyke is emplaced upward which suggests earthquake-induced liquefaction. The presence of this clastic dyke, therefore, is a strong evidence for seismically-induced soft-sediment deformation structures. Pink granite usually described as Tirit granite is exposed between Tirit and Khalsar. Towards the north Tirit granite is in tectonic contact with the serpentinites near the Diskit village at the Shyok-Nubra confluence. Between Diskit and Tegar, ultramafics and serpentinites are seen.

Nubra-Shyok confluence is a key area for understanding the tectonic evolution of NW Himalayas. Near the Tirit village, the NNW-SSE flowing Nubra River, takes a NW turn on meeting the Shyok River, indicating the series of paleo fault lines trending NW-SE (Karakoram Fault, Khalsar Fault). The NNW-SSE trending rupturing is found near village Charasa, which is parallel to the regional trend of the Karakoram Fault, which indicates the active nature of this fault.

The traverses through the high altitude cold desert Nubra valley - the junction of India-Asia collision, rendered an insight into the numerous weathering and erosion processes initiated by the power of glacial, water and wind energy, in carving out the spectacular varied landforms.



35 m tall 'Maitraye Budha' statue overlooking the Nubra valley Geophysical Survey in progress.

Water Resource management in Haryana: Issues and Challenges

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Water is the most precious resource on the earth and is elixir of life. It is indeed of great importance for every activity of human life. Water is assumed as a dynamic renewable natural resource but its availability with suitable quality in time and space is highly important for its usage for human kind. This treasurable gift of nature is under tremendous pressure due to population explosion, increasing urbanization, deforestation and intensification of agricultural practices in various parts of the world. The uneven distribution of global water resources coupled with these problems is creating many challenges for practicing sustainable water resources.

Haryana state, which came into existence on November 1, 1966 from erstwhile Punjab, is a divide between the Ganges and Indus river systems. The state has an area of 44,212 Km² and lies between 27° 39' N to 30° 35' N latitude and 74° 28' E to 77° 36' E longitude with altitudinal variation from 200 m to 12 m above mean sea level. The alluvial plain, including western desertic terrain of sand dunes, covers about 98% of Haryana state. The physiographic conditions of the state makes it a perfect saucer as the peripheral parts of the state are covered by the Siwalik hills in the north, Aravalli hills in the south and the upland sandy landscape in the west and south-west. In the north, the land surface slopes from north-east to south-west, whereas in the south, it slopes from the south-east to the north-west towards the Jhajjar-Rohtak-Jind-Sirsa axis. This makes a low lying basin in the middle part of the State culminating into flat topography on regional level and poor drainage system. The absence of the surface and subsurface drainage is conspicuous in the wide spread central and western part of the state due to peculiar topographic conditions coupled with low rainfall. The northern, southern and eastern parts of the state are facing the problem of water level decline whereas the central part including Rohtak, Jind and a part of Hisar are facing the problem of rise in water level which is creating the problems of water-logging and salinization (mostly confined to the central portion of the state).

Groundwater is not adequately extracted in this brackish/saline belt of the state. Though the rise of the saline water table remained a continuous phenomenon even under natural low rainfall conditions, but it has gained a fast momentum with the introduction of the canal irrigation and its extension from time to time. Saline groundwater in the root zone with capillary rise and consequent evaporation leads to salt built-up and this phenomenon is bound to threaten the agricultural economy. Total annual recharge of groundwater for Haryana State according to estimates is 10.9x10⁹ cu m, being the sum of 6.6x10⁹ cu m in the eastern and 4.3x10⁹ cu m in the western zone. The net annual groundwater draft at present is 4.6x10⁹ cu m in the eastern and 1.4x10⁹ cu m in the western zone. Presently, the development of groundwater resources (draft as a percentage of recharge) is 109 % as per CGWB 2010 report. Groundwater quality in the state has been classified into three broad classes: good, marginal and poor. Only 37% of the state falls under good quality whereas 55% of the state has poor quality. The state has 20% of the poor quality water is saline, 35% is sodic and 45% is saline sodic. According to various studies, shallow groundwater generally has a better quality than the deeper groundwater. Along the rivers Yamuna and Ghaggar groundwater quality is good. The groundwater quality deteriorates towards south-western part of the state. Groundwater salinity is especially high in the inland drainage basin in the central portion of the state. Since good quality groundwater is already being exploited beyond the permissible extent in some areas, due to scarcity of irrigation water and the rising trend of water-table, it is of utmost importance that poor quality groundwater is exploited and used conjunctively for agriculture as well as aquaculture.

Haryana State is in a disadvantageous position with regard to rainfall and surface-water availability. Haryana receives an average of 545 mm rainfall annually against the environmental demand of 1550 mm. The Yamuna river is the only perennial river whereas Ghaggar river is non-perennial and a part of the Indus basin.

The minor streams, Tangri, Sahibi, Markanda and Saraswati flowing into the state join Ghaggar river on its left bank. Irrigation facilities were available only for 1.3 million hectare out of the total cultivable area of 3.6 million hectare, i.e. 35% of the cropped area in 1966. The state therefore accorded highest priority to develop and utilize all surface and groundwater resources.

New major and medium irrigation schemes and lift canal irrigation systems were expedited in addition to modernization of old irrigation systems. The state has seen a great surge in the number of tube wells which has increased from 25311 in 1966 to 843000 in 2015-16 which has put tremendous pressure on the groundwater availability. The state receives surface water irrigation from Bhakra and Western Yamuna Canal Systems.

These two main systems supply water to about 88% of the surface irrigated area. The rest 12% of area in the south-west Haryana consist of upland areas with sand dunes which is not suitable for gravity irrigation. These areas which observe drought conditions need to provide lifesaving irrigation to the crops through lift irrigation schemes like Jui, Siwani, Loharu, Jawahar Lal Nehru and Rewari lift irrigation. The groundwater contours follow more or less a similar pattern as the surface topography. The majority of groundwater flow is directed from both north and south towards the central inland basin. During the rainy season, when high flow in the rivers synchronizes with high rainfall in these areas, surface runoff may be impeded for some weeks and contribute to groundwater table rise. Flood irrigation through canals, recurring floods (1978, 1988, 1993, 1995, 1998, 2010 and 2014), lack of saline groundwater exploitation and absence of surface and sub-surface drainage

systems have aggravated the problem of groundwater table rise resulting into the soil salinization. The problems of soil salinity and sodicity are mainly confined to parts of Karnal, Kurukshetra, Ambala, Gurgaon, Faridabad, Rohtak, Jind and Sonapat districts. Detailed analysis of the above facts concludes that Haryana State is facing twin problems of unchecked rise in water table on one side where as steep decline in water table on the other. The area under rise in water table lies in the canal irrigated central inland drainage basin and Ghaggar drainage basin in the north-west underlain by brackish groundwater. The annual rise in water-table has been observed in Hisar, Sirs and Bhiwani, Jind and parts of Rohtak and Jhajjar districts. The steep decline in water table has been observed in the areas where the groundwater quality is fresh and rice-wheat crop rotation is predominant. Significant annual decline in water-table has been observed in Karnal, Kurukshetra, Kaithal, Yamuna Nagar and Panipat districts. The highest water table decline is observed in Mahendragarh & Rewari districts due to poor rainfall resulting into less recharge. This decline in water table is associated with deterioration in groundwater quality as well. These problems need to be tackled on priority by using the recent techniques of Geospatial technology for identifying the hotspots through spatio-temporal mapping. It calls for encouraging the farmers for crop diversification, growing of salt resistant crops, amelioration of various artificial recharge measures, efficient irrigation methods and conjunctive use of both ground and surface water. The south Haryana needs to be covered under surface water irrigation due to adverse groundwater conditions.



Effect of open cast coal mine on local hydrogeological Environment in Barjora block of Bankura district, West Bengal

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Open cast coal mining to extract coal from relatively shallow depth has gained momentum in India since 2-3 decades because of favourable technoeconomic consideration, and sometimes it is being done at the expense of environmental sustainability. Factors may be many but approach should be scientific, quantitative and integrated while assessing the impact on environment. Approximately 25 open cast coal mines (OCCM) are operating in the Lower Gondwana coal formations of Raniganj coal field. Mining with inappropriate environmental management system may affect local hydrological environment, especially micro-level groundwater system-which in most cases happen to be the lifeline of rural economy. Trans-Damodar OCCM, presently inoperative, started its operation in the Borjora block of Bankura district, West Bengal near Durgapur barrage and will restart its operation soon. Huge waste dump because of poor reclamation strategy at the mine sites of almost all OCCMs is noticed in this region. These artificial hillocks changes local watershed and surface water chemistry. Various hydrogeological issues may be associated with OCCM. Broadly it can affect the local groundwater system in two aspects - physical and chemical.

During excavation groundwater inrush from multilayer aquifers may occur into the excavation

causing lowering of water table in the surrounding areas of the mine. Groundwater flow dynamic is likely to change. An excavation of 2.03km^2 of maximum depth 200m may have an area of influence on approximately 5km^2 area. Apart from the groundwater inflow into the mine it can also draw water from surface water bodies. The irrigation canal, emerged from Durgapur barrage across Damodar river, passing through this region may loss water approximately $1473\text{m}^3/\text{d}$ from its discharge through 5km stretch close to mining area during enhancement of the mine. Water loss from irrigation canal may actually create impact on agriculture further south of the mine area.

Acid mine drainage (AMD) is a common phenomenon which triggers various groundwater contamination in and around the OCCM. The acidic water may leach heavy metals present in the spoil dump and contaminate groundwater bodies. Hydrogeochemical study does not show appreciable effect of AMD in this mine area. It may be attributed to self buffering of the lithologic system. However, high value of total dissolved solid (TDS) is observed around the OCCM. Evaluation of groundwater quality indicates that groundwater may turn alkaline in nature in near future from leachate derived from mine spoils.



INC-IAH NEWS

INC-IAH EXECUTIVE COUNCIL ELECTION RESULTS' 2019

The election was conducted with Shri Ashish Chakraborty nominated as Election officer. The election was conducted for the post of president - 1, Vice president - 1, secretary - 1, Treasurer - 1, Executive Members – 5.

On the basis of the voting results, the newly elected executive council is as under:



President- Prof D.C. Singhal



Vice President- Prof A.K. Sinha



Secretary- Dr. Dipankar Saha



Treasurer-Dr. Sudhanshu Sekhar



Executive Member- Dr. Anil Kumar



Executive Member-Dr. B.S. Chaudhury



Executive Member- Sh M.K.Garg



Executive Member- Sh Ranjan Sinha



Executive Member- Dr. M.A. Farooqi



First Meeting of Executive Council, INC-IAH, Held at Jamnagar House. New Delhi, 1st August, 2019

**Upcoming INC-IAH Programme- National Conference on Groundwater
Management in Mining and Social Sectors”
At Ranchi on 21st September 2019.**

The Indian National Chapter of IAH (INC - IAH) and the Society of Geo Scientists, Jharkhand(SGSJ) are jointly organizing a National Conference on “Groundwater Management in Mining and Social Sectors” at CPMDIL, Ranchi on 21st September 2019. The objective of this one day national conference is to create a platform for interactions amongst different stakeholders like Government Organizations, Academicians, Research Institutes, industries, NGOs, Voluntary Organizations, Individuals, to express their views and experiences on “Groundwater Management in Mining and Social sector” and better understand the problems and suggest the remedies.

The theme of the conference is Ground Water Management in Mining and Social Sectors.

The Sub themes are:-

- Ground Water Challenges in Urban/Rural areas.
- Water Challenges in mining environment
- Assessment of Ground Water
- Ground Water Quality and Water Contamination
- Water Conservation , Rainwater Harvesting & Ground Water Recharge
- Ground Water Sustainability
- Groundwater related opportunities and challenges in Eastern Indian States
- Efficient Water Management in Mining and Urban areas

Important dates of Paper submission

- Submission of Abstracts- **31st August 2019**
- Intimation of acceptance of Abstracts for oral/poster presentation-**5th September 2019**
- Submission of Full paper-**10th September 2019**

The Abstract should not exceed 350 words. The full paper should include Title, Authors affiliation, abstract, 5 key words and full paper content in MS Word. The full paper is to be kept within 10 pages. The submission of paper is only through e-mail- -

sshekhar1962@gmail.com/ kumaruday10@gmail.com / sinha.anal@rediffmail.com. Only Abstract volume will be published in the conference; however selected full papers may also be published after the conference.



Johna Falls – Ranchi, Jharkhand

Achievements of INC-IAH Members

- Prof. B. S. Chaudhary, Chairman, Department of Geophysics, Kurukshetra University, Kurukshetra participated in International DAAD/ BMZ Alumni Seminar 2019 “Digitalization plus Industry 4.0” from 29th April - 5th May 2019 in Zwickau, Germany followed by participation in the republica 2019 (#rp19) conference from 6th to 8th May 2019 in Berlin, Germany.
- Prof. B. S. Chaudhary, Chairman, Department of Geophysics, Kurukshetra University, Kurukshetra delivered invited talk on the topic “Indian Space Program and Water Resources Management: Indian Scenario” at the Department of Geography, University of Hamburg, May 23, 2019.
- J. Sivaramakrishnan, Scientist 'B', along with other INC-IAH members and Scientists of Central Ground Water Board, SWR, Bangalore, Member-IAH, has successfully completed four weeks of "Tailor made training on Applied Groundwater Modelling" at IHE, DELFT, Institute for Water Education under the auspices of UNESCO, The Netherlands from 8th July 2019 to 2nd August 2019.



Colloquium Given By Dipankar Saha at :

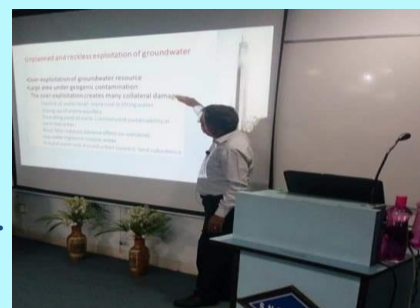
- Main Hall of Physical Research Laboratory, Ahmedabad on 15-5-19.



The title of the talk :

**GROUNDWATER- A CRITICAL BUT STRESSED
NATURAL RESOURCES IN INDIA.**

- Farmian hall of
S .N. Bose National Centre of Basic Science on 19-7-19
(Bosc Colloquium)
GROUNDWATER – THE LIFE LINE OF INDIA IS IN PERIL.
A question answer session and discussion followed the talk..



A paper entitled “ Large Scale Uranium Contamination of Groundwater Resources in India” co-authored by Dr. R.C. Jain and Sudhir K. Srivastava, Member, INC-IAH was adjudged as one of Journal’s Environmental Science and Technology Letter best paper of 2018- Declared in 9th April, 2019

To check fall in Gurugram's groundwater table, MCG to seal 560 borewells- TOI 6.5.2019

Gurugram: Taking into consideration the depleting groundwater level in the city, Municipal Corporation of Gurugram(MCG) is drawing up a plan to seal 560 borewells in the city. "These 560 borewells are fragmented across the city in areas where either the canal water supply hasn't reached or isn't enough to meet the demand. I have asked my team to draw up a plan to provide canal water in all these areas," said MCG commissioner Yashpal Yadav. He added that as part of the plan, they will build tanks and provide boosters in these areas to help officials store canal water and supply them to the households. Once the residents start receiving canal water, the borewells will be sealed. Many areas in the city, especially new sectors, do not get water supply through pipelines, forcing the residents to rely on borewells. Over the last five years, the city's water table has depleted by almost two-and-a-half metre. TOI had reported in 2018, that the city's water table has seen an 82% decline in the last 10 years. The data collected by Gurugram's groundwater cell fell to 36.21 metres below ground level in 2016. In 2006, this was 19.85 metres, showing an alarming decline of about 17 metres over the decade. In the last five years, the pace of decline has been 1.5-2m every year. This is faster than the rate of depletion than that in Delhi. Yadav said that groundwater exploitation was worsening the tables and hence they have decided to seal the borewells. "I have already sought a report from the team on the project and we will try to start the canal supply to all the areas as soon as possible with help from GMDA," said Yadav. However, there are a lot of illegal borewells running in the city beyond the 560 borewells in MCG's records and unless the government authorities crack down on these as well, the problem of groundwater exploitation is far from dealt.



LUCKNOW: A highly polluted Gomti may contaminate urgent steps are not taken to sanitize the lifeline river. At several points, the riverbed is made of porous sediment, which may allow to seep into underground aquifer, experts have warned. The fresh comes after the Uttar Pradesh Solid Waste Management and Committee (UPSWMMC), a panel constituted by the NGT, issuing an advisory against using Gomti's water for bathing, washing and other purposes. Statistics show that out of 2.46 lakh litres of sewage produced daily in Lucknow, around 1.44 lakh litres are treated while the rest flows unprocessed into the river through 33 high drains. Besides, 180 small drains also discharge effluents and solid waste into the river. A recent study by professor Venkatesh Dutta, a noted environmentalist, has also found that the dissolved oxygen level of

Gomti is zilch in many places against a normal of 8.5 mg/litre. "The froth blanketing the river near Gomti barrage and Kudiya Ghat and Pipraghat is a sign that the situation is alarming," said professor Dhruv Sen Singh of Lucknow University based on initial observations of his ongoing study on water quality of Gomti. "Frothing means extreme pollution. It occurs when untreated sewage, chemical discharge from factories, solid waste and organic substances release compounds known as surfactants," Prof Singh said. High level of heavy metal contamination is also indicated through frothing. "Pollutants include nickel, cobalt, arsenic and [cadmium](#). Since the Gomti riverbed is made of sand and silt, which are porous and permeable, these pollutants can trickle down with water and contaminate groundwater," the professor said. Singh pointed out that in some places, a clay-like layer could also be found on the riverbed. "The layer is formed because of pollutants like construction material, sewage and household waste. This layer is not permeable and thus, acts as a barrier against pollutants seeping in. But, at the same time, it does not allow natural recharge of groundwater," he added. Polluted groundwater can lead to health issues, including skin allergies and water-borne diseases such as typhoid and jaundice.

In the US, wells being drilled ever deeper as groundwater vanishes:25.7.2019

(<https://arstechnica.com/science/2019/07/wells-are-getting-deeper-as-groundwater-gets-depleted/>)



Groundwater is an "invisible resource," [writes](#) environmental engineer Debra Perrone. It "flows slowly under our feet through cracks in rocks and spaces in sediments," she says, contrasting it with the more visible and obvious dams and rivers on the surface. This invisible resource is a quiet hero, supplying around a quarter of the US' daily freshwater needs. Its distributed nature makes groundwater a challenging resource to manage. Unlike on the surface, where we can manage

through public infrastructure like dams and reservoirs, groundwater is mostly tapped through millions of wells drilled by individuals, businesses, and farms. But current levels of groundwater use are not sustainable: resources are being steadily depleted as groundwater use outpaces natural replenishment. This depletion means that shallower wells may run dry. Across the US, people are drilling deeper and deeper wells, report Perrone and her colleague Scott Jasechko in a paper in *Nature Sustainability* this week. That suggests that the easy-to-access water is already vanishing. But it's also not sustainable to keep going deeper.

Where the wells are

Perrone and Jasechko drew on 64 state-, regional- or county-level public databases recording the construction of wells, allowing them to pull together a database of nearly 12 million wells in the US. They looked across five large systems of water-carrying rock layers, called aquifers: the High Plains aquifer in the Central US and aquifer systems in California's Central Valley, Florida, the Mississippi embayment, and the Northern Atlantic Coastal Plain. They found that wells across the US have generally been getting deeper since 1950. This trend toward deeper wells showed up across the majority of areas that were included in the database. Deeper wells and depleting groundwater may be related, but it's not necessarily that simple. There are other reasons why people might drill deeper wells—to avoid contamination in shallower wells, for example, or because improved technology or laxer legislation makes it possible where it wasn't before. And even if people would like to drill deeper as shallower wells dry up, it's not always possible: as you drill deeper, groundwater may no longer be high quality or may not be as easy to extract in useful quantities. To explore the relationship between groundwater depletion and deepening wells, the researchers used data on groundwater levels from the US Geological Survey. They found different patterns in different regions: for example, while depletion and well depth seemed to be moving in concert in California's Central Valley, the same was not true in the Floridan and North Atlantic Coastal Plain aquifers. The complex and varying features of different aquifers probably make deepening a viable response in some places but not others.

Deeper isn't a long-term answer

Although shallower wells are at risk of drying out, drilling deeper comes with a host of concerns. For one thing, it's expensive: it may be an option available to some users, but it's not possible for everyone. It's also more energy-intensive to pump water from deeper wells, meaning that a trend toward deeper wells would likely increase the energy cost and carbon emissions of groundwater use. Finally, there's just a limit to how far it's possible to go—because of poor-quality water at very deep levels, as well as the difficulty of extracting useful amounts of water in certain kinds of rock layers. This study looks at the US, but this is really a global issue, the authors write. Not only is the US one of the world's largest food exporters (with a great deal of that food reliant on groundwater), but similar dynamics will be at play in other countries that rely on depleting groundwater, including China and India. Ultimately, better management of this crucial resource requires data, which in turn can help to inform policy. That kind of policy is likely to become increasingly important as the climate crisis changes rainfall patterns: groundwater resources, write Perrone and Jasechko, "may become increasingly valuable because they are generally more resilient to short-term climate variations than surface waters."

- *Nature Sustainability*, 2018. DOI: [10.1038/s41893-019-0325-z](https://doi.org/10.1038/s41893-019-0325-z) ([About DOIs](#)).

<https://envirobites.org/2019/06/02/ancient-groundwater-brings-a-new-lease-of-life-to-arid-ecosystems/>

Scientists create a global map of where groundwater meets oceans- The Hindu 8.6.2019

(<https://www.thehindu.com/sci-tech/science/scientists-create-a-global-map-of-where-groundwater-meets-oceans/article27697520.ece>)



Scientists have created high-resolution maps of points around the globe where groundwater meets the oceans — the first such analysis of its kind that may help protect both drinking water and the seas. In a study published in the journal *Geophysical Research*

Letters, researchers from The Ohio State University in the U.S. showed that nearly one-half of fresh submarine groundwater discharge flows into the ocean near the tropics. They also found that regions near active fault lines send greater volumes of groundwater into the ocean than regions that are tectonically stable. They found that dry, arid regions have very little groundwater discharge, opening the limited groundwater supplies in those parts of the world to saltwater intrusion. The team worked with researchers at NASA's Jet Propulsion Laboratory and the University of Saskatchewan to combine topographical data from satellites and climate models to show the flow of groundwater around the world's coasts.

Managing freshwater

The findings may help coastal communities better protect and manage their drinking water. "Freshwater-groundwater discharge is a natural line of defense against saltwater intrusion," said Audrey Sawyer, an assistant professor at Ohio State. "It's a problem that dry regions have as little groundwater discharge as they do because these are also the places where people are going to tend to look for groundwater to meet their freshwater needs," said Dr. Sawyer. The research work, the first near-global and spatially distributed high-resolution map of fresh groundwater flow to the coast, could give scientists better clues about where to monitor groundwater discharge.

When researchers think about coastal water quality and the way water affects the biochemical makeup of the world's lakes and oceans, they typically think about rivers and streams — and for good reason. Most of the water that gets to lakes and oceans comes from surface water sources. However, groundwater plays an important role, too, carrying minerals and, in some cases, pollutants, to surface bodies of water. "If you've ever been swimming in a lake or in the ocean in the summertime and you go through a cold patch, that is probably a place where groundwater is coming out," Dr. Sawyer said. "And that's just one way that groundwater affects surface water — in that case, it's affecting temperature, but it also affects the chemistry of the water. These effects can be hard to measure over large scales," he said. The team started building these images. The research group focuses on groundwater, and realised that there was limited information showing where groundwater was most likely to flow into the oceans. The study found that in some parts of the world, groundwater could be polluting oceans and lakes with nutrients and other chemicals.

Groundwater, for example, can carry higher concentrations of nitrates — a key contributor of the types of harmful algal blooms — as well as high concentrations of mercury. Understanding how and where groundwater gets to surface water could help policy-makers create better plans to improve those bodies of water. The study also found that climate heavily influences groundwater flow, and that cities in dry areas are especially vulnerable to salt water contamination of aquifers.

FORTHCOMING CONFERENCES/SEMINAR

- **1-7 Sep 2019 – Bali, Indonesia;** 3rd World Irrigation Forum & 70th International Executive Council (IEC), ICID, Development for water, food and nutrition security in a competitive environment. Organised by Indonesian National Committee of ICID (INACID). <https://icid2019.com/> e-mail- inacid.indonesia@gmail.com
- **4-6 Sep 2019 – Southern Sun Hotel, Johannesburg, South Africa;** 2nd Annual SADC Groundwater Conference, Groundwater Contribution to SDGs in the SADC region. Organised by Southern Africa Development Community - Groundwater Management Institute (SADC-GMI). <http://www.sadc-gmi.org> e-mail- thokozani@sadc-gmi.org
- **9-13 Sep 2019 – Liège, Belgium: Groundwater Quality 2019,** Groundwater quality in the transition between rural and urban environments. Organised by IAHS with support of IAH, H2020 ITN INSPIRATION, CLAIRE and NICOLE.
<http://aimontefiore.org/GQ2019> e-mail- c.dizier@aim-association.org.
- **21 Sept 2019- Ranchi, India:** National Conference on Groundwater Management in Mining and Social Sectors” organised by The Indian National Chapter of IAH (INC - IAH) and the Society of Geo Scientists, Jharkhand(SGSJ), e-mail- sshekhar1962@gmail.com, kumaruday10@gmail.com, sinha.anal@rediffmail.com
- **22-27 Sep 2019 – Malaga, Spain;** 46th IAH Congress: Groundwater management and governance – coping with water scarcity; Organised by IAH Spanish National Chapter with the support of the Center of Hydrogeology University of Malaga. <http://www.iah2019.org> e-mail- organizing@iah2019.org / scientific@iah2019.org / sponsors@iah2019.org
- **2-5 Oct 2019 – Pyatigorsk (Russia):** Session of the Commission on Mineral and Thermal Water (CMTW IAH); Organised by IAH Russian chapter, St. Petersburg University Centre for Geology LLC. e-mail- nv.70@hotmail.com.
- **21-24 Oct 2019- Roorkee, India;** 8th International Ground Water Conference on Sustainable management of soil-Water Resources, Organised by Dept of Hydrology, IIT Roorkee; www.igwc2019.com, e-mail igwc2019@gmail.com
- **24-27 Nov 2019 – Brisbane;** IAH/NCGRT Australasian Groundwater Conference 2019; Organised by National Centre for Groundwater Research and Training, Flinders University; <http://www.groundwater.com.au/events/1116> e-mail- enquiries@groundwater.com.au
- **28-29 Nov 2019 – Nagpur, India:** National Symposium on Challenges in Groundwater and Surface Water Resources in India, organised by Gondwana Geological Society (GGS) <http://www.ggsnagpur.org>, e-mail- ggsseminar2019@gmail.com
- **11 - 14 Dec 2019 Chennai, India:** 6th Asia Pacific Coastal Aquifer Management Meeting (APCamm), Anna University, Chennai (More information available on: <http://www.apcamm.earth>)
- **26-28 Feb 2020 – Roorkee, India;** Roorkee Water Conclave; Hydrological Aspects of Climate Change. Organised by Indian Institute of Technology Roorkee and the National Institute of Hydrology ; <http://www.iitr.ac.in/rwc2020/index.html> e-mail- info.rwc@iitr.ac.in
- **2-8 March 2020- IGC 2020** at Delhi, India,, The 36th International Geological Congress (IGC 2020 or 36IGC) will be organized in Delhi, India on 2-8 March, 2020. Visit the congress website @ <http://www.36igc.org/> Prof L. Elango and Dr. Dipankar saha are the theme leaders of Theme 38: Hydrogeology for Societal benefits, One may contact them.
- **29 Mar - 2 Apr 2020 – Caserta, Italy;** MinWat 2020; 3rd International Multidisciplinary Conference on Mineral Waters: Genesis, Exploitation, Protection, and Valorisation. Organised by IAH Commission on Mineral and Thermal Water (IAH CMTW), IAH National Chapter of Italy (IAH Italy), University of Naples. <https://minwatitaly2020.org> e-mail- segratario@iahitaly.it
- **18-22 May 2020 – Porto, Portugal** (ISEP Convention Centre); Geoethics & Groundwater Management: theory and practice for a sustainable development; Organised by IAH Portugal Chapter / ISEP - School of Engineering, Polytechnic of Porto / IAH Spain Chapter. <https://geoeth-gwm2019.wixsite.com/porto>

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e-News letter published by : INC of IAH

(Registered under Dept of Industries & Commerce, Haryana Registration and Regulation of Society Act-2012)

Registration No-HR/02281/2016

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