केंद्रीय भूमि जल बोर्ड
Central Ground Water Board
जल संसाधन, नदी विकास और गंगा संरक्षण विभाग
Department of Water Resources, River Development and Ganga Rejuvenation
जल शक्ति मंत्रालय
Ministry of Jal Shakti,
भारत सरकार
Government of India

BHUJAL SAMVAD

APRIL TO JUNE, 2024,
VOL.25

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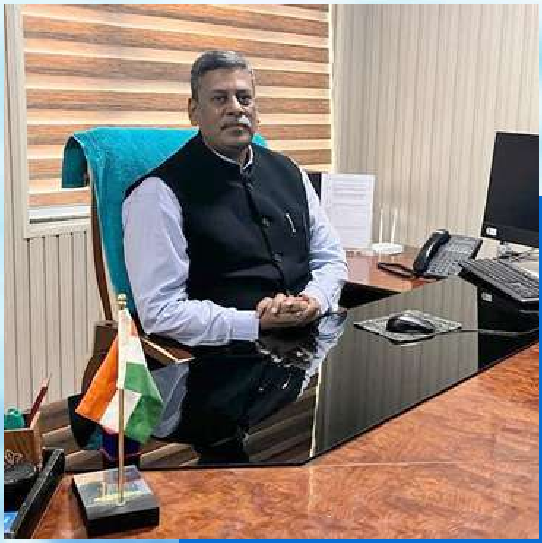
MESSAGE



It gives me great pleasure to present before you the latest release of Bhujal Samvad Volume 25 which includes major accomplishments of Central Ground Water Board during April to June, 2024.

We are delighted to announce that CGWB has participated in the Global Science Policy Forum held in Kathmandu, Nepal during April 2024 which is featured in the In focus Section.

Ground Water Augmentation through Artificial Recharge in water stressed areas of Jodhpur, Jaisalmer and Sikar districts of Rajasthan are covered in details in the 'Cover story' section.

Our 'Report' section focuses on one of the major issues of Water Quality Scenario of selected areas of Bangalore and a case study of Tankfilling by treated Sewage water. The 'Pathshala' segment focus on Ground water Quality sampling ans its processes.

Thoughts and Feedback of the avid readers are most welcome to make Bhujal Samvad a success. Do share your ideas with us through our social media pages or send email to our editorial office (mediacell-cgwb@nic.in)

We are eager to hear from You!

भूजल संवाद

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Dept. of Water Resources,
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Recharge Shafts, Mundru, Block Shrimadhopur, district Sikar

IN FOCUS

Dr S.K. Ambast, Chairman, CGWB participated in the Global Science Policy forum:Socially Inclusive Solar Irrigation Systems held in Kathmandu, Nepal from 24 to 26 April 2024. He has addressed the gathering at the Inaugural Session of the event and also moderated a Panel Discussion.


National Accreditation Board for Testing and Calibration Laboratories

CERTIFICATE OF ACCREDITATION

REGIONAL CHEMICAL LABORATORY CENTRAL GROUND WATER BOARD SOUTH EASTERN COASTAL REGION CHENNAI

has been assessed and accredited in accordance with the standard

ISO/IEC 17025:2017

"General Requirements for the Competence of Testing & Calibration Laboratories"

for its facilities at

E WING C BLOCK RAJAJI BHAVAN, CHENNAI, TAMIL NADU, INDIA

in the field of

TESTING

CGWB SECR Chennai Regional Cheminal Laboratory has received NABL Accreditation.

A Meeting was held between Dr S.K. Ambast, Chairman, CGWB and World Bank representative Smt. Anju Gaur. The World Bank will support CGWB in Rejuvenation of Palaeochannels and ground water data analysis.

The first joint meeting between CGWB and GSI on collaboration study to assess the precursor, co-seismic and post seismic aquifer response from deep aquifers along Kopili fault zone was held at GSI office complex, NER, Shillong.

Sh. T.B.N. Singh, Member Secretary, CGWA delivered a presentation on "Ground Water Regulations for Food and Beverages Industries" in the Conference on Water Stewardship of Food and Beverages Sector at Lee-Meridian Hotel. The Programme was organised by CII(Confederation of Indian Industries)

Scientists and Engineers from CGWB are participated in a training on Airborne Electromagnetic Methods at Aarhus University, Denmark. The training includes advanced techniques for electromagnetic geophysical surveys applied in groundwater science.

Ms Anju Gaur, Senior Water Resources Management Specialist, World Bank Group ha visited CGWB. A presentation was made on Visualisation and Analysis of Geospatial Data.

Shri Subodh Yadav IAS, JS visited Kerala Region and assessed the ground truthing/inspection of the work of short-listed applicants in some of the categories of National Water Awards, 2023 being conferred by Ministry.

A Technical Talk delivered by Director ICAR-CSSRI, Dr R. K. Yadav under Mission LiFE (Lifestyle for Environment) -2024, on the theme of World Environment Day (WED) 2024-Land Restoration, Desertification and Drought Resilience, on 4th June 2024 at CHQ Faridabad

Dr S.K. Ambast, Chairman, CGWB, delivered a talk on “Condition, Assessment and Management Plan (CAMP)” for River Basins. in which he emphasised on the need for consolidation of data on groundwater level and quality in all basin states for planning and effective management of river basins in “Stakeholder Advisory Committee (SAC)”

"Ground water Augmentation through Artificial Recharge in certain water stressed areas of Jodhpur, Jaisalmer and Sikar districts of Rajasthan"

CGWB, Western Region, Jaipur

BACKGROUND OF THE STUDY

Water resources in the arid part of the Rajasthan are very meagre and majority of the population depends on ground water extraction to meet their essential water requirements. With frequent droughts and chronic water shortages in these areas, most people have problem for drinking & domestic needs. In absence of adequate surface and ground water resources, rain water plays an important role in the survival and livelihood of arid zone dwellers.

Rajasthan is the driest and most water-deficient State in India. It has a total geographic area of 3,42,239 Sq. Km. and administratively, it is divided into 33 districts and 302 blocks. As per Ground Water Resources Estimation carried out jointly by the CGWB & GWD, Govt. of Rajasthan, out of a total of 302 assessment units (Block) in the state, 216 (71.52%) have been categorized as 'Over-exploited', 23 (7.62%) Critical, 22 (7.28%) Semi-critical and 38 (12.58%) Safe assessment units and 03 (0.99%) blocks having saline groundwater as per Ground Water Estimation Report 2023. The groundwater development of more than 100 % in major parts of the State is causing depletion of groundwater resources, which in turn creates water scarcity in western desert districts of the State. In such a scenario, the sustainability of water resources is a big challenge.

OBJECTIVES

The artificial groundwater recharge project for an innovative recharge work in 08 over-exploited blocks of Jodhpur, Jaisalmer and Sikar districts of Rajasthan under a Central Sector Scheme by the CGWB are being implemented. Under the project it has been planned to undertake various activities like construction of Concrete Gravity Dam at Bastawa Mata & Zoned Earth-fill dam with Clay Core at Indroka and check dams, anicut & recharge shafts at various feasible locations. The concrete / earthen dams including other smaller structures are being constructed on pilot basis with an objectives of Ground water Augmentation through Artificial Recharge in the water stressed area.

Considering the substantial ground water recharge expected in downstream over-exploited areas, the objectives of AR project may be summarized as given below:

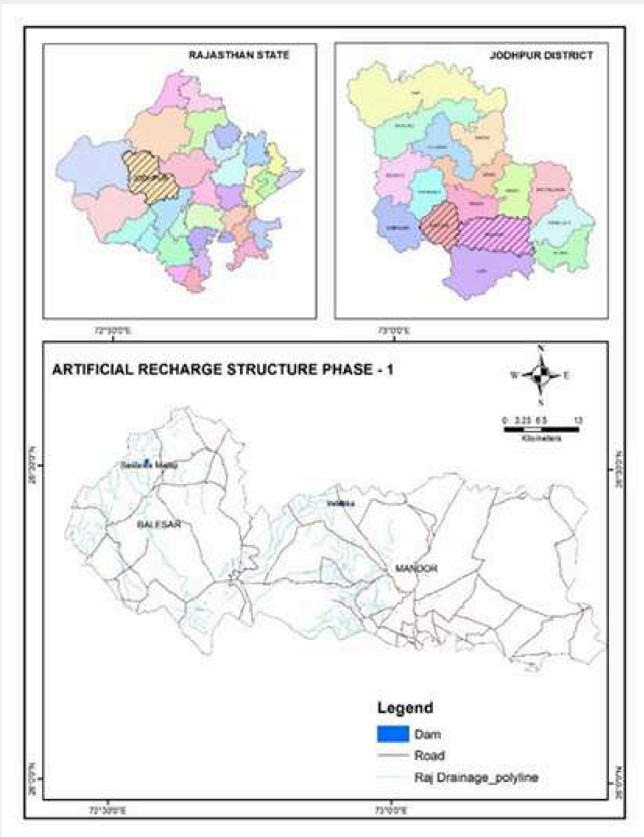
- Aquifer Rejuvenation through construction of area specific/ innovative Recharge structures and projecting the impact in terms of sustainability of resources on a long-term basis.
- Augmentation of ground water resources,
- To arrest ground Water decline,
- Improvement in ground water quality
- Sustainability of borewells/tubewells
- Enhancement of Soil moisture availability
- Reduction in evaporation losses through enhanced GW recharge

SCOPE OF WORK

The artificial recharge project has been taken up in 03 Nos. of phases to expedite the implementation. In Phase-1, construction of Zoned Earth Fill Dam with Clay Core at Indroka and Concrete Gravity Dam at Bastawa Mata are under execution. In phase-2, small structures like MCD, Anicut, CCD & Recharge shafts at 101 sites were taken up. In Phase-3 (extended Phase-2) 53 Nos. of small structures like MCD, Anicut, CCD were taken up. The details are given below:

PHASE-1:

Construction of Zoned Earth Fill Dam with Clay Core at Indroka (Block Mandore) and Concrete Gravity Dam at Bastawa Mata (Block Balesar) in Jodhpur district, Rajasthan



- Construction of the Concrete Gravity Dam at Bastawa Mata (Block Balesar) andZoned Earth Fill Dam with Clay Core at Indroka (Block Mandore) in Jodhpur district, Rajasthan, which are completed as of now. The dams have been executed by M/s WAPCOS Ltd with the revised total cost of the project of Rs. 34.63 Cr, which includes a defect liability period of 01 year after construction and 03 years of O&M by M/s WAPCOS Ltd. Some of the salient features of the dams are given below:

Salient Features of Bastawa Mata & Indroka Dam:

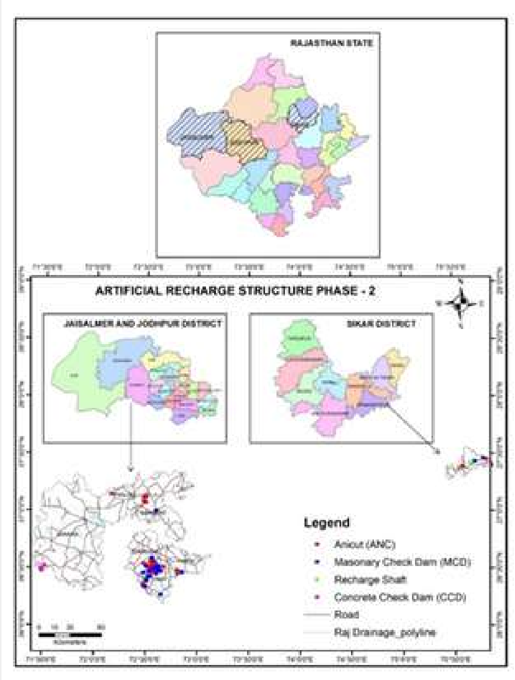
Sl. No.	Description/Features	Bastawa Mata (Gotavar Dam)	Indroka (Veer Shiromani Mukandas Khichi Dam)
1	Type of Dam	Concrete Gravity Dam	Zoned Earth-fill Dam with Clay Core
2	Location	Village: Bastawa Mata, Block: Balesar, District: Jodhpur	Village: Indroka, Block: Keru, District: Jodhpur
3	Catchment Area	2000 Ha	270 Ha
4	Average Annual Rainfall	266 mm	357 mm
5	River/Nala	Gotavar River	Local Stream
6	Reservoir Area	25 Ha	14 Ha
7	Reservoir Capacity	1.05 MCM	0.29 MCM
8	Length of Dam at Top	233 m	715 m
9	Width of Dam at Top	4 m	4.5 m
10	Height from River Bed Level	18.6 m	5.6 m
11	Height of Dam from foundation	22.6 m	6.6 m
12	Average River Bed Level (Elevation)	262.5 m	270.0 m
13	Full Reservoir Level (Elevation)	278.5 m	273.0 m
14	Maximum Water Level (MWL) (Elevation)	279.55 m	274.0 m
15	Dam Top Level (Elevation)	280.6 m	275.6 m
16	Design Discharge Capacity (Spill Channel)	96 Cumec	11 Cumec
17	Project Cost	Sanctioned Cost: Rs. 19.42 Cr. Executed Cost: Rs. 20.22 Cr (Phase-I upto 11 m)	Sanctioned Cost: Rs 15.21 Cr Executed Cost: Rs. 9.98 Cr (Upto 7 m)

Glimpse of Bastawa Mata Dam (Gotavar Dam)

Glimpse of Indroka Dam (Veer Shiromani Mukandas Khichi Dam)

PHASE-2:

Construction of 101 Water Harvesting Structures



Under this phase, various structures like (Masonry Check Dams (MCD), Anicuts, Concrete Check Dams (CCD) & Recharge shafts have been executed at 74 Nos. of sites in parts of Balesar, Shekhla, Lohawat, Tinwari and Phalodi blocks of Jodhpur district and 06 Nos. of sites in parts of Shrimadhopur block of Sikar district of Rajasthan. At 19 Nos. of sites (16 sites of Balesar, Lohawat & Phalodi blocks of Jodhpur and 03 sites of Gram Panchayat OLA, block Sankra of Jaisalmer districts, where either work could not be started or partially completed due to the local hindrance are recommended for foreclose of ARS sites. On 02 site at Mahroli, block Shrimadhopur, district Sikar & at village Bonada, GP OLA, block Sankra, district Jaisalmer, the construction work is under progress. These water conservation structures are executed by M/s WAPCOS Ltd. The sanctioned cost of the project is about Rs. 73.98 Cr.

PHASE-3(EXTENDED PHASE-2):

Construction of 53 Water Harvesting Structures

Under this phase, various structures like (Masonry Check Dams (MCD), Anicuts & Concrete Check Dams (CCD) are under execution at 53 sites in parts of Mandore, Bawri, Shekhla, Lohawat, Tinwari, Phalodi, Bap, Shergarh, Bhopalgarh & Balesar blocks of Jodhpur district, Mohangarh, Jaisalmer, Sankra blocks of Jaisalmer district, Barmer Gramin, Siwana & Chautan blocks of Barmer district, Bansur block of Alwar district and Udaipur Vati block of Jhunjhunu district. These water conservation structures are being executed by M/s WAPCOS Ltd. The sanctioned cost of the project is about Rs. 68.43 Cr.

Check Dam, Bada Kotecha, block Tinwari, district Jodhpur

Check Dam, Village Sujannagar, block Balesar, district Jodhpur

Recharge Shafts, Mundru,
Block Shrimadhopur, district Sikar

Check Dam, Bhalu Laxmangarh,
Block Shekhala, district Jodhpur

Recharge Shafts, Mundru,
Block Shrimadhopur, district Sikar

Check Dam, Bhalu Laxmangarh,
Block Shekhala, district Jodhpur

DISTRIBUTION OF ARTIFICIAL RECHARGE STRUCTURES

AR PROJECT PHASE-2

Sl. No.	District	Block	Block wise no. of AR Structures	District wise No. of AR Structures
1	Jodhpur	Balesar	57	90
2		Sekhala	9	
3		Lohawat	17	
4		Tinwari	6	
5		Phalodi	1	
6	Jaisalmer	Sankra	4	4
7	Sikar	Srimadhopur	7	7
Total Number of AR Structures in Rajasthan				**101**

AR PROJECT PHASE-3

Sl. No.	District	Proposed Structures	Work Completed	Work Under Progress
1	Jodhpur	22	16	17
2	Jaisalmer	24	7	3
3	Alwar	1	1	0
4	Jhunjhunu	2	0	2
5	Barmer	4	6	1
Total		**53**	**30**	**23**

MONITORING OF THE AR PROJECT & CO-ORDINATION WITH STATE GOVT. AGENCY:

For effective implementation of AR Project in Rajasthan, the dam & WHS sites were continuously been monitored through the team of officers from Ministry of Jal Shakti, CGWB, CWC, CSMRS, Line Department of State Govt. Agencies (Zila Parishad & WDSC), Regional Monitoring Committee (RMC) & M/s WAPCOS Ltd. Further, design & drawings of Indroka & Bastawa Mata Dams were approved by the Project Implementation Committee (PIC) & monitored its execution at the site. Moreover, projects were also been monitored by the Hon'ble Minister Jal Shakti, GoI, Hon'ble Minister of Parliamentary Affairs, Law & Justice, Govt. of Rajasthan, Chairman CGWB & by Gram Panchayats as well. The visit by the dignitaries has given the AR project a wide publicity & awareness towards water conservation and its management in Western Rajasthan in specific.






IMPACT ASSESSMENT OF AR PROJECT:

- To study the impact assessment of Indroka dam, 02 nos. of piezometers have been constructed in the vicinity of the Dam, 01 Nos. each in upstream and downstream side of the dam. Whereas in regards to Bastawa Mata Dam, 03 Nos. of piezometers have been constructed in upstream and 01 Nos. in downstream side of the dam.
- Further, 30 Nos. of Piezometers are already constructed in the vicinity of Recharge Structures in clusters under Phase-2 and 50 Nos. of piezometers are further proposed to cover the remaining recharge structures proposed under Phase-2 & 3.


CONCLUSION:

The water level in the Western Rajasthan region depleted regularly converting the area to an over-exploited, causing a draught like situation. By constructing these structures in the area there would be great impact on ground water resources in terms of improvement in water quality, check of decline of ground water levels in the area. In the long term the recharge through these structures would be improved. These structures have now become a bench mark and villagers are taking inspiration to construct such small water harvesting structures in their village.

During monsoon of this year, reservoir of all the water harvesting structures is found overflowed with rain water. As per the feedback received from villagers residing in the area, particularly Balesar and Tinwari block area, they are experiencing rise in water levels in their borewells and improved efficiency of irrigation and increase in irrigated area etc. The rain water retained and stored in these water harvesting structures has resulted in enhancing the availability of drinking water for wild cattle as well. The combined storage to the tune of 30,00,000 cubic meter of rain water has been proposed to be achieved through the zoned earth-fill dam with clay core at Indroka, Concrete Gravity Dam at Bastawa Mata and small water harvesting structures like check dam, anicut, recharge shafts & model talab, which were constructed in the area under various phases of AR Project in Rajasthan.

Introduction

It is estimated that 61,754 million liters per day (MLD) of domestic wastewater is generated in India. The present treatment capacity is only for 22,963 MLD with a big gap in treatment of sewage water (CPCB, 2016). Reusing treated sewage or wastewater is an excellent approach to addressing the water shortage issue and is attracting global attention (Contreras et al., 2017, Huertas et al., 2008). Typically, treated sewage or wastewater is utilized in power plants for cooling, watering golf courses, building construction, firefighting, and car washing (Zabalaga et al., 2007; Katsoyiannis et al., 2017, Yang et al., 2017). In India, the discharge of untreated wastewater especially sewage is the most important water polluting source as the treatment capacity as per CPCB is only 37%. To address this issue and to convert the problem of sewage into opportunity, Govt. of Karnataka has embarked on this novel concept of filling the existing tanks/ponds by secondary treated water generated from treatment of sewage in STP's of Bangalore city to augment the ground water recharge. The water stored in the tanks/ponds is not used for irrigation or any other purpose but only for storage and recharge. Increasing stresses on groundwater and subsequent overdrafts have sparked the development of several advanced MAR technologies, including soil aquifer treatment (SAT). SAT is a method that recharges wastewater effluent through intermittent percolation in infiltration basins (Maayan Grinshpan et al., 2021). The Koramangala-Chellaghatta (KC) and Hebbal-Nagawara (HN) Valley Projects are the marquee projects of the State Govt. which had been implemented by Minor Irrigation (MI) Department, Karnataka and Bangalore Water Supply and Sewerage Board (BWSSB), Bangalore. The tanks are owned by various agencies like MI Dept., Bengaluru Bruhat Mahanagar Palike (BBMP), Karnataka Urban Water Supply and Sewerage Board (KUWSSB), Municipal Council, Panchayat Raj Engineering Division (PRED) and Zilla Panchayat. Whereas BWSSB is the nodal body that collects, treats and disposes treated domestic sewage. using the two types of sewage treatment plants (STP) which work under the operational principles either of sequential batch reactors (SBR) or the activated sludge process (ASP) based technologies in combination with Biological Nutrient Removal (BNR), disc filtration and disinfection by chlorination.

Geology and hydrogeological framework

In KC valley project 145 tanks are being filled with the secondary treated water which is uplifted from Koramangala, Bellandur STP and transferred under lift as well as gravity to about 13 tanks/ponds clusters. These 13 clusters consist of 145 existing tanks/ponds out of which 133 fall in Kolar District encompassing Bangarpete, KGF, Kolar and Malur taluks, 7 fall in Chintamani taluka of Chikballapur district and 5 in Hoskote taluk of Bengaluru Rural District. A total of 356 MLD of treated water is being pumped and transferred to these 136 tanks and the designed storage capacity of these 145 tanks is 5473.11 Mcft.

In HN valley project, 65 tanks/ponds are being filled with the secondary treated water of 210 MLD which is transferred under lift as well as gravity from 3 STP's i.e., from Hebbal (150 MLD), Hennur (40 MLD) and Horamavu (20 MLD). Out of these 65 tanks/ponds, 44 fall in Chikballapur District encompassing Chikballapur, Gauribidanur, Gudibande and Shidlaghatta taluks, 12 tanks are located in Bengaluru Urban District encompassing Bengaluru (North) and Yelahanka taluks, and 9 are in Devanahalli taluk, Bengaluru Rural District. The designed storage capacity of these 65 tanks is 3829 Mcft.

Objective

The sewage water carries various types of contaminants to the water bodies. The quality of water is very important as it is highly consumed by humans for domestic, agricultural and drinking purpose. The presence of contaminants in the secondary treated sewage water being used for storage/recharge in tanks and ponds may have impact on surface and ground water of the area. In the year 2022-23, CGWB, SWR, Bangalore carried out the study with the objective to assess the physico-chemical and biological parameters of treated water, surface water and ground water, to decipher the inclusive water quality of all the 3 components viz., treated water, surface water and ground water. The study was also aimed to assess the usability of surface and ground water for drinking and irrigation purposes and identify the impact of tank filling scheme on surface and ground water quality, if any.

Material and Methodology

As a part of this study, total of 120 samples (Fig.-1) were collected in December 2022 which included 67 from KC valley (1 STP treated water, 32- surface water from tanks and 34 from borewells) and 53 samples from HN valley (3 STP treated water, 25 surface water from tanks and 25 from borewells). The samples were collected during December 2022 and were analysed for 17 basic parameters (pH, Electrical Conductivity, Total Dissolved Solids, Total Alkalinity, Total Hardness, Sodium, Potassium, Calcium, Magnesium, Carbonate, Bicarbonate, Chloride, Sulphate, Nitrate, Fluoride, Phosphate, Silicate), 11 heavy metal parameters(Chromium, Nickel, Copper, Zinc, Arsenic, Selenium, Cadmium, Lead, Uranium, Iron, Manganese) and 3 biological and bacteriological (Chemical Oxygen Demand, Biological Oxygen Demand and E.Coli) parameters.

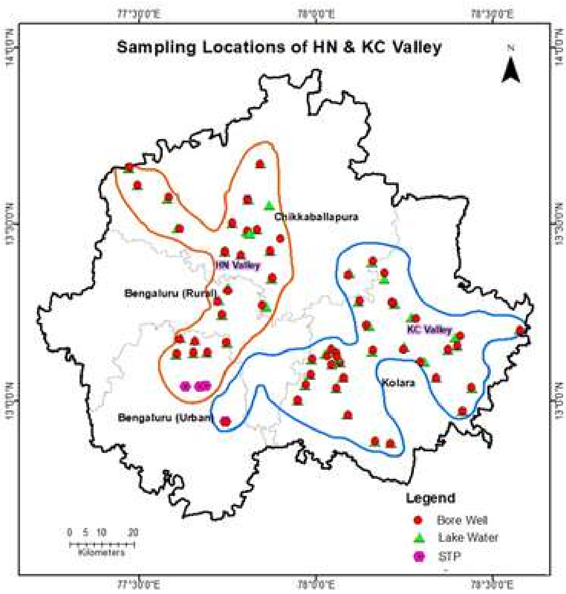


Figure 1 : Sampling Locations of KC and HN valley

Results and Discussion

The number of samples and range of the major parameters considered for discussion are tabulated in Table-1. The results were also compared with the standards prescribed for drinking water in BIS 10500, Revised 2012 and the number of samples more than permissible limit is reflected in Table-2. The discussions are split for KC valley and HN valley based on source of samples i.e., Treated Water from STP's, Surface Water from Tanks and Ponds and Groundwater from Borewells. In the area borewells are the only source of ground water abstraction structure.

S. NO	AREA	SAMPLES COLLECTED & ANALYZED	RANGE OF CONSTITUENTS									
			pH	EC	TDS	Cl	NO3	F	U	BOD	COD	E-Coli
1	KC valley	n-67		µS/cm	mg/L				ppb	mg/L		A/P
1a	Treated Water	n-1	6.59	1240	662	170	4.27	1.30	11.20	15.00	92.20	P=n1
1b	Surface Water	n-32	6.94 to 8.15	190-860	116 to 507	7.09 to 131.00	0.2 to 28.48	0.27 to 0.95	0.20 to 17.90	1 to 17	BDL to 123.60	P=n6
1c	Ground Water	n-34	6.43 to 8.88	500 to 2630	295 to 1653	31.90 to 518.00	0.02 to 46.46	0.30 to 1.70	0.40 to 1677	BDL to 11	BDL to 66	P=n4
2	**HN valley**	**n-53**										
2a	Treated Water	n-3	7.13 to 8.01	957 to 1079	623 to 641	138 to 167	34.20 to 43.84	0.78 to 1.30	13.60 to 17.70	4 to 11	15.40 to 48	A
2b	Surface Water	n-25	6.57 to 7.87	204 to 888	141 to 529	18 to 131	0 to 23.06	0.17 to 1.00	0.20 to 34.40	1.50 to 60.00	BDL to 48	P=n4
2c	Ground Water	n-25	5.96 to 7.81	364 to 2510	207 to 1585	35.5-415.35	0 to 100.74	0.11 to 2.00	0.40 to 1427	BDL to 9.40	BDL to 42.80	P=n2

Table-1: Number of Samples and Range of Constituents

*Here, n – number of samples, A – Absent, P – Present.

KC VALLEY					
STP TREATED WATER (N=1)	SURFACE WATER TANK (N=32)	GROUNDWATER (N=34)			
Constituent	**Above permissible limit samples**	**Constituent**	**Above permissible limit samples**	**Constituent**	**Above permissible limit samples**
E. Coli	1	Iron	2	pH	2
		E. Coli	6	Nitrate	2
				Fluoride	1
				Iron	2
				Manganese	1
				Uranium	16
				E. Coli	6
HN Valley					
Constituent	**Above permissible limit samples**	**Constituent**	**Above permissible limit samples**	**Constituent**	**Above permissible limit samples**
Phosphate	1	Uranium	1	pH	1
		BOD	6	Nitrate	6
		E. Coli	4	Fluoride	2
				Iron	1
				Uranium	10
				E. Coli	2
Maximum Permissible Limit of constituents for drinking water as per BIS standard: Fluoride (1.5 mg/L), Nitrate (45 mg/L), Iron (1 mg/L), Manganese (0.3 mg/L), Uranium (30 ppb), E. Coli. (Should not be detectable on 100 ml sample). Phosphate as per WHO – 5 mg/L in surface water.					

Table-2: Constituents wise Number of Samples with reference to BIS, Drinking Water Standards

WATER QUALITY SCENARIO IN KC VALLEY

STP Treated Water Analysis Results of KC valley: The analysis results of 1 STP treated water sample collected from Bellandur-STP indicates that all the analyzed parameters are within the permissible limits of drinking water standards except Fluoride content (1.30 mg L-1). The biological parameters such as COD (92.2 mg L-1) and BOD (15 mg L-1) were within the prescribed limits but E. Coli was present in 100mL sample which means greater risk that pathogens are present and not acceptable as per BIS standards.

Tank Water Samples Analysis Results of KC valley: The results of 32 surface water samples collected from tanks for basic parameters of KC valley indicates that the pH of the samples varied from 6.94 to 8.15, Electrical conductivity from 190-860 µS/cm, TDS ranging from 116-507 mg/L, Chloride from 7.09-131 mg/L, nitrate content varied between 0.2-28.48 mg/L, Fluoride from 0.27-0.95 mg/L. All the parameters were well within the permissible limits. All the heavy metals are within permissible limit except Iron at 2 locations. The highest concentration of iron above the acceptable limit of 1.00 mg/L was observed in Hosahalli Lake (1.83 mg/L). The biological parameters in tank/lake water samples of KC valley network indicated that most of the samples were well within permissible limit, except the presence of E. Coli was seen at 6 locations in tank samples of Madiwala thattala kunta kere, Seesandra Dodda kere, Doddaiyuru kere, Jammanahalli kere, Avalamarkalghatta Dodda kere and Kengunte kere. The pathological contamination may be taking place through treated sewage water as it was containing E-coli at Bellandur STP. The possibility of e-coli contamination entering waterbodies through local sewage nala also cannot be ruled out considering their close proximity to the villages.

<table>
<tr><th colspan="6">KC VALLEY</th></tr>
<tr><th>STP TREATED WATER (N=1)</th><th>SURFACE WATER TANK (N=32)</th><th colspan="4">GROUNDWATER (N=34)</th></tr>
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<tr><td rowspan="7">E. Coli</td><td rowspan="7">1</td><td>Iron</td><td>2</td><td>pH</td><td>2</td></tr>
<tr><td rowspan="6">E. Coli</td><td rowspan="6">6</td><td>Nitrate</td><td>2</td></tr>
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<tr><td rowspan="6">Phosphate</td><td rowspan="6">1</td><td>Uranium</td><td>1</td><td>pH</td><td>1</td></tr>
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<tr><td>Iron</td><td>1</td></tr>
<tr><td>Uranium</td><td>10</td></tr>
<tr><td>E. Coli</td><td>2</td></tr>
<tr><td colspan="6">Maximum Permissible Limit of constituents for drinking water as per BIS standard: Fluoride (1.5 mg/L), Nitrate (45 mg/L), Iron (1 mg/L), Manganese (0.3 mg/L), Uranium (30 ppb), E. Coli. (Should not be detectable on 100 ml sample). Phosphate as per WHO – 5 mg/L in surface water.</td></tr>
</table>

Table-2: Constituents wise Number of Samples with reference to BIS, Drinking Water Standards

WATER QUALITY SCENARIO IN KC VALLEY

STP Treated Water Analysis Results of KC valley: The analysis results of 1 STP treated water sample collected from Bellandur-STP indicates that all the analyzed parameters are within the permissible limits of drinking water standards except Fluoride content (1.30 mg L-1). The biological parameters such as COD (92.2 mg L-1) and BOD (15 mg L-1) were within the prescribed limits but E. Coli was present in 100mL sample which means greater risk that pathogens are present and not acceptable as per BIS standards.

Tank Water Samples Analysis Results of KC valley: The results of 32 surface water samples collected from tanks for basic parameters of KC valley indicates that the pH of the samples varied from 6.94 to 8.15, Electrical conductivity from 190-860 µS/cm, TDS ranging from 116-507 mg/L, Chloride from 7.09-131 mg/L, nitrate content varied between 0.2-28.48 mg/L, Fluoride from 0.27-0.95 mg/L. All the parameters were well within the permissible limits. All the heavy metals are within permissible limit except Iron at 2 locations. The highest concentration of iron above the acceptable limit of 1.00 mg/L was observed in Hosahalli Lake (1.83 mg/L). The biological parameters in tank/lake water samples of KC valley network indicated that most of the samples were well within permissible limit, except the presence of E. Coli was seen at 6 locations in tank samples of Madiwala thattala kunta kere, Seesandra Dodda kere, Doddaiyuru kere, Jammanahalli kere, Avalamarkalghatta Dodda kere and Kengunte kere. The pathological contamination may be taking place through treated sewage water as it was containing E-coli at Bellandur STP. The possibility of e-coli contamination entering waterbodies through local sewage nala also cannot be ruled out considering their close proximity to the villages.

Ground Water Samples Analysis Results of KC valley: The results of 34 borewell samples for basic parameters of KC valley indicates that the pH of the samples varied from 6.43 to 8.88, Electrical conductivity ranged from 500-2630 µS/cm, TDS were ranging from 295-1653 mg/L, Chloride from 31.9-518 mg/L, nitrate content varied between 0.02 and 46.46 mg/L. More than permissible limit of nitrate was observed in 2 borewell samples with highest concentration of nitrate being observed at Holahalli (46.46 mg/L). More than permissible limit of fluoride concentration was observed in Suluru with value of 1.70 mg/L. In heavy metals, Manganese more than the permissible limit of 0.3 mg/L was observed at Chintamakanhalli (0.306 mg/L).

Sample collection from Choudenahalli Lake, Kolar District (KC Valley)

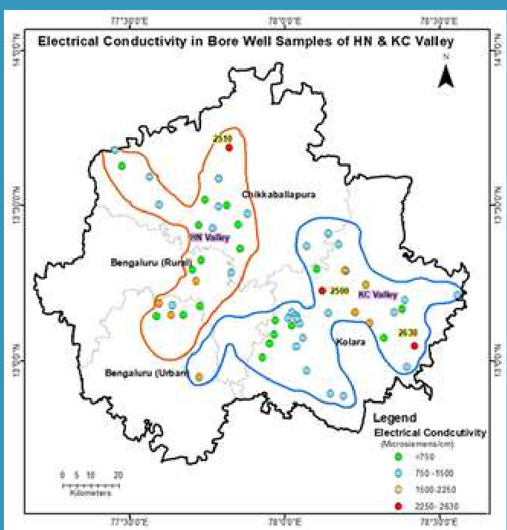
Iron more than the permissible limit of 1.00 mg/L was observed in 2 samples located at Avalamarakalghatta and Madderi with values 8.21 and 2.96 mg/L respectively. Uranium was observed in excess of 30 ppb in15 samples located at Lakshmisagar, Narsapura, Gowdahalli, Suluru,Kolar, Kendati, Seesandra, Bodhikote, Chinnapur, Kamasamudra, Kurtahalli, Dandupalya, Kalluru, Jammannnahalli, Mulbagilu and Lingapura. The high uranium content in the ground water samples is most probably due to geogenic sources.

Sample Collection from Borewell in Gowdahalli village, Kolar District (KC Valley).

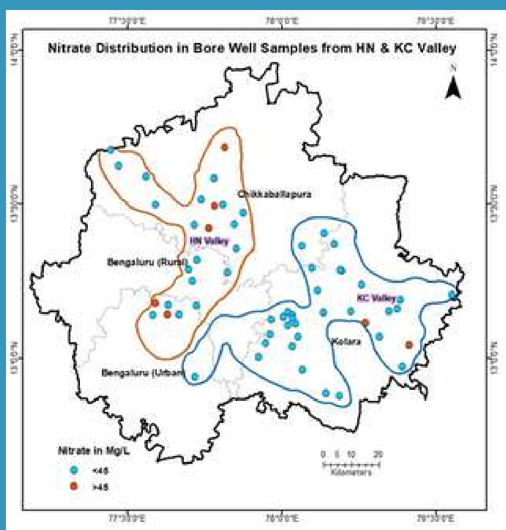
The biological parameters in KC valley borewell samples indicated that the COD and BOD were well within the permissible limit. However, the presence of E. Coli was seen in 4 locations of Chikaiyuru, Kendatti, Dandupalya and Mulbagilu which shows the chances of pathological contamination may be through local sewage water contributing to the borewells as the input treated sewage treated water is free from pathological contamination.

Based on the results of basic chemical parameters analysis, the ground water suitability for irrigation purpose was arrived based on Sodium Adsorption Ration (SAR), Residual Sodium Carbonate (RSC) and Soluble Sodium Percentage (SSP).

It indicates that SAR value ranged from 0.54 to 4.82, RSC value ranged from (–) 9.60 to 1.60 and SSP value ranged from 13.90 to 60.00. Most of the borewell water samples are good and suitable for irrigation purpose. However, based on SSP the sample from Garudapalya (60) was not suitable for irrigation.



Electrical Conductivity in Ground Water (Borewells) of KC and HN valley.



Nitrate in Ground Water (Borewells) of KC and HN valley.

WATER QUALITY SCENARIO IN HN VALLEY

STP Treated Water Analysis Results of HN valley: The analysis results of 3 STP treated water samples collected from Hebbala-STP, Hennur-STP, Horamavu-STP indicates that all the analyzed parameters are within the permissible limits of drinking water standards. As per WHO standards, phosphate (PO4) concentration in surface water should not exceed 5 mg/L, the treated water of Horamovu was found to have PO4 concentration of 6.78 mg/L. The nitrate concentration was also found to be elevated in all 3 STPs located at Hebbala (34.2 mg/L), Hennur (43.84 mg/L), Horamavu (34.26 mg/L) but it is within the permissible limit of 45 mg/L and may need to be brought down.

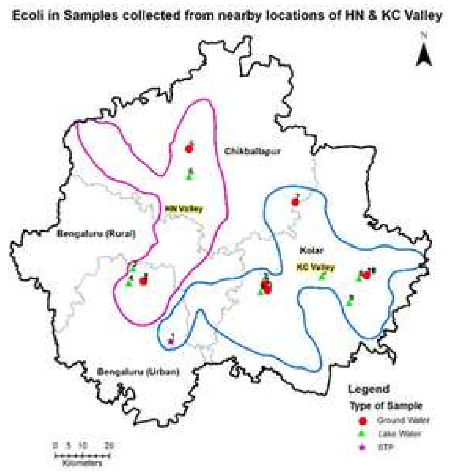
Tanks Water Samples Analysis Results of HN valley: The results of 25 surface water samples collected from tanks for basic parameters of HN valley indicates that the pH of the samples varied from 6.57 to 7.87, Electrical conductivity from 204-888 µS/cm, Chloride from 18-131 mg/L, nitrate content varied between 0-23.1 mg/L, Fluoride from 0.17-1 mg/L and TDS ranging from 141-529 mg/L. All the parameters were well within the permissible limits. All the heavy metals are within permissible limit except Uranium which was observed in excess of 30 ppb in only Devanahalli lake sample (34.40 µg/L). The biological parameters in tank water samples of HN valley network indicated that BOD was more than permissible limit of 30 mg/L at 6 locations in Bagalur, Hunasur, Bharatinagar, Tarahunase, Gollahalli and Amani Bhadran Lakes.

Sample Collection from Hebbal STP Outlet, HN Valley, Bengaluru Urban District.

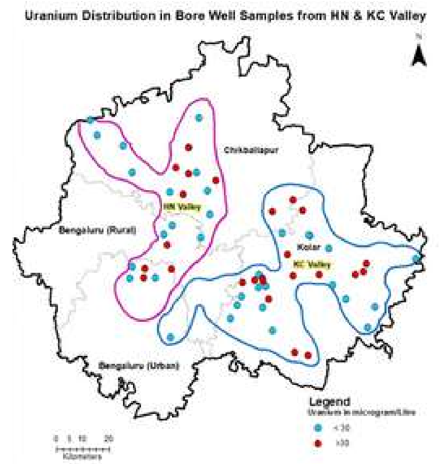
The presence of E. Coli was also observed at 4 locations of Bharatinagar, Tarahunase, Harohalli, and Dibbur lakes which shows the chances of pathological contamination may be through local sewage water entering waterbodies as the input treated sewage treated water is free from pathological contamination.

Ground Water Samples Analysis Results of HN valley: The results of 25 borewell samples for basic parameters of HN valley indicates that the pH of the samples varied from 5.96 to 7.81, Electrical conductivity from 264-2510 µS/cm, Chloride from 35.5- 415.35 mg/L, nitrate content varied between 0-100.74 mg/L. More than permissible limit of nitrate was observed in 6 borewell samples with highest concentration of nitrate being observed at Tarahunase (100.74 mg/L). More than permissible limit of fluoride concentration was observed in Ramasandra and Varavani with values 2.0 and 1.90 mg/L respectively. The TDS of the samples were ranging from 207-1585 mg/L. All the heavy metals are within permissible limit except Uranium which was observed in excess of 30 ppb in Devanahalli, Gollahalli, Dibbur, P.Byrasagara, Hunasur, Ramasandra, Chikkajala, Bandammana kere and Bharatinagar. The highest Iron content was found in Venkatagirikote (11.1 mg/L).

The biological parameters in HN valley borewell samples indicated that the COD and BOD were well within the permissible limit. However, the presence of E. Coli was seen in borewell samples of Bharatinagar and P.Byrasagara which shows the chances of pathological contamination may be through local sewage water contributing to the borewell contamination as the input treated sewage treated water is free from pathological contamination.



E-Coli in Surface Water (Lakes) and Ground Water (Borewells) of KC and HN valley



Uranium in Ground Water (Borewells) of KC and HN valley.

Based on the results of basic chemical parameters analysis, the ground water suitability for irrigation purpose was arrived based on Sodium Adsorption Ration (SAR), Residual Sodium Carbonate (RSC) and Soluble Sodium Percentage (SSP). It indicates that SAR value ranged from 0.71 to 5.43, RSC value ranged from (–) 6.60 to 2.00 and SSP value ranged from 19.20 to 54.60. The SAR showing the sodicity of the sample for irrigation was low in all the samples and indicates that all are suitable for irrigation. Most of the borewell water samples are good and suitable for irrigation purpose, except SSP which was more than 50% in 9 samples and not found suitable for irrigation.

Pearson Correlation: Pearson correlation coefficient (r) is a dimensionless index that ranges from -1.0 to 1.0 inclusive and reflects the extent of a linear relationship between two data sets. The positive correlation indicates that if concentration of one of the constituent increases, the other constituent will increase, whereas for negative correlation it is reverse. It was calculated for 17 parameters viz., pH, Electrical Conductivity, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Sulphate, Nitrate, Fluoride, Phosphate, Silicate, Total Dissolved Solids, COD and BOD for ground water, whereas Carbonate was considered for ground water of KC valley as it was present in ground water. The Pearson correlation analysis was carried out for surface and ground water samples of KC valley and HN valley to study the correlation between different constituents. Correlation analysis (CA), principal component analysis (PCA) and Hierarchical cluster analysis (HCA) have been broadly used as unbiased methods in the analysis of water-quality data for drawing meaningful information (K. Singh et., al, 2005)

The Pearson correlation matrix for **KC valley tank water samples** is presented in Table-3. The analysis indicates positive correlation in 97 pairs of constituents ignoring the perfect 1.00 value for the same constituent, whereas negative correlation has been observed between 39 pairs of constituents. Electrical Conductivity which is directly related to TDS, is because of the all ions present in the water, hence EC has a positive correlation with almost all constituent ions except Phosphate. Phosphate has a negative or no correlation with almost all the parameters except COD, which have weak positive relationship. Calcium, Sodium, Bicarbonate and Chloride are strongly correlated.
However, Calcium and Magnesium are not strongly correlated with Sulpate, indicating a potential different source for Sulphate other than geogenic origin, which could possibly be the treated sewage water in this case. Phosphate and potassium show negative or no correlation to the other major ions and can be expected from agricultural runoff mixed with fertilizers.

	pH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	F	PO4	Si	TDS	COD	BOD
pH	1.00																
EC	0.25	1.00															
TH	0.16	0.91	1.00														
Ca	0.39	0.76	0.71	1.00													
Mg	-0.21	0.43	0.61	-0.13	1.00												
Na	0.36	0.91	0.69	0.69	0.18	1.00											
K	-0.31	0.13	0.29	-0.05	0.46	-0.11	1.00										
HCO3	0.31	0.88	0.80	0.65	0.38	0.85	0.00	1.00									
Cl	0.18	0.83	0.81	0.66	0.40	0.69	0.35	0.53	1.00								
SO4	-0.06	0.53	0.47	0.25	0.38	0.49	0.06	0.41	0.27	1.00							
NO3	-0.08	0.45	0.31	0.50	-0.12	0.51	-0.34	0.32	0.30	0.32	1.00						
F	0.42	0.57	0.28	0.57	-0.25	0.79	-0.45	0.64	0.24	0.34	0.59	1.00					
PO4	-0.28	-0.22	-0.18	-0.23	0.00	-0.24	-0.02	-0.14	-0.19	-0.27	-0.19	-0.15	1.00				
Si	-0.13	0.38	0.30	0.43	-0.05	0.41	-0.25	0.33	0.20	0.25	0.70	0.53	-0.04	1.00			
TDS	0.26	1.00	0.91	0.77	0.40	0.92	0.13	0.89	0.82	0.55	0.47	0.60	-0.23	0.39	1.00		
COD	0.21	-0.02	-0.10	0.20	-0.37	0.14	-0.31	0.04	-0.05	-0.12	0.20	0.37	0.21	0.10	0.02	1.00	
BOD	-0.2	0.072	-0.05	0.044	-0.11	0.221	-0.24	0.059	-0.01	0.193	0.286	0.267	0.015	0.421	0.096	0.224	1

Table - 3: Pearson Correlation Coefficient Matrix for Tank Water Samples (n=32) – KC Valley

The Pearson correlation matrix for **KC valley ground water samples** is presented in Table-4. The analysis indicates positive correlation in 98 pairs of constituents ignoring the perfect 1.00 value for the same constituent, whereas negative correlation has been observed between 55 pairs of constituents. In ground water also, EC has a positive correlation with almost all constituent ions except Phosphate, pH and Carbonate. Strong positive correlation between Carbonate and pH is evident as Carbonate exists only at a higher pH. The negative correlation of pH and Carbonate with constituents like Calcium, Magnesium, Bicarbonate, Total Hardness and Sulphate could be explained as precipitation of various chemical species at higher pH. Sodium and Chloride show a strong positive correlation indicating a possible similar source. Strong negative correlation between dissolved silica and pH is because of the fact that dissolution of silicate minerals is favored in acidic conditions.

	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F	PO4	Si	TDS	COD	BOD
pH	1.00																	
EC	-0.30	1.00																
TH	-0.35	0.91	1.00															
Ca	-0.39	0.91	0.96	1.00														
Mg	-0.16	0.67	0.81	0.62	1.00													
Na	-0.17	0.87	0.65	0.67	0.42	1.00												
K	-0.02	0.44	0.17	0.21	0.05	0.40	1.00											
CO3	0.74	-0.18	-0.22	-0.21	-0.17	-0.11	0.00	1.00										
HCO3	-0.24	0.73	0.57	0.53	0.50	0.66	0.69	-0.23	1.00									
Cl	-0.24	0.95	0.88	0.91	0.58	0.82	0.33	-0.12	0.56	1.00								
SO4	-0.21	0.57	0.61	0.59	0.48	0.48	0.08	-0.17	0.17	0.46	1.00							
NO3	-0.19	0.59	0.49	0.41	0.53	0.59	0.37	-0.19	0.49	0.45	0.52	1.00						
F	-0.16	-0.18	-0.30	-0.24	-0.35	0.01	-0.02	-0.18	0.04	-0.31	-0.02	-0.07	1.00					
PO4	0.55	-0.09	-0.09	-0.12	-0.02	-0.15	0.18	0.71	-0.06	-0.11	-0.05	0.05	-0.15	1.00				
Si	-0.62	0.25	0.25	0.17	0.36	0.16	0.18	-0.74	0.37	0.14	0.14	0.37	0.16	-0.34	1.00			
TDS	-0.28	0.99	0.88	0.88	0.64	0.88	0.53	-0.18	0.78	0.93	0.56	0.62	-0.17	-0.08	0.26	1.00		
COD	-0.31	0.39	0.32	0.45	-0.04	0.48	0.02	-0.04	0.14	0.42	0.27	0.08	0.19	-0.02	0.08	0.38	1.00	
BOD	0.04	0.03	0.00	0.05	-0.10	0.03	0.01	0.06	-0.05	0.09	0.09	-0.23	0.11	0.10	-0.07	0.03	0.30	1.00

Table - 4: Pearson Correlation Coefficient Matrix for Ground Water Samples (n=34) – KC Valley

The Pearson correlation matrix for **HN valley tank water samples** is presented in Table-5. The analysis indicates positive correlation in 114 pairs of constituents ignoring the perfect 1.00 value for the same constituent, whereas negative correlation has been observed between 22 pairs of constituents. Here also EC has a positive correlation with almost all constituent ions except pH. The negative correlation of pH with constituents like Calcium, Magnesium, Bicarbonate, TH and Sulphate could be explained as precipitation formation of various chemical species at higher pH. The positive correlation of BOD with phosphate, potassium and nitrate is indicative of anthropogenic pollution, could be agricultural runoff mixed with fertilizers. Also there is strong positive correlation between Nitrate, Phosphate, Potassium, Calcium, Magnesium, Sodium, Bicarbonate and Chloride amongst each other and thus could be of same origin.

	PH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	F	PO4	Si	TDS	COD	BOD
PH	1.00																
EC	-0.13	1.00															
TH	-0.05	0.96	1.00														
Ca	0.04	0.89	0.96	1.00													
Mg	-0.15	0.95	0.95	0.82	1.00												
Na	-0.14	0.97	0.89	0.78	0.92	1.00											
K	-0.33	0.70	0.60	0.57	0.57	0.62	1.00										
HCO3	-0.02	0.92	0.94	0.88	0.92	0.88	0.53	1.00									
Cl	-0.29	0.90	0.82	0.75	0.81	0.88	0.79	0.70	1.00								
SO4	0.04	0.70	0.64	0.55	0.69	0.78	0.25	0.66	0.49	1.00							
NO3	-0.03	0.75	0.77	0.78	0.69	0.64	0.69	0.79	0.58	0.42	1.00						
F	0.18	0.32	0.36	0.26	0.45	0.39	-0.36	0.45	0.06	0.49	0.03	1.00					
PO4	-0.01	0.76	0.79	0.79	0.72	0.64	0.66	0.83	0.57	0.40	0.97	0.11	1.00				
Si	-0.06	0.59	0.58	0.51	0.60	0.59	0.26	0.67	0.40	0.64	0.67	0.34	0.63	1.00			
TDS	-0.14	0.99	0.95	0.88	0.94	0.97	0.70	0.92	0.90	0.72	0.75	0.30	0.76	0.62	1.00		
COD	-0.25	-0.01	0.01	-0.01	0.02	-0.02	0.18	0.07	-0.03	-0.01	0.09	-0.29	0.11	-0.02	0.02	1.00	
BOD	-0.09	0.36	0.33	0.34	0.28	0.32	0.54	0.34	0.41	0.01	0.49	-0.18	0.48	0.19	0.37	0.22	1.00

Table - 5: Pearson Correlation Coefficient Matrix for Tank Water Samples (n=25) – HN Valley

The Pearson correlation matrix for **HN valley ground water samples** is presented in Table-6. The analysis indicates positive correlation in 99 pairs of constituents ignoring the perfect 1.00 value for the same constituent, whereas negative correlation has been observed between 37 pairs of constituents. Here also EC has a positive correlation with almost all constituent ions except phosphate, pH and Potassium. Calcium is strongly positively related with Sodium and Chloride whereas Sodium is strongly related with Bicarbonate, Sulphate, Chloride and Nitrate. Hence Sodium, Chloride, Bicarbonate, Sulphate and Nitrate could have origins from both sources viz., geogenic and from pollution due to treated sewage water. Phosphate has weak negative relationship or no relationship with other constituents. Potassium is not strongly related with any of the ions. Hence Phosphate and Potassium could be from a different source than the other constituents like irrigation runoff mixed with fertilizers. Strong positive correlation coefficient value between BOD and COD indicates that the wells have significant level of biological contamination which is proportional to the COD.

	PH	EC	TH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	F	PO4	Si	TDS	COD	BOD
PH	1.00																
EC	0.12	1.00															
TH	0.01	0.95	1.00														
Ca	0.01	0.78	0.77	1.00													
Mg	0.01	0.68	0.77	0.19	1.00												
Na	0.19	0.96	0.85	0.73	0.58	1.00											
K	0.18	0.38	0.26	0.28	0.12	0.32	1.00										
HCO3	0.35	0.70	0.68	0.33	0.71	0.73	-0.08	1.00									
Cl	-0.05	0.94	0.90	0.88	0.52	0.87	0.45	0.45	1.00								
SO4	0.22	0.82	0.69	0.53	0.54	0.84	0.47	0.50	0.72	1.00							
NO3	-0.11	0.64	0.64	0.53	0.45	0.59	0.31	0.18	0.66	0.61	1.00						
F	0.60	0.42	0.29	0.08	0.36	0.49	0.05	0.67	0.18	0.46	-0.06	1.00					
PO4	-0.01	-0.24	-0.24	-0.15	-0.21	-0.21	-0.19	-0.14	-0.25	-0.16	-0.08	0.08	1.00				
Si	-0.52	-0.08	-0.03	0.01	-0.06	-0.10	-0.43	-0.15	-0.03	-0.03	0.18	-0.29	0.37	1.00			
TDS	0.15	0.99	0.94	0.76	0.68	0.98	0.34	0.73	0.91	0.84	0.66	0.43	-0.23	-0.07	1.00		
COD	0.21	0.15	0.06	0.35	-0.25	0.15	0.22	-0.08	0.19	0.15	-0.06	0.27	-0.16	-0.21	0.11	1.00	
BOD	0.12	0.20	0.12	0.52	-0.33	0.17	0.25	-0.20	0.34	0.14	0.00	0.09	-0.17	-0.10	0.14	0.90	1.00

Table - 6: Pearson Correlation Coefficient Matrix for Ground Water Samples (n=25) – HN Valley

Conclusions: The results of **KC valley** indicate that out of the 33 constituents analysed for 34 ground water samples, 7 constituents viz., pH (2 samples), Nitrate (2 samples), Fluoride (1 sample), Iron (2 samples), Manganese (1 sample), Uranium (16 samples) and E. Coli (4 samples) are not confirming to the permissible limits of BIS-2012 for drinking purpose. In case of surface water samples collected from tanks/lakes, Iron was more than permissible limit (> 1.00 mg/L) at 2 locations, presence of E. Coli was seen at 6 locations. The analysis results of Belandur STP treated water sample indicates that E.coli was present, thus, the treated water may be contributing to bacteriological contamination of surface water and ground water. However, the contamination due to local untreated sewage water entering the tanks and ground water system cannot be ruled out. The nitrate contamination is most probably due to contamination from local sewage contribution as the treated water does not contain elevated levels of nitrate. The Fluoride and Uranium contamination is due to geogenic sources (parent rock-granitic gneisses, granites). The SAR, RSC and SSP results indicates that most of the groundwater samples are good and suitable for irrigation purpose, except sample from Garudapalya which has higher value of SSP @ 60% and was found to be not suitable for irrigation. The Pearson correlation analysis for surface and ground water indicated that EC has a positive correlation with almost all constituent. In tank water samples, Pearson correlation is indicating a potential different source for Sulphate other than geogenic origin, which could possibly be the treated sewage water in this case.

The results of **HN valley** indicate that all the constituents of ground water samples are well within the permissible limit of BIS-2012 for dinking purpose except fluoride (>1.5 mg/L) in 2 samples, nitrate (>45 mg/L) in 6 samples, Uranium (>30 ppb) in 10 samples and E-coli in 2 samples. In case of surface water samples collected from tanks/lakes, Iron was more than permissible limit (>1.5 mg/L) at 5 locations, Uranium was more than permissible limit (30 ppb) at 1 location only, BOD was more than permissible limit of 30 mg/L at 6 locations, presence of E. Coli was seen at 4 locations. The analysis results of 3 STP treated water samples indicates that all the analyzed parameters are within the permissible limits of drinking water standards. Thus, the treated water is most probably not contributing to any contamination of surface and ground water. The Fluoride and Uranium contamination is due to geogenic sources (parent rock-granitic gneisses, granites). The nitrate contamination is most probably due to agricultural activity or local sewage contribution. The SAR, RSC and SSP results indicates that most of the groundwater samples are good and suitable for irrigation purpose, except SSP which was more than 50% in 9 samples and not found suitable for irrigation. The Pearson correlation analysis for surface and ground water indicated that EC has a positive correlation with almost all constituent. In tank water samples, positive Pearson correlation of BOD with phosphate, potassium and nitrate is indicative of anthropogenic pollution, could be from agricultural runoff mixed with fertilizers. In ground water samples, Sodium, Chloride, Bicarbonate, Sulphate and Nitrate could have origins from both sources viz., geogenic and from pollution due to treated sewage water.

Pathshala

Ground Water - Sampling, Preservation & Storage

Gulshan Rani, CHQ Faridabad

Introduction

Understanding the effects of contamination on the environment is vital for developing effective strategies to protect and restore natural ecosystems. Hence Groundwater quality data is of utmost importance to support informed decision-making for the sustainable management of water resources. It is critical for protecting the health of humans and the environment, complying with regulations, promoting economic benefits, and ensuring sustainable water resource management. For this, the first step towards generating a significant database is collection, storage and handling of the groundwater samples to the laboratory.

Major Components for Sample Collection and Preservation

A beforehand planning is crucial before starting the actual sampling process. The purpose of monitoring and parameters to be analysed should be kept in mind for making necessary arrangements considering the following parameters before actual sample collection.

- Number of samples
- Volume of sample
- Type of Sample Container
- Preservation Techniques

General parameters analysed to determine the ground water quality and their sampling and storage requirements are specified as follows:

PARAMETERS FOR ANALYSIS	SAMPLE CONTAINER	MINIMUM SAMPLE SIZE (ML)	PRESERVATION	MAXIMUM STORAGE RECOMMENDED
Field Parameters: pH, Temperature, EC, etc.	-	-	-	Analyze immediately
Major Basic parameters: Ca^{2+}, Mg^{2+}, Total Hardness, Na^{+}, K^{+}, F^{-}, CO_3^{2-}, HCO_3^{-}, SO_4^{2-}, Cl^{-}, NO_3^{-}, SiO_2, PO_4^{3-}	PE	1000	-	3 months
Trace Elements: Iron, Manganese, Arsenic, Uranium, Zinc, Nickel, Lead, Cadmium, Chromium, Selenium etc.	PE(A)	500 (For AAS); 60 (For ICPMS)	For dissolved metals filter immediately, add HNO3 to pH < 2	6 months

- PE = Polyethylene or equivalent; PE(A) = Polyethylene acid wash (rinsed with 1+1 HNO3)
- AAS = Atomic Absorption Spectroscopy; ICPMS = Inductively Coupled Plasma Mass Spectrometry.

Sample Handling and Submission to the Laboratory

Properly designed and executed handling of samples will ensure sample integrity from collection to data reporting. The following procedures summarize the major aspects of sample handling (as per APHA, 2017):

- **Sample Labels:** Use labels to prevent sample misidentification.
- **Sample Seals:** Use sample seals to detect unauthorized tampering with samples up to the time of analysis.
- **Field Log Book:** Specify the purpose of sampling; source and type of sample; depth of sample; location of sampling point; date of sampling; name of field officer; and method of preservation used if any and other relevant field observations.
- **Sample delivery to the laboratory:** Deliver samples to laboratory as soon as practicable after collection. Ground Water samples should be transported to Laboratory as soon as possible, preferably within 48 hours. Sample should be refrigerated below 6°C for Temperature sensitive constituents.
- **Receipt and logging of sample:** In the laboratory, the sample collector inspects the condition and seal of the sample and reconciles label information and seal against the record before the sample is accepted for analysis. After acceptance, the collector assigns a laboratory number, logs sample in the laboratory log book, and stores it in a secured storage room or cabinet or refrigerator at the specified temperature (below 6°C for Temperature sensitive constituents) until it is assigned to an analyst to follow the parameter wise timeline for analysis.

Shodh

Research Publications by CGWB Officers in Reputed International Journals

Title: Hydrogeochemical factors influencing the dynamics of groundwater characteristics in eco-sensitive areas of the Southern Western Ghats, India

Scientific Reports

Bakshe P., Chandran M., Viju B.J., Narikkatan A.K., Jugade R.M.

Abstract : The inter-ionic relationships of groundwater present in a region as well as various chemical and physical factors all have an impact on the geochemistry of groundwater in an aquifer. To assess the factors influencing the geochemical composition of groundwater in the eco-sensitive area of Western Ghats, Kerala, India, various weathering, and ionic indices were analyzed. Results show groundwater ranges from soft to extremely hard and acidic to alkaline, with high Mn and Fe levels. WQI analysis found 7% of samples unfit for drinking due to Fe/Mn contamination in the southeast part of the study area. Main water types are CaHCO3 (46%) and CaMgCl. Geochemical modeling indicates silicate and carbonate weathering, cation exchange, and reverse ion processes influence the aquifer. Groundwater is often supersaturated with iron minerals, saturated with carbonate minerals, and undersaturated with sulfate and chloride minerals. Cluster analysis (CA) revealed that NO3- and K+ are derived from anthropogenic sources. Principal component analysis (PCA) resulted in three factors. Factor 1 is for geogenic processes, while Factors 2 and 3 imply the anthropogenic and weathering of iron-rich minerals. Hierarchical cluster analysis defines anthropogenic input, silicate and carbonate weathering, and different patterns of mineralization in the groundwater. The study underscores the need for comprehensive management to protect groundwater quality, considering the complex interplay of natural processes and human factors.

Title: Multi-model seismic susceptibility assessment of the 1950 great Assam earthquake in the Eastern Himalayan front

Geosystems and Geoenvironment

Bhadran A., Duarah B.P., Girishbai D., Achu A.L., Lahon S., Jesiya N.P., Vijesh V.K., Gopinath G.

Abstract : The seismic susceptibility and mitigation management is paramount concern in tectonically active area like Northeastern India. This area has been devastated innumerably during the 1950 Assam great earthquake. The present study area falls in the foreland basin (Brahmaputra Valley) of Eastern Himalaya. This region is seismically vulnerable due to the tectonic complexity caused by the convergence of the Eurasian, Indian, and Burmese plates. In such, an area optimal disaster management and preparedness is necessary to define the non-linear character of seismic susceptibility, where population and unscientific urbanization have increased manifold. Therefore, for the present study, various multi-criteria decision making (MCDM) methods such as analytical hierarchy process (AHP), fuzzy-AHP (FAHP), and maximum entropy technique (MaxEnt) have been used for determining the seismic susceptibility, by assigning weightage to nine controlling factors such as: predominant frequency (f0), geology (G), vulnerability index (K), peak amplification (A0), liquefaction potential (LP), groundwater condition (WT), shear wave velocity (Vs30), peak ground acceleration (PGA), and land use/land cover (LU). The MaxEnt model exhibits the highest accuracy (87.5%) when the performance of the models was compared using the receiver operating characteristic curve (ROC) and area under the curve (AUC) value. Further, overlay analysis of best seismic susceptibility model using MaxEnt and PGV-based Japan Meteorological Agency (JMA) intensity shows that 40% the study area is in the very high and high seismic risk zone. In tectonically active areas, this kind of integration work is essential to improves the mitigation strategy and aids urban planners in designing earthquake-resistant buildings.

Title: **Hydrogeology of southeastern coastal parts of Great Nicobar Island, India: development of an integrated conceptual model for a hitherto unexplored island in the Indian Ocean**

Quarterly Journal of Engineering Geology and Hydrogeology

Roy I., Sarkar S., Kumar A., Mukherjee M., Nandi R., Chowdhuri A.N., Barman N., Choudhury A., Gayen A.

Abstract : The vulnerability of oceanic islands in the face of climate change, vis-a-vis human development, is a serious issue at present. The island of Great Nicobar in the Nicobar archipelago in the Indian Ocean will face major challenges owing to its impending development activities. The eastern coastal part of the island was investigated through exploratory drilling, geophysical investigations, and water-table monitoring. Field investigations show that coralline sand is the major groundwater repository and is commonly developed through dug wells. Exploratory drilling down to 100 m depth revealed that the underlying Tertiary consolidated aquifer is of limited potential and showed increased salinity with depth. Water is also present along the contacts of shale-sandstone. The mean seasonal fluctuations in the depth to the water table was 0.18 m. Geoelectrical sections identified promising fresh groundwater zones along the east coast, with freshwater-bearing semi-weathered coralline limestone and coralline sand having a resistivity of 146–622 ohm m. Based on generated data, a 3D model of the aquifer system was constructed. The observed soil infiltration rate was 0.3–0.5 cm h-1. The specific capacity of the dug wells was c. 5 m2 min-1. The permeability of the phreatic aquifer was 5-11 m/day and the transmissivity was 0.11–0.2 m2 min-1. The optimum yield of the unconfined aquifer was 17-21 m3/day. The tidal influences on the aquifer system also added complexity to the island's hydrogeological dynamics. Despite the challenges of restricted access due to the presence of aboriginal tribes in the island, the present study provides the maiden set of hydrogeological data for the island, revealing the disposition of the aquifers, their properties and their spatio-temporal behaviour.

Title: **Achievements and significance of national hydrograph stations network and 55 years of continuous groundwater level monitoring in India**

Groundwater for Sustainable Development

Dixit M., Arora M., Jayaprakash H.P., Achutha V.R.

Abstract : Groundwater management is not only about technology but also about the governance of the resources. The National Hydrograph Stations Network (NHSN) has been operated by the Central Groundwater Board (CGWB), India for more than 55 years and covers a large geographical area. It has over 25000 monitoring wells, including dug wells, bore wells, tube wells, and springs across India's 18 regional offices, including 28 states and 8 union territories. During the last two decades, the NHSN has gone through a significant modernization process, involving the installation of bore well stations equipped with Digital Water Level Recorders (DWLR). Groundwater level data is collected from the wells in January (winter/non-monsoon), May (pre-monsoon), August (co-monsoon), and November (post-monsoon), and continuously examined quarterly to monitor the groundwater's quantity, quality, and significance changes. The present study aims to understand and provide details about the NHSN that include, 1) data streaming from field hydrograph stations to the regional offices for analysis; 2) automatic and manual publication of the fluctuation in groundwater; 3) chemical analysis of observed data, etc. Additionally, the study analyses the borewells, temporal and spatial changes in the groundwater level, chemical content, and groundwater assessment in the country. The spatial and temporal analysis of bore well stations further indicates the network's capability in recent decades. It is noteworthy that, the total number of assessment units in the safe category has increased after the implementation of the National Aquifer Mapping program (NAQUIM) in year 2012. The exercise spearheaded by the CGWB and the increased involvement of the society is improving the groundwater scenario in India. Groundwater monitoring is important for the conservation of water resources and also essential for the policymakers for sustainable development and management. These results provide valuable understandings for decision-making and strategies to improve the resilience of water resources in the region. © 2024

TITLE: **CONTROLLING ARSENIC CROSS-CONTAMINATION IN MULTI-AQUIFER SYSTEM OF GANGETIC FLOOD PLAIN THROUGH OPTIMAL WELL SPACING BASED ON AQUIFER RESPONSE MODELLING—A CASE STUDY FROM BUXAR DISTRICT AND NEIGHBOURING AREAS, BIHAR, INDIA**

WATER CONSERVATION SCIENCE AND ENGINEERING

DWIVEDI S.N., ROY I., SHUKLA R.R., ALAM F., KUMAR S., KUMAR P., SINGH R.

Abstract : Availability of safe drinking water in the face of arsenic contamination of groundwater has become a global concern, and India is no exception to this alarming problem. Buxar district in the state of Bihar, India, has four blocks affected by arsenic contamination. Groundwater system of the area consists of multiple aquifers, with an arsenic-infested shallow aquifer system and an arsenic-safe deeper aquifer system, separated by a discontinuous clay layer of variable thickness. In response to the increasing demand of potable water, there is a recent trend of either constructing new wells that tap the deeper aquifer or deepening of the existing tube wells. However, unregulated exploitation of the deeper aquifer poses a significant risk, as it can disrupt the hydrodynamics of the entire groundwater system, leading to increased threats of cross-contamination of the deeper arsenic-safe aquifer from the overlying arsenic-contaminated aquifer. In the present study, modelling of the piezometric head of the deeper confined aquifers through distance drawdown analysis using the Theis non-equilibrium equation has been carried out. Findings indicate that the hydraulic head of the deeper aquifer rests at higher level than the water level of the shallow aquifer, thereby acting as a natural flow-pattern defence against the movement of contamination from the shallow aquifer to the deeper aquifer. To address this concern and understand the hydrodynamic balance within the aquifer system, an aquifer response modelling based on Theis non-equilibrium equation has been attempted. This model employs field-determined aquifer parameters to determine the optimal pumping discharge and spacing between wells constructed in the deeper arsenic safe aquifer. The objective is to devise a strategy for keeping the deeper arsenic-safe aquifers protected from any threats of cross-contamination from the overlying arsenic-contaminated aquifer. The results of the study suggest that water supply schemes in the arsenic-affected areas should be designed with a maximum discharge of 50 m3/h. Additionally, a minimum spacing of 2 km between two adjacent high discharge community water supply wells is recommended. The approach presented in the study can be used to determine the safe discharge and optimal spacing criteria between high discharge community water supply wells for pumping the arsenic safe confined aquifers in similar hydrogeological settings. Implementation of the suggested measures is crucial to ensure safe and clean drinking water for present and future generations in the arsenic contaminated areas.

TITLE: **AN OVERVIEW OF HEAVY METALS TREATMENT & MANAGEMENT FOR LABORATORY WASTE LIQUID (LWL)**

JOURNAL OF ENVIRONMENTAL CHEMICAL ENGINEERING

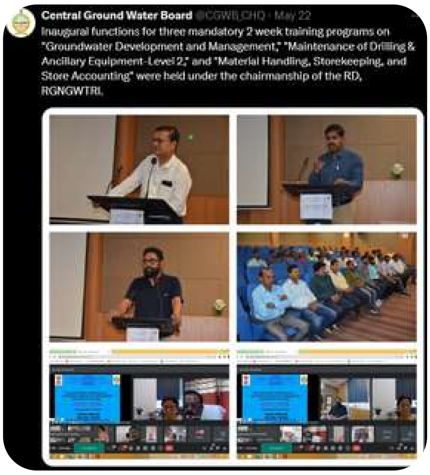
DHENKULA S.P., SHENDE A.D., DESHPANDE L., POPHALI G.R.

Abstract : The laboratory waste liquid (LWL) is the discarded liquid after the completion of analysis and is produced from the testing laboratories including regulatory institutions, colleges, universities and research organizations. This LWL is laden with a variety of heavy metals due to the use of heavy metal salts in analysis and the treatment and safe disposal of LWL is seldom given due consideration. Thus, the management of hazardous laboratory waste liquid (HLWL) containing heavy metals is essential at the source itself. Accordingly, this article presents systematic review of three processes for heavy metals removal viz. precipitation, adsorption, and membrane separation. The review covers various factors such as heavy metal removal efficiencies & concentration ranges, optimum pH, most frequently studied methods, less studied aspects, its commercial availability, operational ease, and the potential of risk minimization with due concern to toxic heavy metals. The concentrations of heavy metals in LWL is also presented. Based on the review, activated carbon (AC) adsorption appears to be the best option for LWL having heavy metals concentration of less than 10 mg/L. The heavy metals removal efficiency of more than 95% can be achieved at an AC dose of 0.2-1 g/L. The hydroxide precipitation was found to achieve more than 95% removal efficiencies at higher heavy metals concentrations. Thus, for concentrations higher than 10 mg/L up to 3000 mg/L, the hydroxide precipitation followed by activated carbon adsorption may prove beneficial.


Central Ground Water Board
Published by केंद्रीय भूमि जल बोर्ड
1 May
The 1st SLC meeting for GWRA, 2024 of Goa was organized on 29.4.2024 at WRD, Porvorim Goa. The meeting was chaired by Sri P.S.Badami, Chief Engineer, WRD and Sri D.Y.Salelkar, Chief Engineer (project). Sri N. Jyothi kumar, Regional Director and Member Secretary of SLC gave the welcome address. The dynamic GWRA report of Goa for 2023 was released in the meeting. Ministry of Jal Shakti, Department of Water Resources, RD & GR

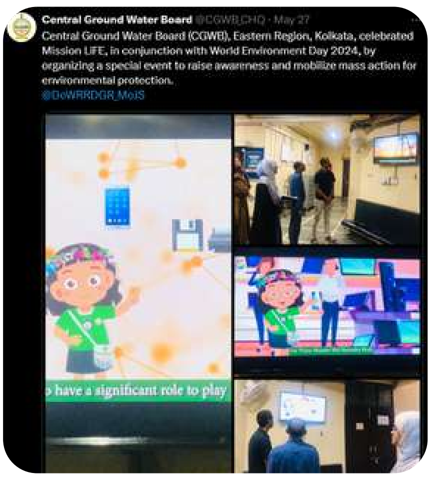

Central Ground Water Board @CGWB_CHQ · Apr 23
1st SLC meeting for Dynamic Ground Water Resources Assessment -2024 of Chhattisgarh state was conducted under the Chairmanship of Shri Rajesh Sukumar Toppo, Special Secretary, WR Dept., Govt. Of Chhattisgarh. @DoWRRDGR_MoJS


Central Ground Water Board @CGWB_CHQ · Apr 26
First Quarterly dialogue of CGWB SECR Chennai & CWC with
Tamil Nadu state, U T of Puducherry and Andaman & Nicobar
today on the topic" Coastline Management & sea water ingres
@DoWRRDGR_MoJS


Central Ground Water Board @CGWB_CHQ · May 22
Inaugural functions for three mandatory 2 week training programs on "Groundwater Development and Management," "Maintenance of Drilling & Ancillary Equipment-Level 2," and "Material Handling, Storekeeping, and Store Accounting" were held under the chairmanship of the RD, RGNGWTRI.


Central Ground Water Board's post
Central Ground Water Board
Published by केंद्रीय भूमि जल बोर्ड
3 May
CGWB, Jammu organized the 1st UT SLEC meeting for J&K at Civil Secretariat Jammu
30/04/2024.The Additional Chief Secretary to Government of J&K, Sh. Shaleen Kabra
the meeting. Sh. KC Naik Chairman, JKWRRA and Chief Engineers from PHE and I&FC
Jammu/Kashmir attended the meeting as Special Invitees. Sh. M. L. Angurala, Head of
CGWB(NWHR), Jammu gave the welcome address and a presentation on GEC 2015 an
requirements for GWRA 2024. Ministry of Jal Shakti, Department of Water Resource
DP JnK


Central Ground Water Board
Published by Gargee Baruah Sharma
30 May
On the Third day of the Mission LiFE celebration for World Environment
and Div-XV, jointly took a creative approach in promoting environment
and displaying posters featuring slogans on environmental protection.


Central Ground Water Board @CGWB_CHQ · May 27
Central Ground Water Board (CGWB), Eastern Region, Kolkata, celebrated Mission LiFE, in conjunction with World Environment Day 2024, by organizing a special event to raise awareness and mobilize mass action for environmental protection.
@DoWRRDGR_MoJS
have a significant role to play


Central Ground Water Board @CGWB_CHQ · May 28
Team from CGWB, State Unit Office Belgaum and NIH Belgaum & Roorkee carried out Sample collection for the Key wells established in Bardez and Tiswadi Taluks, Goa State for Isotope Analysis under Pre-monsoon fieldwork of NAQUIM 2.0 study pertaining to Coastal Salinity.


Central Ground Water Board
Published by केंद्रीय भूमि जल बोर्ड
· 6 June ·
CGWB, NR, Lucknow organized a Tier-III Training on the subject "Groun
Management" at Hotel Maa Kripa & Banquets, Lucknow on the occasio
under Mission LiFE and My YUVA Bharat.
Ministry of Jal Shakti, Department of Water Resources, RD & GR


Central Ground Water Board @CGWB_CHQ · May 30
CGWB, SECR, Chennai and Div-VI celebrated Mission LiFE pr
World Environment Day 2024, with state Ground Water Depa
Sivakumar Regional Director and Sh. K. Prabhakaran Chelf E
planted saplings along with other officers.


Central Ground Water Board @CGWB_CHQ · Jun 3
CGWB, NR, Lucknow organized various activities under the Mission Life for World Environment Day 2024. Officers and officials actively participated in a plantation drive, where they received saplings and pledged their commitment to environmental sustainability. @DoWRRDGR_MoJS


Central Ground Water Board @CGWB_CHQ · Ju
A Technical Talk delivered by Director ICAR-CSS
Mission LiFE- 2024 on the theme of world Enviro
Land Restoration, Desertification and Drought R
2024 at CHQ Faridabad. @DoWRRDGR_MoJS
भारत सरकार
GOVERNMENT OF INDIA


Central Ground Water Board @CGWB_CHQ · Jun 6
As part of the Mission LIFE program, officers and officials of the CGWB, NER, Guwahati took part in a plantation drive held on the premises of the Regional Office. @DoWRRDGR_MoJS


Central Ground Water Board
Published by केंद्रीय भूमि जल बोर्ड
· 24 June ·
Customised Training on Ground Water Development and Management for Newly Inducted officers/officials of NERIWALM, Tezpur at RGNGWTRI under Synergy of CSTIs of MoJS.
Ministry of Jal Shakti, Department of Water Resources, RD & GR


Central Ground Water Board @CGWB_CHQ · Jun 11
Officer of CGWB WCR Ahmedabad carried out Preliminary Yield Test of Piezometer drilled at Limbadiya village, Gandhinagar Taluka, Gandhinagar District. Depth of well drilled was 190m,tapping Phreatic Aquifer in Alluvium Formation with average discharge of 4.33 lps. @DoWRRDGR_MoJS


Central Ground Water Board
Published by केंद्रीय भूमि जल बोर्ड
A joint visit to Bastawa Mata (Gotawar Dam) site in Jodhpur was conducted by officers from CGWB, CWC, CSMRS, and WAPCOS Ltd. to review the progress of work under AR Project Phase-1. Ministry of Jal Shakti, Department of Water Resources, RD & GR

COLLECTABLE

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1. Joint visit of CGWB, Wapcos & Team of Zila Parishad Alwar to ARS site Khera, Block Bansur, Alwar
2. 1st SLC meeting for Dynamic Ground Water Resources Assessment 2024 of Chhattisgarh state conducted under the Chairmanship of Sh Rajesh Sukumar Toppo, Special Secretary, WR Dept., Govt. Of Chhattisgarh
3. Joint visit of CGWB & WAPCOS along with Dr. D. N. Mandal, Scientist 'D' from CHQ Faridabad to Indroka (block Keru) in Jodhpur district to review the progress at dam site.
4. 1st joint meeting between CGWB and GSI on collaboration study to assess the precursor, co-seismic and post seismic aquifer response from deep aquifers along Kopili fault zone held at GSI office complex, NER, Shillong.
5. 1st SLC meeting for GWRA 2024 of Andhra Pradesh held at District Data Centre, Ground Water & Water Audit Department, NTR District, Andhra Pradesh
6. Ground Water Resource Assessment 2023 Report of Karnataka released by Shri Subodh Yadav, IAS, Jt. Secretary (Admn, IC & GW), MoJS at Vikas Soudha, Bangalore
7. Ist Quarterly Meeting for Goa arranged by CWC & CGWB with WRD, Govt. of Goa at Goa.

COLLECTABLE

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1. Meeting held between CGWB, MER and GSI regarding collaborative study under MoU in Nalanda District, Bihar
2. CGWB, Lucknow organized Tier-III Training on the subject "Ground Water Development and Management" on the occasion of World Environment Day under Mission LiFE and My YUVA Bharat.
3. Visit of Dr. S.K. Ambast, Chairman, CGWB, to CGWB ER, Kolkata.
4. विश्व पर्यावरण दिवस के उपलक्ष में मुख्यालय फरीदाबाद में पौधारोपण किया गया एवम उसके पश्चात सभी को तुलसी के पौधे वितरित किए गए।
5. Officers of CGWB WCR Ahmedabad carried out Preliminary Yield Test of Piezometer drilled at Limbadiya village, Gandhinagar Taluka, Gandhinagar District
6. Sh.T.B.N.Singh, Member Secretary, CGWA delivered a presentation on "Ground Water Regulations for Food and Beverages Industries" in the Conference on Water Stewardship of Food and Beverages Sector
7. Team from CGWB, Belgaum & NIH Belgaum & Roorkee carried out Sample collection for the Key wells established in Bardez and Tiswadi Taluks, Goa for Isotope Analysis under Pre-monsoon fieldwork of NAQUIM 2.0 study pertaining to Coastal Salinity.

COLLECTABLE

1. Scientists and Engineers from CGWB are participating in a training on Airborne Electromagnetic Methods at Aarhus University, Denmark.
2. National accreditation board for testing and calibration laboratories (NABL) organised a one Day program on "World Accreditation Day" in Raipur
3. CGWB, Chennai and Div-VI celebrated Mission LiFE programme for World Environment Day 2024, with state Ground Water Department.
4. Regional Director, CGWB, Guwahati delivered an invited talk on "Accreditation Supporting Safe and Clean Environment" in Guwahati to commemorate World Accreditation Day.
5. International Yoga Day with the theme "Yoga for Unity and Harmony at CGWB offices
6. A Technical Talk has been delivered by Director ICAR-CSSRI, Dr R. K. Yadav under Mission LiFE (Lifestyle for Environment) -2024, on the theme of World Environment Day (WED) 2024-Land Restoration, Desertification and Drought Resilience at CHQ Faridabad.
7. The Indian Delegation participated in the celebration of International Yog Day in Denmark.