Integrated Approach for the salinity sources in Groundwater from Aligarh to Firozabad District, Uttar Pradesh

File Number : PDF/2023/000867

Submitted By : Dr. DAYA SHANKAR SINGH
[**S**ERB **Q**ualified **U**nique **I**dentification **D**ocument: SQUID-1992-DS-1458]

Submission Date : 08-Aug-2023

PROPOSAL DETAILS

(PDF/2023/000867)

Principal Investigator	Mentor & Host Institution
Dr. DAYA SHANKAR SINGH daya.singhudai@gmail.com Research Scholar(Department of Geology, University of Lucknow) **Contact No** : +919169644112 **Date of Birth** : 14-Aug-1992 **Name of Father/Spouse :** UDAY BHANU SINGH	**Rajesh Singh** rsingh.nihr@gov.in Scientist D(Environmental Hydrology Division) **National Institute of Hydrology** Jal vigyan bhawan, roorkee, Uttarakhand-247667 **Contact No.** : +919267483749 **Registrar Email** : dir.nihr@gov.in **No. of PHD Scholars** : 1 **No. Post-Doctoral Fellow** : 3

Details of Post Doctorate

Ph.D. (Geology)[Degree Awarded on : 06-Apr-2023]

Integrated Approach for the salinity sources in Groundwater from Aligarh to Firozabad District, Uttar Pradesh

Research Supervisor/Guide & Institution :

Prof. Ajai Mishra

University of Lucknow

Brief details of Thesis work :

The study area, Aligarh also comes under this Alluvial Aquifer system as a district of Uttar Pradesh. It has a high potential for water resources because it is situated in the doab of River Ganga and Yamuna. But the present circumstances are increasing the stress on water resources quantitively and qualitatively because, in the last five decades, the growth rate of the population is more than 20%, the number of industries and factories is increasing very sharply due to urbanization, rainfall is also showing the declining trend and the rivers have low water discharge during the lean periods. The stress on groundwater is assumed in such a way that from the year 2000 to 2020, the build-up area has increased from 4.5 to 185%.

Therefore, to tackle this situation or for the sustainability of water resources, a Qualitative sustainability assessment and a Quantitative sustainability assessment plan have been designed separately. In this study, the Quantitative sustainability assessment has been done by the Water Budget Calculation and by the Storage Capacity (3D-Modelling) for the year 2018. While the Qualitative sustainability assessment of water resources has been calculated by the three methods. First by the Individual water quality parameters assessment, Second by the water quality index method, and third by the co-relation statistics of water parameters.

According to the Quantitative sustainability assessment, in the “Water Budget” method, the calculated dynamic water resource is about 519Ham and the static water resource is 33475Ham while the calculated saline water resource is about 13643Ham. In the “Storage Capacity” resource calculation method, the total water potential of the study area has been calculated, by the water holding capacity of the lithology and by the Confined and Unconfined, water potential calculation method. The calculated water potential in the Unconfined zone is 4048059.95 Ham where the calculated resource potential separately in the clay, medium sand, and Sandy clay type lithology is 49967.70 Ham, 3693710.99 Ham, 304381.26 Ham respectively. Therefore, in the unconfined zone, the actual extractable groundwater resource from medium sand and Sandy Clay is about 3998091.25 Ham; while for the confined zone, the calculated freshwater resource is about 1857.59Ham and the calculated saline water resource is about 1331.54ham. The method which has been applied in this study is very new to know the exact lithological water holding capacity.

According to the Qualitative sustainability assessment, four years of water quality data (2016, 2017, 2018, and 2019) have been analyzed to know the overall quality of water resources. this analysis has been done in three methods; First method is by “Individual Water Quality'' parameters, where each parameter has been analyzed and compared with the standards for each block and each year in a comparative way. This study has been processed for both the water uses as potable and Irrigation. This type of study was very important because in the study area salinity problems have already been reported. So, to get suitable water from a suitable location, this study has been done for the very first time. According to this analysis, the high value of Nitrate (NO_3-) is also reported from the central part of the city area/urban area. This value of nitrate may increase just because of the leakage of the sewerage network to the groundwater or to nearby groundwater recharge structures. So, for the mitigation, there should be a proper sewerage network. It has been observed in the study area, the value of Sodium (Na+) and Chloride (Cl-), is very much high and the parameters such as Nitrate (NO3-), Sodium Percentage (SP), Sodium Adsorption Ratio (SAR), Permeability Index (PI), Residual Sodium Carbonate (RSC), Potential Soil Salinity (PS), TDS and Soluble Sodium Percentage (SSP) are the by-product of the Sodium and Chloride for the agricultural parameters, so they have also high values. These high values are focused on the central part of the study area in the block Chandaus, Khair, Lodha, Gonda, and Iglas. It is because in these blocks the depth of the saline zone is very shallow which is contaminating the water resources.

The second method is the “Collective water Quality” method, where collectively all the parameters and all the years' data have been analyzed by the “Water Quality Index” method where the non-suitability of groundwater is reported for all the years.

The last method is the “Correlative Water Quality”, where with the help of Pearson Correlation and factor analysis methods the most dominating parameters have been identified. The cause of these dominating parameters is either Geo-genic (Chloride, Magnesium, Sodium, Carbonate, pH, Bicarbonate, and Calcium) or Anthropogenic (Total Dissolved Solid, Total Hardness, and Sulphate).

The adopted methodology and the concerned findings of the present study may be applicable to all types of areas because through this study it can be identified how much water potential capacity in the area has and how much water is there. While the complete water quality and its root causes can be identified by the adopted methodology.

For quantitate sustainability, artificial recharge structures are the best tool to increase and maintain water resources where the water level is more than 5mt except in Chandaus, Khair, and Gonda blocks; because in these blocks’, saline water has been reported from very shallow depths.

In qualitative sustainability, for the mitigation and sustainability of the water resources quality, the study area is divided into three parts High, Medium, and Low Salinity. In high saline areas, the water supply should be by the canals through which dilution will take place, and where it is low; any type of method can be used for the water supply.

In the present proposal, I want to find out the root cause of this salinity problem and develop a salinity-tolerable bore well for GW Sustainability.

Technical Details :

Research Area : Earth & Atmospheric Sciences (Earth & Atmospheric Sciences)

Project Summary :

Drinking and irrigation water is one of the key drivers of a nation's sustainable development. However, urbanization, agricultural practices, industrial activities, and climate change poses significant threats to groundwater quality. But these are not only the sources of Groundwater contamination; Geogenic contaminations are also there. It contaminates the groundwater by the dissolution of natural mineral deposits in the Earth's crust. This contamination causes major threats to life the contamination of water and food. Salinity contamination is one of them and its severity can be understood by the fact that about 1.3 million hectares of land is salt affected in Uttar Pradesh (ICAR). The western part of Uttar Pradesh, from Aligarh to Firozabad District and surrounding areas, has a (greater than 5000Microsiemens Per Centimeter) highest salinity contamination. For salinity mitigation, a lot of work and suggestions have been carried out by different organizations such as the Indian Council of Agriculture Research (ICAR), Uttar Pradesh Remote Sensing Application Centre (UPRSAC), Aligarh Muslim University, etc. in the form of Crop Shifting, Crop Diversification, Shifting Irrigation practices (by canals and sprinklers), and Fertilizers Management (Gypsum and Phosphorus) but these are not the permanent solution because the salinity is not focused only on the surface but it is up to a certain depths. Therefore, for the mitigation of this problem, the solution should not be based on the alternatives but it should be based on the supporting lithology. This study is being proposed to develop a salinity-tolerable bore well which will extract the saline water with the intermixing of fresh water. Thus the saline zone/ saline water will decrease and eventually, it will be diluting out with the groundwater recharge.

Objectives :

- To find out the saline zone by the analysis of Groundwater and Soil samples.
- To prepare a chronological model for the salinized zones.
- To develop a salinity tolerable bore well model.

Keywords :

Groundwater Quality, Salinity-tolerable, Bore-Well, Salinized zone, Saline water

Expected Output and Outcome of the proposal :

The social-economic and agricultural development of a region always depends upon the availability of freshwater resources. The scarcity of these vital resources can hamper the overall development of the area. The impact of this salinity contamination is so horrible that in some parts of the study area, people wait for the Jal Nigam water Tankers for their daily need for water. As the population is increasing, their need and demand are also increasing for groundwater. They are growing only selective crops that are creating an economic hamper and resulting in migration. People do not like to marry their girls from these areas due to the constraining of fresh water. Therefore, for proper development in the area, lithological salinity mitigation is very important. Socio-economically, the outcome of this study will be very fruitful to demarcate the highly saline areas, it will increase the social as well as economic development of the area and stop human migration. Several water-related diseases, which are generally caused due to water pollutants can be recognized by this type of study and it will suggest their eradication. Scientifically, the outcome of the proposed study would be highly helpful for vertical and horizontal delineation/demarcation of salinity contamination in the aquifer system for drinking water augmentation, groundwater targeting, water quality studies, etc. The study area is the center of Tourist places, so it will be directly beneficial for the people.

Reference Details :

S.No	Reference Details
1	**Dr. Prashant Rai** **Scientist** **Regional Director,** **Uttaranchal Region** **419-A, KANWALI ROAD** **BALUWALA, Near Urja Bhawan** **DEHRADUN** **PIN 248006** **[+9452271135]** rdnur-cgwb@nic.in
2	**Prof. Ajai Mishra** **Department of Geology, University of Lucknow** **Lucknow-226007[+9450393719]** ajaimishra2007@yahoo.co.in

Integrated Approach for the salinity sources in Groundwater from Aligarh to Firozabad District, Uttar Pradesh

Methodology

1. **Study Area:** From the Western Part of Uttar Pradesh (Aligarh, Mathura, Agra, and Firozabad District), high salinized zones (>5000µS/cm) are reported in the pockets at shallow depths as shown in Figure 1. Therefore, to demarcate the vertical and horizontal extension of these saline zones the geophysical survey and groundwater & soil sampling will be done respectively.

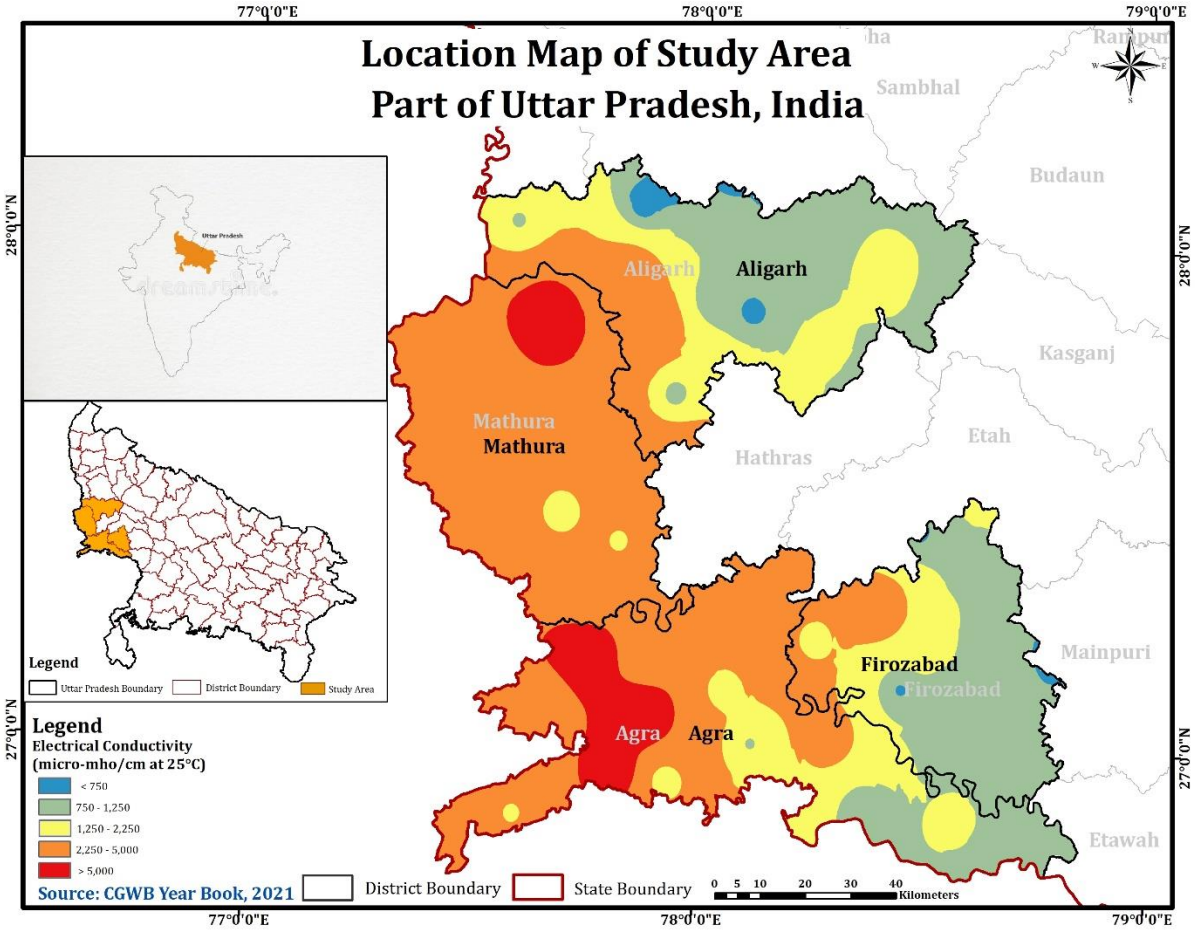


Figure 1: Location Map of the Study Area

2. **Sampling & Laboratory Analysis:**

For this study, the groundwater and soil samples will be collected from the salinity-affected pockets on the 3×3 km grid for their quality analysis. pH and EC (Electrical Conductivity) will be analyzed for both the water samples and soil samples and some other parameters will also be analyzed for the statistical analysis as Sodium (Na^+) and Potassium (K^+), Calcium (Ca^{+2}), Manganese (Mg^{+2}), Chloride (Cl^-), Carbonate (CO_3^-), Bicarbonate (HCO_3^-), Total Dissolved Solids (TDS), Sulphate (SO^{-4}),

and Nitrate (NO^{-3}) (Haritash et al., 2008; Systronics T-128; Prasanna et al., 2010; APHA, 1995; Shimadzu, 1800; Domenico and Schwartz, 1990). These results will be suitable to explain the horizontal extension while for the vertical extension of these zones, the geophysical survey will be done.

3. **Modeling and documentation of salinized zones:** During this study, a saline zonation map and 3-D Model will be prepared with the help of groundwater quality, geophysical parameters, lithological chronology, statistical analysis, and Remote Sensing & GIS techniques. In addition, we will select the ideal lithological pockets for dating, through which the sources and the root cause of this salinity contamination can be identified.

Therefore, to develop a salinity tolerable bore well; the bore well slots will be proposed at particular depths for the intermixing of saline and fresh water based on the above study.

Significant outcome from proposed work

Groundwater salinity is majorly affecting crop production as well as human health. The social-economic and agricultural development of a region always depends upon the availability of freshwater resources. The scarcity of these vital resources can hamper the overall development of the area. The impact of this salinity contamination is so horrible that in some parts of the study area, people wait for the Jal Nigam water Tankers for their daily need for water. As the population is increasing, their need and demand are also increasing for groundwater. They are growing only selective crops that are creating an economic hamper and resulting in migration. People do not like to marry their girls from these areas due to the constraining of fresh water. Therefore, for proper development in the area, lithological salinity mitigation is very important.

Socio-economically, the outcome of this study will be very fruitful to demarcate the highly saline areas, it will increase the social as well as economic development of the area and stop human migration. Several water-related diseases, which are generally caused due to water pollutants can be recognized by this type of study and it will suggest their eradication.

Scientifically, the outcome of the proposed study would be highly helpful for vertical and horizontal delineation/demarcation of salinity contamination in the aquifer system for drinking water augmentation, groundwater targeting, water quality studies, etc.

Therefore, this study will be definitely beneficial to different stakeholders and areas which are facing similar types of problems such as Punjab, Rajasthan, Haryana, etc.

4. Year-wise work plan:

Two years' time schedule of activities giving milestones (each milestone ***(Y) represents a period of one year).***

Y1*:*

- In the starting three months, the Groundwater and soil samples will be collected grid-wise for the pre-monsoonal study from the known contaminated areas.
- In the next three months, the sample analysis and salinity zonation map will be prepared and the most contaminated grid will be identified for each affected area.

- In the next quarter, the post-monsoonal sampling of Groundwater will be done from the previous grid locations and lithological core samples will also be collected from the most salinity-affected grid by the coring and drilling.
- In the last quarter of the year, the post-monsoon groundwater samples will be analyzed and the most contaminated grid will be identified for each affected area and soil samples collected after drilling will be sent to a laboratory or institution for analysis.

Y2:

- In the starting three months, the selective sampling will be done from high saline zones based on first-year analysis.
- In the next Six months, a compilation of data for the interpretation of saline zone will be carried out. Based on these results and analysis; 3-D models and saline zone maps will be prepared with their chronology and a salinity-tolerable bore well will be bored.
- In the last three months, the preparation of manuscripts and submission of reports will be done.

Dissemination of the research data in workshops, seminars, and conferences will be done, throughout the project tenure time when and where it is suitable.

BIO-DATA

1. **Name and full correspondence address:** Dr. Daya Shankar Singh
Department of Geology,
University of Lucknow
Lucknow-226007, U.P.

2. **Email(s) and contact number(s):** daya.singhudai@gmail.com

3. **Institution** University of Lucknow

4. **Date of Birth** 14 August 1992

5. **Gender (M/F/T)** M

6. **Category Gen/SC/ST/OBC** Gen

7. **Whether differently abled (Yes/No)** No

8. **Academic Qualification (Undergraduate Onwards)**

S. No.	Degree	Year	Subject	University/Institution	% of marks
1.	B.Sc.	2012	Physics, Math, Geology	University of Lucknow,	59
2.	M.Sc.	2014	Geology	H.N.B. Garhwal University,	72.21
3.	Ph.D.	2023	Geology	University of Lucknow	-

9. **Ph.D, thesis title, Guide's Name, Institute/Organization/University, Year of Award.**
Title:
"Study of the Aquifer Systems and Sustainability of Ground Water Resources in and around Aligarh District, Central Ganga Plain, Uttar Pradesh"

Guide's Name:
Prof. Ajai Mishra

University:
University of Lucknow

Year of Award: 2023

10. Work experience (in chronological order).

S. No.	Positions held	Name of the Institute	From	To	Pay Scale
1.	Assi. Hydrogeologist	GeoVision Infocom Pvt. Ltd.	15 Sep 2014	30 Dec 2015	26,300/ Month
2.	Young Professional	Central Ground Water Board, Northern-Region, Government of India	13 Oct 2020	19 Jan 2023	Level 11 (Pay Matrix 7th CPC)

11. Professional Recognition/ Award/ Prize/ Certificate, Fellowship received by the applicant.

S. No.	Name of Award	Awarding Agency	Year
1.	UDDEEPAN Award	University of Lucknow	2023

12. Publications ***(List of papers published in SCI Journals, in year wise descending order).***

S. No.	Author(s)	Title	Name of Journal	Volume	Page	Year
1.	Singh, D. S.	National Aquifer Mapping and Management Plan (NAQUIM) of Fatehpur District, Uttar Pradesh	Central Ground Water Board, Report Publication.	1	1-113	2022
2.	Singh, D. S., & Mishra, A.	Suitability of Groundwater Quality with Precipitation in the Western Part of Indo-Gangetic Plain, Uttar Pradesh	Journal of the Geological Society of India	11	1422-1428	2021
3.	Singh, D. S., Singh, R., & Mishra, A.	Determination of silt thickness in Durga Kund for its de-isolation at Varanasi UP India	Water Science	1	13 – 17	2020

13. Detail of patents.

S. No	Patent Title	Name of Applicant(s)	Patent No.	Award Date	Agency/Country	Status
NA	NA	NA	NA	NA	NA	NA

14. Books/Reports/Chapters/General articles etc.

S. No.	Title	Author's Name	Publisher	Year of Publication
1.	River Ramganga: A Less Discussed Tributary of Ganga River	Mishra, A., Verma, S., & Singh, D. S.	Applied Water Sciences, Springer	2018

15. Any other Information (maximum 500 words)

. **Software Proficiency:**

- Rock Works
- ArcGIS
- ERDAS Imagine
- MATLAB
- Origin
- Modflow

Instrumental Proficiency:

- Atomic Absorption Spectrometer (AAS)
- Ion-Chromatograph
- Spectrophotometer

TRAINING:

- "Geogenic Contamination of Ground Water in Central Gangetic Plain" held at GSI, Lucknow from 31 December 2018 to 05 January 2019, organized by Geological Survey of India, Lucknow.

- "10th Course on Application of Geo-informatics for Disaster Management" held at GSI Training Institute from 20 February 2017 to 22 March 2017, organized by Geological Survey of India Training Institute, Hyderabad.

- "Sustainable Development and Management of Ground Water Resources" held at Department of Geology, Bundelkhand University Jhansi Uttara Pradesh from 26- 12-2016 to 30-12-2016, organized by Central Ground Water Board, Northern Region Lucknow.

- "Ground Water Resource in Uttar Pradesh: Challenge and Management" held at Lucknow Uttar Pradesh on 30-03-2016, organized by Central Ground Water Board, Northern Region Lucknow.

- “Training Programme on role of Remote Sensing & GIS Natural Resources Management” organized by Remote Sensing Application Centre, Uttar Pradesh Lucknow, during the period of 14 March to 18 March 2016.

- “Geo-Environmental Hazards and Neo-Tectonics Activities in Himalaya” organized by Department of Geology, H.N.B. Garhwal University, S.R.T. Campus; Tehri Garhwal on 28-30 October 2014

- “Science Academic Workshop on Tectonic Geomorphology” at H.N.B. Garhwal University campus Srinagar, Uttarakhand 2012. ➢ “Participatory Ground Water Management” organized by National Ground Water Training & Research Institute - Raipur on 15 – 19 February 2021.

- “Managed Aquifer Recharge” organized by National Ground Water Training & Research Institute - Raipur 8 – 12 November 2021.

- “Hands-on Training Program on Water Resources Management under DSTSTUTI” organized by Department of Geology, University of Lucknow 30 May 2023 – 5 Jun 2023.

JOURNAL GEOLOGICAL SOCIETY OF INDIA
Vol.97, November 2021, pp.1422-1428

Suitability of Groundwater Quality with Precipitation in the Western Part of Indo-Gangetic Plain, Uttar Pradesh

Daya Shankar Singh* and Ajai Mishra
Department of Geology, University of Lucknow, Lucknow - 226 007, India
E-mail: *daya.singhudai@gmail.com*; ajaimishra2007@yahoo.co.in*

ABSTRACT

In this study, the study area has been classified into two parts as the city area and the critical area on the basis of different uses and demands. About two decades groundwater samples were collected and analyzed for the drinking and irrigation water quality parameters such as water quality index (WQI) and sodium absorption ratio (SAR) respectively. A graph has been plotted amongst water quality index, SAR values, and precipitation. It shows that WQI of critical area and city area is directly proportional to SAR values while the precipitation has a reverse correlation with the SAR and WQI for both the areas at a certain range. The response of precipitation and parameters is not the same for both the areas because the availability of open area is high in critical areas while very low in the city area. Each groundwater sample was also analyzed for both the parameters and also compared with the standards of World Health Organization, 2017, and Bureau of Indian Standards, 2012. Therefore it can be suggested that a proper drainage network and water harvesting structures should be constructed for the heavy rain period and lean period respectively for the sustainable groundwater resources.

INTRODUCTION

The main source of groundwater is precipitation. During or after the precipitation, the water interacts and dissolves the atmospheric and lithological elements (Singh, et al., 2020). These elements are not only derived from lithological weathering (geogenic) but also by anthropogenic activity. The adverse change in the elemental concentration is known as pollution that means the concentration of elements in a certain range is unsafe (Wasim et al., 2014). While in this case, the elemental concentration always depends upon the amount of precipitation/percolation and pollution in that area because the precipitation is reversely correlated with the concentration (Ahmad and Ahmad, 2014).

In the study area, some parameters such as as salinity, alkalinity, hardness, electrical conductivity and total dissolved solids are already above to the permissible limits of World Health Organization, 2017 and Bureau of Indian Standards, 2012 (Perween and Fatima, 2015). However, the cause of these contaminations and its impact on agricultural production is not known.

In the study area, groundwater dependency is about 93% for the drinking and irrigation water (Source: District Sankhikiy Patkrika, UP 2016). The use of this water is directly or indirectly related to the human health as well as crop production, as the ground water is already polluted (Perween and Fatima, 2015; Wasim, et al., 2014; Ahmad and Ahmad, 2014; Irfan and Khurshid, 2017). While the population and dependency on groundwater are increasing everywhere (rural and urban), in the urban area, pollution is increasing and open areas are decreasing, while in the rural areas, pollution is less but the open area is more.

Several studies have been carried out for the drinking water suitability but as the data shows that more than 87 % of groundwater is being used for the irrigation (Source: Statistical Diary, Directorate of Economics and Statistics, Govt. of U.P.) so there is an urgent need to check the suitability of water for irrigation and drinking and the cause of this contaminations.

Therefore, in this study, the correlation with the precipitation has been done both for the drinking and irrigation water by their suitability parameters as water quality index (WQI) and sodium absorption ratio (SAR) respectively for the last two decades.

STUDY AREA

The study area, Aligarh is a part of a fertile and thick aquifer plain which is situated in the Ganga-Yamuna Doab portion (CGWB NR, 2016). In the study area, the decadal growth rate of the population is 22.78% (Aligarh Census, 2011) which is increasing the density of the population and the concretization so, the study area has been classified into two parts as the city area and the critical area on the based on water demand and availability as shown in Fig. 1.

Geographically, it lies between latitude 27°34'26" to 28°10'46" N and longitudes 77°28'17" to 78°36'02" E in the Survey of India Toposheet (53H, L, 54E, and I) in the western part of Uttar Pradesh. The study area comes under sub-humid climate with the 781.6 mm of rainfall (Source: Indian Meteorological Department).

MATERIAL AND METHODS

For this study, the groundwater quality data for seven years (2001, 2004, 2010, 2012, 2013, 2015, and 2016) has been analyzed. The groundwater samples for the years 2015 and 2016 (in July yearly) were collected from the study area. It was collected in a clean high-density polyethylene (HDPE) cans of 500ml capacity for the physico-chemical analysis (Haritash et al., 2008). Some parameters, such as pH and EC (Electrical Conductivity) were measured on the spot in the field while sodium (Na^+) and potassium (K^+) were measured by the flame photometer (Systronics T-128). Calcium (Ca^{2+}), manganese (Mg^{2+}), chloride (Cl^-), carbonate (CO_3^-) and bicarbonate (HCO_3^-) were determined by volumetric titration method (Prasanna et al., 2010; APHA, 1995). Total dissolved solids (TDS) and total hardness (TH) were calculated by the byproduct of analyzed parameters while sulphate (SO_4^-) and nitrate (NO_3^-) were measured by the UV and visible spectro-photometer (Shimadzu, 1800).

The accuracy of these analyses has also been verified by ion balance calculation (Domenico and Schwartz, 1990).

These same parameters were also collected from government organizations such as Central Ground Water Board (CGWB) and Uttar Pradesh Ground Water Department (UPGWD) for the years 2001, 2004, 2010, 2012, and 2013. These groundwater samples were also collected in July every year.

DOI: 10.1007/s12594-021-1882-0 | 0016-7622/2021-97-11-1422/$ 1.00 © GEOL. SOC. INDIA

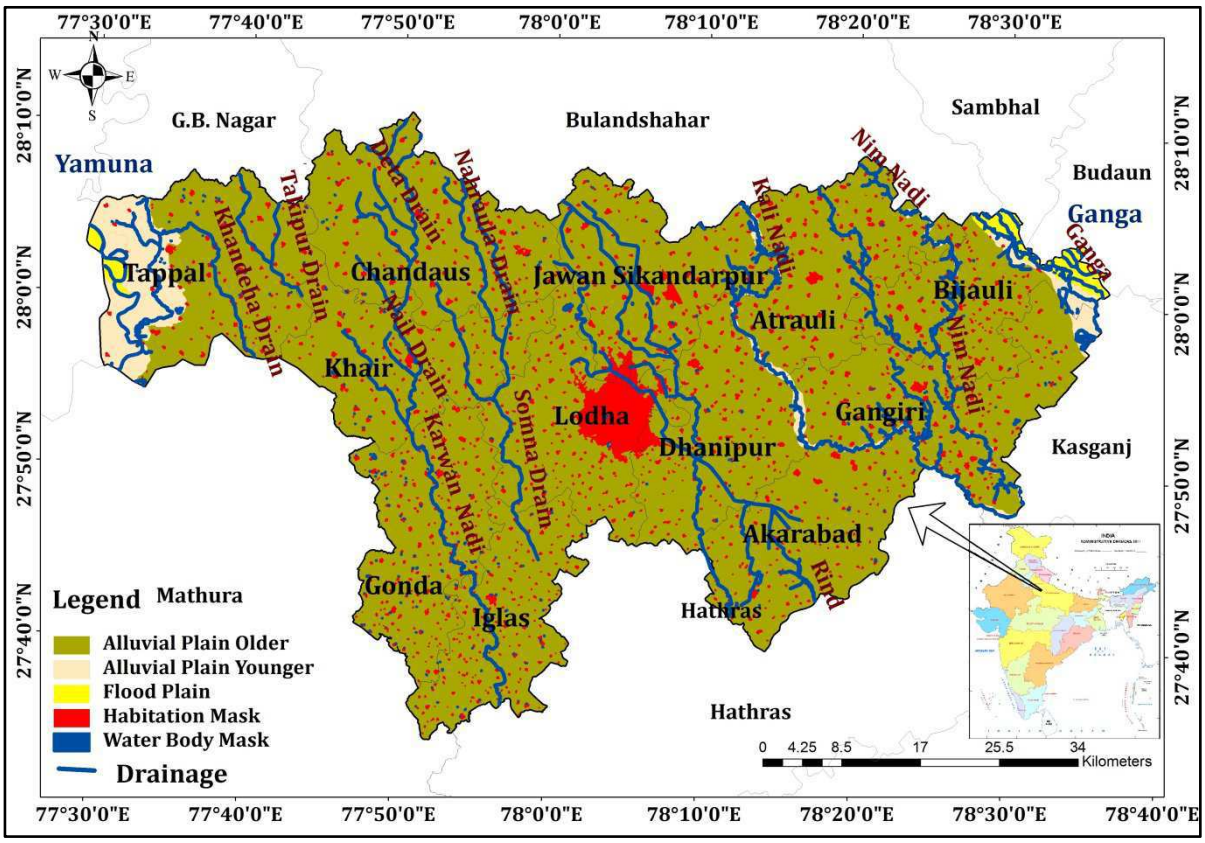


Fig.1. Location Map of the study area in the western part of the Indo-Gangetic plain Uttar Pradesh (Source: Survey of India, Toposheet)

Precipitation

Rainfall data were collected from the IMD and Open Government Data (OGD) Platform India (Table 1). This rainfall data was also collected for those seven years in which the maximum rainfall took place in the year of 2012 in the study area.

Table 1. SAR Values and Average rainfall of the study area

Year	Average Rainfall (mm) (Source: IMD Data)
2016	629.9
2015	513.8
2013	1007
2012	1054
2010	673.8
2004	477.1
2001	461.2

Water Quality Index (WQI)

Water quality index (WQI) is the overall drinking water quality parameter (Chatterjee and Raziuddin, 2002; Horton, 1965) which was calculated by the weighted arithmetic index method (Kumar et al., 2017). 13 parameters of water quality have been analyzed. These parameters were also compared with the World Health Organization (WHO, 2017) and Bureau of Indian Standards (BIS, IS 10500: 2012) (Table 2).

The parameter WQI was calculated for both the city area (Dhanipur, Jawan Sikandarabad, and Lodha blocks of the district) and the critical area (Chandaus and Iglas blocks of the district) as well as for each sample.

The water quality index (WQI) was calculated by the following formulas. So, the quality rating or sub-index (q_n) was calculated using the following formula in Table 3.

$$q_n = \frac{(V_n - V_{i0})}{(S_n - V_{i0})} \times 100 \quad (1)$$

Where, q_n = quality rating for the nth water quality parameter. V_n = estimated value of the nth parameter at a given sampling station. S_n = standard permissible value of nth parameter. V_{i0}= ideal value of the nth parameter in pure water. (0 for all other parameters except the pH, which is 7)

The unit weight (W_n) was calculated (in Table 3) by a value inversely proportional to the recommended standard value (S_n) of the corresponding parameters.

$$W_n = \frac{K}{S_n} \quad (2)$$

Where, W_n = unit weight for n^{th} parameter; S_n = standard value for n^{th} parameters; K = proportionality constant. Where $K = \Sigma 1/S_n$

The overall water quality index was calculated by aggregating the quality rating with the unit weight linearly by using equation (1) and (2), (in Table 2)

$$\textit{Water Quality Index (WQI)} = \frac{\Sigma (q_n \times W_n)}{\Sigma W_n} \quad (3)$$

Sodium Absorption Ratio (SAR)

The sodium adsorption ratio (SAR) is used to predict the sodicity hazard of the water and the danger of sodium accumulation in soil (Collins and Jenkins, 1996). If the value of Sodium Absorption Ratio is high; it means sodium accumulation ratio in the soil is high and it will decrease the permeability of the soil. Similarly for the Kelly's

File No. : PDF/2023/000867/EAS | Page 12 of 37

Table 2. Water Quality Values with standards

S. No.	Parameter		Water Sample Result Years 2016	2015	2013	2012	2010	2004	2001	WHO guidelines, 2017 Standard	BIS Guidelines (IS 10500: 2012) Permissible limit	Maximum Permissible limit
1	Na^+	(City)	120.00	165.00	123.00	290.50	128.23	148.33	293.50	200	-	200
	Na^+	(Critical)	197.83	196.00	251.50	345.00	468.00	71.00	115.67			
2	Ca^{2+}	(City)	30.22	46.00	55.33	290.50	29.00	22.67	45.00	100	75	200
	Ca^{2+}	(Critical)	29.33	88.00	46.00	345.00	56.00	10.00	41.33			
3	Mg^{2+}	(City)	32.25	40.00	30.33	15.18	32.40	77.00	66.25	150	30	100
	Mg^{2+}	(Critical)	47.67	84.00	26.35	7.20	237.60	38.00	51.33			
4	Cl^-	(City)	54.36	124.00	23.70	108.25	26.50	186.67	300.00	250	250	1000
	Cl^-	(Critical)	143.00	184.00	79.50	121.00	277.00	39.00	82.67			
5	HCO_3^-	(City)	357.25	451.50	545.00	393.50	360.00	427.00	512.50	600	-	600
	HCO_3^-	(Critical)	369.11	488.00	683.00	421.00	537.00	326.00	451.33			
6	CO_3^-	(City)	20.00	0.00	0.00	57.00	0.00	0.00	0.00	200		200
	CO_3^-	(Critical)	29.00	0.00	0.00	78.00	0.00	0.00	0.00			
7	SO_4^-	(City)	49.56	41.50	53.33	213.50	136.50	73.67	164.50	200	250	400
	SO_4^-	(Critical)	141.47	103.00	87.50	235.50	1277.00	3.80	680.00			
8	EC	(City)	873.56	1258.50	1039.00	1732.50	1027.50	1378.00	1998.75	2250	-	-
	EC	(Critical)	1389.83	1941.00	1499.50	1950.00	4500.00	648.00	1079.33			
9	pH	(City)	8.32	7.95	7.90	8.26	7.23	8.09	8.13	6.5-9.2	6.5-8.5	No relax.
	pH	(Critical)	8.51	8.00	7.97	8.58	7.25	8.05	8.27			
10	TDS	(City)	672.88	879.85	847.07	1383.60	717.73	944.90	1414.85	500	500	2000
	TDS	(Critical)	985.45	1150.20	1179.90	1559.90	2863.70	491.70	1427.60			
11	TH	(City)	208.50	280.00	261.67	207.50	207.50	376.67	385.25	300	200	600
	TH	(Critical)	269.38	570.00	222.50	195.00	1130.00	182.50	313.33			
12	NO_3^-	(City)	23.39	29.50	11.87	49.60	19.38	27.00	25.50	50	45	No relax.
	NO_3^-	(Critical)	18.90	91.00	28.50	43.00	0.00	8.50	18.13			

ratio, when the sodium (Na^+) ion value is more than sum of calcium (Ca^{2+}) and manganese (Mg^{2+}) ions value, the water is not suitable for the drinking purposes. (Kelly, 1957; Richards, 1954; Jain, 1998) and it will decrease the agricultural production (Hem, 1985; Kolpin, 1997; Matson et al., 1997).

$$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})/2}}$$

Where, Na^+, Ca^{2+}, and Mg^{2+} represent concentrations expressed in milliequivalents per liter for each constituent. The parameter SAR was carried out for the whole study area as well as for each sample and each year.

Calculated SAR value for each year (Source: Calculated from analyzed data)

Year	Calculated SAR value (meq./l)
2016	4.36
2015	5.21
2013	4.62
2012	4.26
2010	3.48
2004	4.42
2001	4.21

RESULTS AND DISCUSSION

The data which was obtained by the analysis of groundwater samples for the year 2015, 2016 and collected from the government stake holders for the years of 2001, 2004, 2010, 2012, 2013; assembled in a table (Table 2) and compared with the WHO, 2017 and BIS (BIS, IS 10500: 2012), 2012 standards. The values of sodium (Na^+), electrical conductivity (EC), chloride (Cl^-) were above to the permissible limit for the years of 2001, 2004, and 2010. According to Richard, if the maximum value of SAR is 5.21, it is in the excellent category.

SAR values Standard (Source: Richard 1954)

SAR	Suitability for irrigation
<10	Excellent
10-18	Good
18-26	Doubtful
26>	Unsuitable

It is a very important parameter for the agricultural suitability of water (Irfan and Khurshid, 2018; Milovanovic, 2007) while for the drinking water quality, the value of WQI range from poor water quality to unfit according to Chatterjee and Raziuddin, 2002 in Table 4.

Based on water demand, the study area is divided into two parts one is city/urban area and another is a critical area (where the stage of groundwater development is more than 90% or where the water level has a declining trend). For the study of rainfall impacts on different conditions, the water quality index (WQI) and sodium absorption ratio (SAR) were calculated separately for these two parts and correlated with the rainfall data with a graph (in Fig. 2). Similarly for both critical and city areas, WQI graphs show the same trend (Gupta et al., 2016) with the SAR value but WQI for both the

File No. : PDF/2023/000867/EAS | Page 13 of 37

Table 3. Water Quality Index Calculation Table (Source: Calculated from analyzed data)

Parameters	Observed Value	Standard Value (Sn)	1/Sn	Σ(1/Sn)	k	Ideal Value (Vio)	Unit Weight (Wn)	Quality Rating (qn)	Wn*qn	**WQI**
					2016					
Na	136.14	200	0.005	0.217	0.217	0.0	0.001	68.07	0.07	
K	12.98	200	0.005	0.217	0.217	0.0	0.001	6.49	0.01	
Ca	37.76	75	0.013	0.217	0.217	0.0	0.003	50.35	0.15	
Mg	33.12	30	0.033	0.217	0.217	0.0	0.007	110.41	0.80	
Cl	73.98	250	0.004	0.217	0.217	0.0	0.001	29.59	0.03	
HCO_3	364.62	600	0.002	0.217	0.217	0.0	0.000	60.77	0.02	
CO_3	16.41	200	0.005	0.217	0.217	0.0	0.001	8.21	0.01	
SO_4	76.30	250	0.004	0.217	0.217	0.0	0.001	30.52	0.03	
EC	1002.68	300	0.003	0.217	0.217	0.0	0.001	334.23	0.24	
Ph	8.31	8.5	0.118	0.217	0.217	7.0	0.025	87.20	2.22	
TDS	751.31	500	0.002	0.217	0.217	0.0	0.000	150.26	0.07	
TH	230.77	200	0.005	0.217	0.217	0.0	0.001	115.39	0.12	
NO_3	26.59	45	0.022	0.217	0.217	0.0	0.005	59.09	0.28	
	Sum		**0.222**				**0.048**	**85.43**	**4.04**	**84.28**
					2015					
Na	231.22	200	0.005	0.217	0.217	0.0	0.001	115.61	0.13	
K	11.61	200	0.005	0.217	0.217	0.0	0.001	5.81	0.01	
Ca	48.44	75	0.013	0.217	0.217	0.0	0.003	64.59	0.19	
Mg	56.33	30	0.033	0.217	0.217	0.0	0.007	187.78	1.36	
Cl	213.44	250	0.004	0.217	0.217	0.0	0.001	85.38	0.07	
HCO_3	485.33	600	0.002	0.217	0.217	0.0	0.000	80.89	0.03	
CO_3	0.00	200	0.005	0.217	0.217	0.0	0.001	0.00	0.00	
SO_4	78.11	250	0.004	0.217	0.217	0.0	0.001	31.24	0.03	
EC	1737.56	300	0.003	0.217	0.217	0.0	0.001	579.19	0.42	
Ph	7.88	8.5	0.118	0.217	0.217	7.0	0.025	58.52	1.49	
TDS	1124.50	500	0.002	0.217	0.217	0.0	0.000	224.90	0.10	
TH	351.67	200	0.005	0.217	0.217	0.0	0.001	175.83	0.19	
NO_3	34.71	45	0.022	0.217	0.217	0.0	0.005	77.14	0.37	
			0.222				**0.048**	**129.76**	**4.37**	**91.12**
					2013					
Na	195.17	200	0.005	0.217	0.217	0.0	0.001	97.58	0.11	
K	13.25	200	0.005	0.217	0.217	0.0	0.001	6.62	0.01	
Ca	55.50	75	0.013	0.217	0.217	0.0	0.003	74.00	0.21	
Mg	41.81	30	0.033	0.217	0.217	0.0	0.007	139.36	1.01	
Cl	120.27	250	0.004	0.217	0.217	0.0	0.001	48.11	0.04	
HCO_3	557.67	600	0.002	0.217	0.217	0.0	0.000	92.94	0.03	
CO_3	0.00	200	0.005	0.217	0.217	0.0	0.001	0.00	0.00	
SO_4	110.75	250	0.004	0.217	0.217	0.0	0.001	44.30	0.04	
EC	1394.50	300	0.003	0.217	0.217	0.0	0.001	464.83	0.34	
Ph	7.90	8.5	0.118	0.217	0.217	7.0	0.025	59.72	1.52	
TDS	1094.41	500	0.002	0.217	0.217	0.0	0.000	218.88	0.09	
TH	310.08	200	0.005	0.217	0.217	0.0	0.001	155.04	0.17	
NO_3	16.33	45	0.022	0.217	0.217	0.0	0.005	36.28	0.17	
			0.222				**0.048**	**110.59**	**3.74**	**77.97**
					2012					
Na	294.91	200	0.005	0.217	0.217	0.0	0.001	147.45	0.16	
K	10.19	200	0.005	0.217	0.217	0.0	0.001	5.10	0.01	
Ca	294.91	75	0.013	0.217	0.217	0.0	0.003	393.21	1.14	
Mg	10.19	30	0.033	0.217	0.217	0.0	0.007	33.97	0.25	
Cl	170.91	250	0.004	0.217	0.217	0.0	0.001	68.36	0.06	
HCO_3	342.73	600	0.002	0.217	0.217	0.0	0.000	57.12	0.02	
CO_3	57.82	200	0.005	0.217	0.217	0.0	0.001	28.91	0.03	
SO_4	204.64	250	0.004	0.217	0.217	0.0	0.001	81.85	0.07	
EC	1802.73	300	0.003	0.217	0.217	0.0	0.001	600.91	0.43	
Ph	8.33	8.5	0.118	0.217	0.217	7.0	0.025	88.73	2.26	
TDS	1386.29	500	0.002	0.217	0.217	0.0	0.000	277.26	0.12	
TH	233.64	200	0.005	0.217	0.217	0.0	0.001	116.82	0.13	
NO_3	37.85	45	0.022	0.217	0.217	0.0	0.005	84.10	0.40	
			0.222				**0.048**	**152.60**	**5.07**	**105.75**

File No. : PDF/2023/000867/EAS | Page 14 of 37

Table 3. Water Quality Index Calculation Table (Source: Calculated from analyzed data)

Parameters	Observed Value	Standard Value (Sn)	1/Sn	Σ(1/Sn)	k	Ideal Value (Vio)	Unit Weight (Wn)	Quality Rating (qn)	Wn*qn	**WQI**
					2010					
Na	152.45	200	0.005	0.217	0.217	0.0	0.001	76.22	0.08	
K	6.00	200	0.005	0.217	0.217	0.0	0.001	3.00	0.00	
Ca	40.62	75	0.013	0.217	0.217	0.0	0.003	54.15	0.16	
Mg	62.03	30	0.033	0.217	0.217	0.0	0.007	206.77	1.49	
Cl	63.85	250	0.004	0.217	0.217	0.0	0.001	25.54	0.02	
HCO3	360.54	600	0.002	0.217	0.217	0.0	0.000	60.09	0.02	
CO3	0.00	200	0.005	0.217	0.217	0.0	0.001	0.00	0.00	
SO4	286.54	250	0.004	0.217	0.217	0.0	0.001	114.62	0.10	
EC	1463.08	300	0.003	0.217	0.217	0.0	0.001	487.69	0.35	
Ph	7.35	8.5	0.118	0.217	0.217	7.0	0.025	23.23	0.59	
TDS	972.02	500	0.002	0.217	0.217	0.0	0.000	194.40	0.08	
TH	360.00	200	0.005	0.217	0.217	0.0	0.001	180.00	0.19	
No3	16.14	45	0.022	0.217	0.217	0.0	0.005	35.86	0.17	
			0.222				**0.048**	**112.43**	**3.27**	**68.23**
					2004					
Na	166.13	200	0.005	0.217	0.217	0.0	0.001	83.06	0.09	
K	5.89	200	0.005	0.217	0.217	0.0	0.001	2.94	0.00	
Ca	16.50	75	0.013	0.217	0.217	0.0	0.003	22.00	0.06	
Mg	60.00	30	0.033	0.217	0.217	0.0	0.007	200.00	1.44	
Cl	173.63	250	0.004	0.217	0.217	0.0	0.001	69.45	0.06	
HCO3	420.13	600	0.002	0.217	0.217	0.0	0.000	70.02	0.03	
CO3	0.00	200	0.005	0.217	0.217	0.0	0.001	0.00	0.00	
SO4	48.58	250	0.004	0.217	0.217	0.0	0.001	19.43	0.02	
EC	1342.00	300	0.003	0.217	0.217	0.0	0.001	447.33	0.32	
Ph	8.08	8.5	0.118	0.217	0.217	7.0	0.025	71.75	1.83	
TDS	890.84	500	0.002	0.217	0.217	0.0	0.000	178.17	0.08	
TH	291.88	200	0.005	0.217	0.217	0.0	0.001	145.94	0.16	
No3	22.25	45	0.022	0.217	0.217	0.0	0.005	49.44	0.24	
			0.222				**0.048**	**104.58**	**4.33**	**90.19**
					2001					
Na	207.67	200	0.005	0.217	0.217	0.0	0.001	103.83	0.11	
K	15.19	200	0.005	0.217	0.217	0.0	0.001	7.60	0.01	
Ca	46.33	75	0.013	0.217	0.217	0.0	0.003	61.78	0.18	
Mg	59.58	30	0.033	0.217	0.217	0.0	0.007	198.61	1.43	
Cl	198.75	250	0.004	0.217	0.217	0.0	0.001	79.50	0.07	
HCO3	490.00	600	0.002	0.217	0.217	0.0	0.000	81.67	0.03	
CO3	0.00	200	0.005	0.217	0.217	0.0	0.001	0.00	0.00	
SO4	111.63	250	0.004	0.217	0.217	0.0	0.001	44.65	0.04	
EC	1545.42	300	0.003	0.217	0.217	0.0	0.001	515.14	0.37	
Ph	8.10	8.5	0.118	0.217	0.217	7.0	0.025	73.33	1.87	
TDS	1129.16	500	0.002	0.217	0.217	0.0	0.000	225.83	0.10	
TH	360.92	200	0.005	0.217	0.217	0.0	0.001	180.46	0.20	
No3	19.47	45	0.022	0.217	0.217	0.0	0.005	43.26	0.21	
			0.222				**0.048**	**124.28**	**4.61**	**96.12**

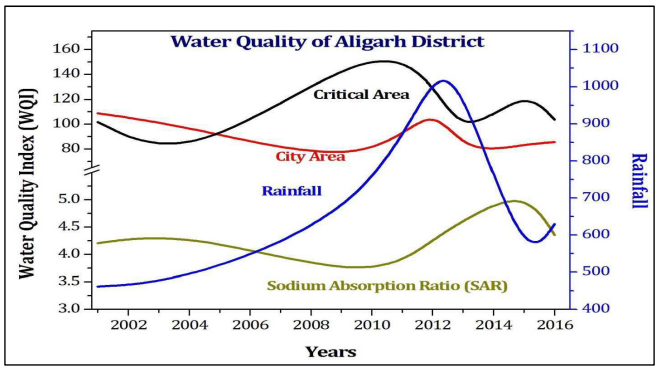


Fig.2. Graph amongst Water Quality Index (WQI), Sodium Absorption Ratio (SAR) and Precipitation (Source: Plotted from the calculated data)

areas and SAR value graphs are showing reverse correlation with rainfall.

In Figure 2, for the WQI of critical area, the suitable rainfall range is 450mm to 850mm from the year 2003 to 2011 and for WQI of the city area, the suitable rainfall range is 700mm to 950mm from the

Table 4. Water quality index and Water quality status (Source: Chatterjee and Raziuddin, 2002)

0-25	Excellent water quality
26-50	Good water quality
51-75	**Poor water quality**
76-100	**Very poor water quality**
>100	**Unfit for drinking**

File No. : PDF/2023/000867/EAS | Page 15 of 37

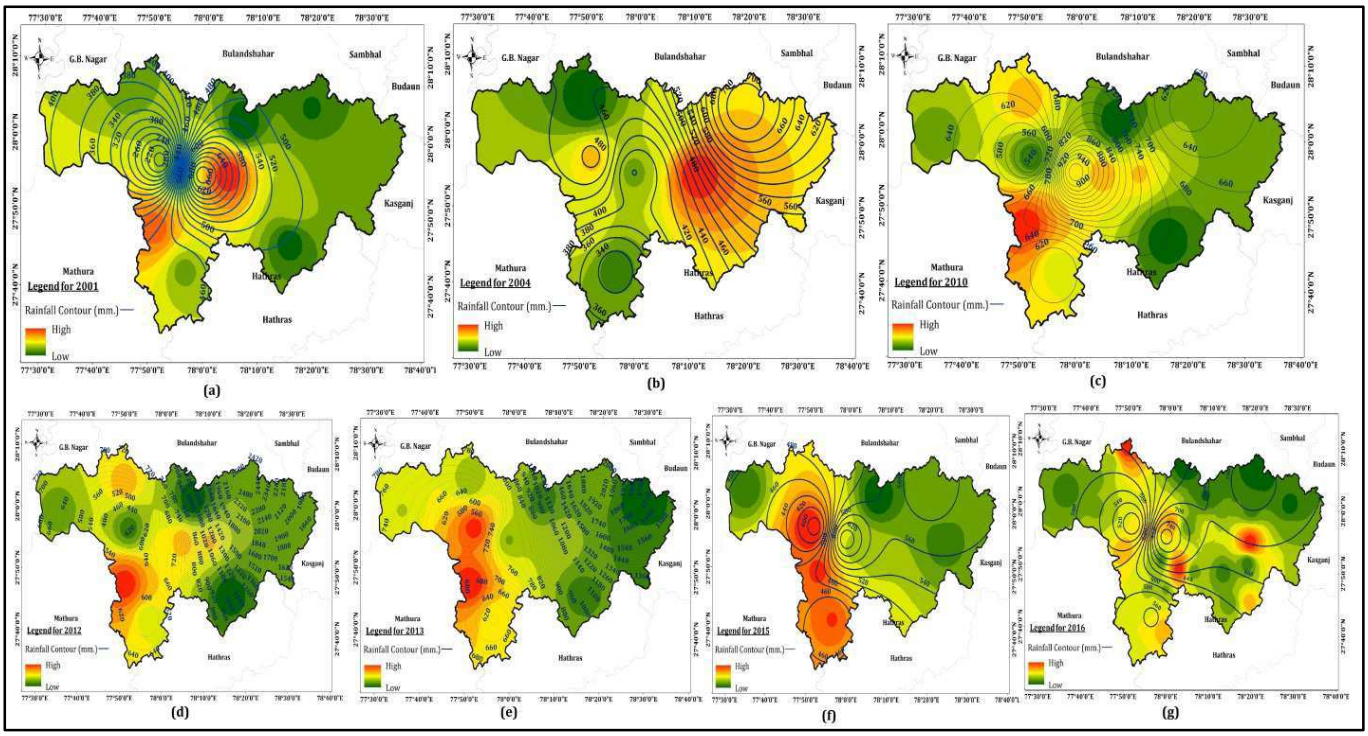


Fig.3. WQI correlation with Precipitation from 2001-2016 (Source: Derived and plotted from the collected data)

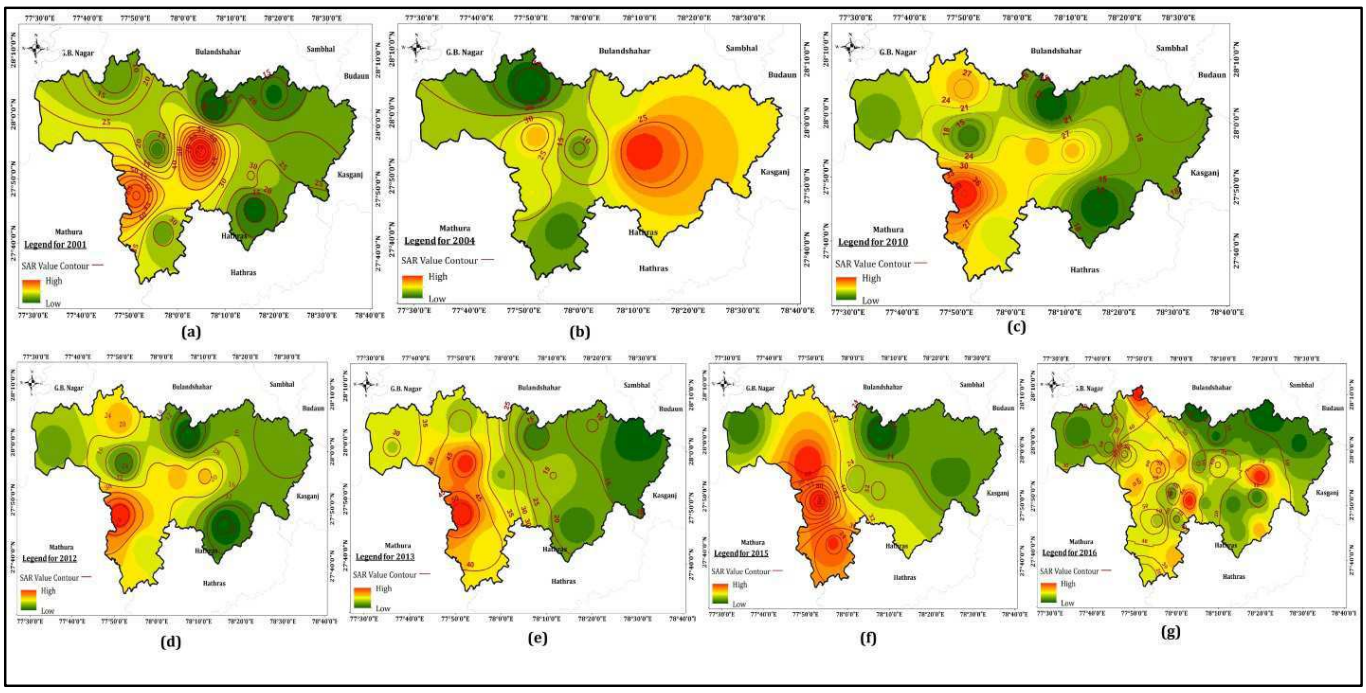


Fig.4. WQI correlation with SAR Values from 2001-2016(Source: Derived and plotted from the collected data)

year 2009 to 2012; in the same way, for the SAR value, the suitable rainfall range is 550 mm to 750 mm from the year 2006 to 2010.

For the detailed study of rainfall impacts on each part of the study area, WQI and SAR were also calculated based on sample collection spots and correlated it with each other for each year. In all the years, WQI values are showing reverse relation with the rainfall (at a certain range approximate from 450mm to 950mm) as shown in Fig.3.

In the same way, the WQI values show matching correlation with the SAR values as shown in Fig.4.

CONCLUSION

The correlation of WQI and SAR values with a certain range of rainfall shows that when the rainfall takes place more than a certain value, it dissolves more ions thus the concentration of elements in the groundwater starts decreasing. While on the other hand when rainfall is less than a certain value with evaporation, the concentration starts increasing. In both cases, WQI and SAR values disturbed.

The graph of the critical area shows that it takes less time to respond to the rainfall, in comparison to the graph of city area. It is because the city area has more built-up area and not many opens space and as

File No. : PDF/2023/000867/EAS | Page 16 of 37

result rain water cannot easily percolate to the groundand it takes more time. While in the critical area, where the open space (agricultural area) is more so the percolation takes place easily and the response is fast. It means that the amount of rainfall plays an important role, if the heavy rainfall takes place, the concentration of the elements starts decreasing. On the other hand, if the rainfall is less, the concentration of the elements starts increasing. Both the high and low values of rainfall is not good for the water quality for both drinking as well as irrigation.

Therefore, for the sustainability of groundwater quality, there should be a proper drainage network for the heavy rain period and the lean period and there should be proper water harvesting structures. It would be better for sustainable groundwater quality.

Acknowledgements: I would like to thank to the Department of Geology, University of Lucknow, Lucknow, for providing the working facilities to carry out this work. I am also very gratefully to Director, Central Ground Water Board, Northern Region for providing the data for this study.

References

Ahmad, A., and Ahmad, F. (2014) Assessment of Drinking Water Quality: A Case Study. Internat. Jour. Curr. Microbio. App. Sci., v.9, pp.608-611.

APHA (1995) Standard Methods for Estimation of Water and Waste Water, nineteenth ed. American Public Health Association, Washington, DC.

Atkinson, E.T. (1875) Descriptive and Historical Account of the Aligarh District. North-Western Provinces Govt. Press, Allahabad pp.348.

B.I.S. (2012) Bureau of Indian Standards, (IS 10500: 2012).

CGWB, NR (2016) Report on aquifer mapping and Underground water management plan Aligarh district, Uttar Pradesh. Northern Region, Lucknow.

Chatterjee, A.A., and Raziuddin, M. (2002) Determination of water quality index (WQI) of a degraded river in Asansol Industrial area, Raniganj, West Bengal. Nat. En. Poll. Tech. v.1(2), pp.181–189.

Collins, R., and Jenkins, A. (1996) The impact of agricultural land use on stream chemistry in the middle Hills of Himalaya, Nepal. Jour. Hydrol., v.71, pp.86.

Domenico, P.A., and Schwartz, F.W. (1990) Physical and chemical hydrogeology. Wiley, New York, pp.410–420.

Griffith, A.J. (2001) Geographic techniques and recent applications of remote sensing to Landscape-water quality studies. Water Air Soil Poll., v.138, pp.181–197.

Gupta, A., Mishra, A., and Singh, D.S. (2016) Environmental Impact Assessment of Water Resources and Urbanization in Varanasi District, U.P. India. Jour. En. Sci. Tox. Food Tech., v.12, pp.62–67.

Haritash, A.K., Kaushik, C.P., Kanal, A., and Kumar, Y.A. (2008) Suitability assessment of groundwater for drinking, irrigation and industrial use in some North Indian Villages. Environ. Monit. Assess. v.145, pp.397–406.

Hem, J.D. (1985) Study and Interpretation of the Chemical Characteristics of Natural Water. USGS Water-Supply v.2254(3), pp.263.

Horton, R.K. (1965) An index number system for rating water quality. Jour. Water Poll. Cont. Fed., v.37, pp.300–305.

Humphreys, W.F. (2009) Hydrogeology and groundwater ecology: Does each inform the other. Jour. Hydrogeol. v.17, pp.5–21.

Irfan, A., and Khurshid, S. (2017) Effect of Water Quality on Human Health in Aligarh City, India. Jour. Integ. Comm. Health, v.6, pp.6–9.

Irfan, A. and Khurshid, S. (2018) Heavy Metal Pollution in Groundwater of Kali River, Sub-Basin, Aligarh City, U.P. India. Internat. Jour. Adv. Res., v.6, pp.520–529.

Jain, P.K. (1998) Hydrology and quality of groundwater around Hirapur district, Sagar , M.P. - A case study of protozoic rocks. Poll. Res., v.17, pp.91–94.

Julian Ijumulana, J., Ligatea, F., Bhattacharyaa, P., Mtalob, F., and Zhangd, C. (2020). Spatial analysis and GIS mapping of regional hotspots and potential health risk of fluoride concentrations in groundwater of northern Tanzania. Sci. Tot. Environ., v.735, pp.1-16.

Kelly, W.P. (1957) Adsorbed Sodium, cation exchange capacity and percentage sodium adsorption in alkali soils. Sci., v.84, pp.473–477.

Kolpin, D. (1997) Agricultural chemicals in groundwater of the Midwestern United States: relations to land use. Jour. Environ. Qual., v.26, pp.1025–1037.

Kumar, A., Mishra, A., and Singh, D. S. (2017) Urbanization Status and Ground Water Quality District Raebareli, Uttar Pradesh, India. Res. Ennviron. Life Sci., v.11, pp.880–884.

Matson, P., Parton, J., Power, A., and Swift, M. (1997) Agricultural intensification and ecosystem properties. Science, v.277, pp.504–509.

Milovanovic, M. (2007) Water quality assessment and determination of pollution sources along the Axios/Vardar River, Southeastern Europe. Desalination, v.213, pp.159–173.

Prasanna, M.V., Chidambaram, S., and Srinivasamoorthy, K. (2010) Statistical analysis of the hydro geochemical evolution of groundwater in hard and sedimentary aquifers system of Gadilam river basin, South India. Jour. King Saud Univ. Sci., v.22, pp.133–145.

Perween, S., and Fatima, U. (2015) Physico-Chemical Analysis of Groundwater Quality in Aligarh City, Uttar Pradesh. Internat. Jour. Sci. Nat., v.3, pp.397–405.

Richards, L.A., (1954) Diagnosis and Improvement of Saline and Alkali Soils. Agriculture Handbook, Department of Agricultural, Washington DC.

Singh, D.S., Singh, R. and Mishra, A. (2020) Determination of silt thickness in Durga Kund for its de-isolation at Varanasi, UP, India. Water Science, v.34(1), pp.13-17.

Wasim, S., M., Khurshid, S., Shah, Z., A. and Raghuvanshi, D. (2014) Groundwater Quality, *In:* Parts of Central Ganga Basin, Aligarh City, Uttar Pradesh, India. Proc. Indian Nat. Sci. Acad., pp.123–142.

WHO (2017) Guidelines for drinking-water quality. *In:* Incorporating 1st Addendum, Fourth Ed. World Health Organization, Geneva.

(Received: 3 July 2020; Revised form accepted: 22 May 2021)

File No. : PDF/2023/000867/EAS | Page 17 of 37

क्रमांक (Sr. No.)
63/1051/0062
1446810

अनुक्रमांक (Roll No.)
1917850

माध्यमिक शिक्षा परिषद, उत्तर प्रदेश
Board of High School and Intermediate Education, U.P.

हाई स्कूल परीक्षा - २००६
High School Examination - 2006

प्रमाणित किया जाता है कि परिषद् के अभिलेखानुसार
This is to certify that according to the Board's record **DAYA SHANKAR SINGH**

आत्मज/आत्मजा श्रीमती (son/daughter of Mrs.) **KIRAN SINGH**

एवं श्री (and Mr.) **UDAY BHANU SINGH**

ने जिनकी जन्म तिथि (whose date of birth is)

14TH AUGUST NINETEEN HUNDRED NINETY TWO (14-08-92) है,

मार्च/अप्रैल वर्ष 2006 की हाईस्कूल की परीक्षा निम्न विवरणानुसार उत्तीर्ण की है :–
has passed High School Examination held on March/April-2006 according to the following details :-

चयनित विषय (Name of the opted subjects) :

1. HINDI / D	2. ENGLISH / D	3. MATHEMATICS / D
4. SCIENCE / D	5. SOCIAL SCIENCE / D	6. DRAWING

नैतिक, खेल एवं शारीरिक शिक्षा की श्रेणी (Category of Moral, Sports & Physical Education) - **A**

उत्तीर्ण श्रेणी (Division) - **FIRST HONOURS**

विद्यालय/केन्द्र (School/Centre) - **PIONEER MONTESSORI I C BARABANKI**

प्रमाणपत्र क्रमांक (Certificate No.)	संस्था०/व्यक्तिगत (Reg./Pvt.)	दिनांक व स्थान (Date & Place)
6300724	REGULAR	25-05-2006 Allahabad

(बासुदेव यादव)
(Basudeo Yadav)
सचिव (Secretary)

'D' indicates Distinction in that particular subject.
'HONOURS' indicates candidate "passed with honour"
Note:For Important Instructions see overleaf.

63008698

University of Lucknow

Lucknow, U.P., India

Serial No. 006103

Provisional Certificate

This is to certify that Shri/Smt./Km. Daya Shankar Singh son / daughter of Shri Uday Bhanu Singh has been declared eligible to receive the degree of **Doctor of Philosophy** in Geology vide Result Notice No. 03/2023 dated 06/04/2023

The topic of his/her thesis was Study of the Aquifer Systems and Sustainability of Ground water Resources in and Around Aligarh District, Central Ganga Plain Uttar Pradesh

University of Lucknow

The 03/05/2023 20

for Controller of Examination

Undertaking by the Principal Investigator

To

The Secretary
SERB, New Delhi

Sir

I Dr. Daya Shankar Singh herby certify that the research proposal titled Integrated Approach for the salinity sources in Groundwater from Aligarh to Firozabad, Uttar Pradesh submitted for possible funding by SERB, New Delhi is my original idea and has not been copied/taken verbatim from anyone or from any other sources. I further certify that this proposal has been checked for plagiarism through a plagiarism detection tool i.e. URKUND approved by the Institute and the contents are original and not copied/taken from any one or many other sources. I am aware of the UGCs Regulations on prevention of Plagiarism i.e. University Grant Commission (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulation, 2018. I also declare that there are no plagiarism charges established or pending against me in the last five years. If the funding agency notices any plagiarism or any other discrepancies in the above proposal of mine, I would abide by whatsoever action taken against me by SERB, as deemed necessary.

Signature of PI with date

Name / designation

Dr. Daya Shankar Singh
Research Scholar

RAJESH SINGH
Scientist D, Environmental Hydrology Division
National Institute of Hydrology, Roorkee – 247 667, Uttarakhand
Phone: +91-1332-249316 / +91-9267483749
rsingh.nih@gmail.com, rsingh.nihr@gov.in

Education and Training

Veer Narmad South Gujarat University	Surat, Gujarat	Chemistry	B.Sc., 2000
-do-	-do-	Analytical Chemistry	M.Sc., 2002
-do-	-do-	Chemistry	Ph.D., 2008
University of Nebraska-Lincoln	Lincoln, NE	Biogeochemistry	Postdoc, 2016-17

Research and Professional Experience

2019-Present	Scientist D, National Institute of Hydrology, Roorkee
2014-2018	Scientist C, National Institute of Hydrology, Roorkee
2016-2017	Water Advanced Research and Innovation Fellow, UNL, NE
2011-2014	Scientist B, National Institute of Hydrology, Roorkee
2007-2011	Manager, Ion Exchange (India) Limited, Mumbai
2007-2011	Consultant, Total Water Management Services India Limited, Mumbai
2002-2007	Chemist, Steag Encotec India Private Limited, Surat

Publications

Refereed Journal Articles

K. Singh, **R. Singh**, G. Pandey, 2023. Impact of nitrogen and sulfur fertilizers on leaching behavior of heavy metals from aquifer sediments to groundwater. Journal of the Taiwan Institute of Chemical Engineers, 105056 (In Press) (I.F.: 5.7)

S. Singh, S. K. Malyan, C. Maithani, S. Kashyap, V. K. Tyagi, **R. Singh**, S. Malhotra, M. Sharma, A. Kumar, B. K. Panday, R. P. Pandey (2023). Microplastics in landfill leachate: Occurrence, health concerns, and removal strategies. Journal of Environmental Management, 342, 118220 (I.F.: 8.91).

S. Singh, C. Maithani, S. K. Malyan, A. Soti, N. M. Kulshreshtha, **R. Singh**, U. Brighu, A. B. Gupta, J. Kumar, S. Yadav, O. Singh, V. C. Goyal (2023). Comparative performance and 16S amplicon sequencing analysis of deep and shallow cells of a full scale HFCW having sequentially decreasing depths reveals vast enhancement potential. Bioresource Technology Reports, 22, 101404.

Patel, S. P. Rai, K. V. Akpataku, N. Puthiyottil, A. K. Singh, N. Pant, **R. Singh**, P. Rai, J. Noble (2023). Hydrogeochemical characterization of groundwater in the shallow aquifer system of Middle Ganga Basin, India. Groundwater for Sustainable Development, 21, 100934.

J. P. Westrop, P. Yadav, P. J. Nolan, K. M**.** Campbell**, R. Singh**, S. E. Bone, A. H. Chan, A. J. Kohtz, D. Pan, O. Healy, J. R. Bargar, D. D. Snow, K. A. Weber (2023). Nitrate stimulated release of naturally occurring sedimentary uranium. Environmental Science and Technology, 57(10), 4354-4366 (IF: 11.357).

S. Singh, M. Rawat, S. K. Malyan, **R. Singh**, V. K. Tyagi, K. Singh, S. Kashyap, S. Kumar, M. Sharma, B. K. Pandey, R. P. Pandey (2023). Global distribution of pesticides in freshwater resources and their remediation approaches. Environmental Research, 225, 115605 (I.F.: 8.431).

K. Singh, **R. Singh**, G. Pandey, 2023. Hydrogeochemistry, solute source identification, and health risk assessment of groundwater of cancer prone region in India. Water Supply, 23(1), 317-342 (IF: 1.768).

P. Tamang, V. K. Tyagi, N. Gunjyal, A. M. Rahmani, **R. Singh**, P. Kumar, B. Ahmed, P. Tyagi, R. Banu, S. Varjani, A. A. Kazmi, 2023. Free nitrous acid (FNA) pretreatment enhances biomethanation of lignocellulosic agro-waste (wheat straw). Energy, 264, 126249 (IF: 8.857)

M. Malhotra, K. Aboudi, L. Pisharody, A. Singh, J. R. Banu, S. K. Bhatia, S. Varjani, S. Kumar, C. Gonz´alez-Fern´andez, S. Kumar, **R. Singh**, V. K. Tyagi, 2022. Biorefinery of anaerobic digestate in a circular bioeconomy: Opportunities, challenges and perspectives. Renewable and Sustainable Energy Reviews, 166, 112642 (IF: 16.799).

M. Rahmani, V. K. Tyagi, B. Ahmed, A. A. Kazmi, C. S. P. Ojha**, R. Singh**, 2022. Critical insights into anaerobic co-digestion of wheat straw with food waste and cattle manure: Synergistic effects on biogas yield and kinetic modeling. Environmental Research, 212, 113382 (IF: 8.431)

V. C. Goyal, O. Singh, **R. Singh**, K. Chhoden, S. K. Malyan, 2022. Appraisal of heavy metal pollution in the water resources of Western Uttar Pradesh, India and associated risks. Environmental Advances, 8, 100230.

S. K. Malyan, O. Singh, A. Kumar, G. Anand, **R. Singh**, S. Singh, Z. Yu, J. Kumar, R. K. Fagodiya, A. Kumar, 2022. Greenhouse gases trade-off from ponds: An overview of emission process and their driving factors. Water, 14, 970 (IF: 3.530).

S. K. Malyan, S. Yadav, V. Sonkar, V. C. Goyal, O. Singh, **R. Singh**, 2021. Mechanistic understanding of the pollutant removal and transformation processes in the constructed wetland system. Water Environment Research, 93(10), 1882-1909 (IF: 3.306).

S. Kumar, M. Kumar, V. K. Chandola, V. Kumar, R. K. Saini, N. Pant., N. Kumari, A. Srivastava, S. Singh, **R. Singh**, G. Krishan, S. P. Induwar, S. Kumar, B. K. Yadav, N. S. Maurya, A. Chaudhary, 2021. Groundwater quality issues and challenges for drinking and irrigation uses in Central Ganga basin dominated with Rice-Wheat cropping system. Water, 13, 2344 (IF: 3.530).

S. K. Malyan, S. S. Kumar, R. K. Fagodiya, P. Ghosh, A. Kumar, **R. Singh**, L. Singh, 2021. Biochar for environmental sustainability in the energy-water-agroecosystem nexus. Renewable and Sustainable Energy Reviews, 149, 111379 (IF: 16.799).

S. Kumar, V. Kumar, R. K. Saini, N. Pant, **R. Singh**, A. Singh, S. Kumar, S. Singh, B. K. Yadav, G. Krishan, A. Raj, N. S. Maurya, M. Kumar, 2021. Floodplains Landforms, Clay deposition and irrigation return flow govern arsenic occurrence, prevalence and mobilization: A geochemical and isotopic study of the Mid-Gangetic floodplains. *Environmental Research*, 201, 111516 (IF: 8.431).

Malakar, **R. Singh**, K. A. Weber, J. Westrop, C. N. Elofson, M. Kumar, D. D. Snow, 2021. Occurrence of arsenite in surface and groundwater associated with a perennial stream located in Western Nebraska, USA. *Journal of Hazardous Materials*, 416, 126170 (IF: 14.224).

N. Pant, S. P. Rai, **R. Singh**, S. Kumar, R. K. Saini, P. Purushothaman, Y. S. Rawat, K. Pratap, M. Sharma, 2021. Impact of geology and anthropogenic activities over the water quality with emphasis on fluoride in water scarce Lalitpur district of Bundelkhand region, India. *Chemosphere*, 279, 130496 (IF: 8.943).

B. K. Pandey, **R. Singh**, R. P. Pandey, S. Das, J. Kumar, P. Kumar, S. Kumar, V. K. Pandey, 2021. Water quality appraisal of a mountainous river: A case study of Rispana River, Dehradun. *Water & Energy International*, 64(1), 14-23 (IF: 0.21).

R. P. Pandey, P. Kumar, B. K. Pandey, J. V. Tyagi, **R. Singh**, S. Kumar, S. Saini, 2021. Development of Rejuvenation Plan for Rispana River System, Uttarakhand, India. Water & Energy International, 64(2), 6-18 (IF: 0.21).

S. Ali, Babali, S. Singh, **R. Singh**, M. Tyagi, R. P. Pandey, 2021. Influence of multidrug resistance bacteria in river Ganges in the stretch of Rishikesh to Haridwar. Environmental Challenges, 3, 100068.

S. Sundriyal, U. Bhan, S. Selvakumar, **R. Singh**, D. P. Dobhal, 2021. Two decadal changes in the major ions chemistry of melt water draining from Dokriani Glacier, central Himalaya, India. *Journal of the Geological Society of India*, 97, 308-314 (IF: 1.466).

V. C. Goyal, O. Singh, **R. Singh**, K. Chhoden, J. Kumar, N. Singh, N. G. Shrivastava, L. Carvalho, 2021. Ecological health and water quality of village ponds in the subtropics limiting their use for water supply and groundwater recharge. *Journal of Environmental Management*, 277, 111450 (IF: 8.91).

K. Singh, G. Pandey, **R. Singh**, 2021. Carcinogenic trace metals in groundwater of Bathinda district, Punjab, India. International Journal of Engineering, Science and Technology, 13(1), 105-111.

S. Kashyap, **R. Singh**, U. P. Singh, 2020. Inorganic and organic anion sensing by azole family members. *Coordination Chemistry Reviews*, 417, 213369 (IF: 24.833).

S. S. Kumar, A. Kumar, S. Singh, S. K. Malyan, S. Baram, J. Sharma, **R. Singh**, A. Pugazhendhi, 2020. Industrial wastes: Fly ash, steel slag and phosphogypsum- Potential candidates to mitigate greenhouse gas emissions from paddy fields. *Chemosphere*, 241, 124824 (IF: 8.943).

E. Salila, M. P. Sharma, **R. Singh**, 2020. Climate change impacts on water quality of water bodies - A review. *International Journal of Environment and Climate Change*, 10(3), 26-37.

S. K. Malyan, **R. Singh**, M. Rawat, M. Kumar, A. Pugazhendhi, A. Kumar, V. Kumar, S. S. Kumar, 2019. An overview of carcinogenic pollutants in groundwater of India. *Biocatalysis and Agricultural Biotechnology*, 21, 101288.

सुजाता एवं राजेश सिंह [illegible]। निर्मित आर्द्रभूमि तकनीक प्रदूषण को कम करने की प्रभावशाली तकनीक। जल चेतना [illegible]

K. Singh, **R. Singh**, S. K. Malyan, M. Rawat, P. Kumar, S. Kumar, M. K. Sharma, G. Pandey, 2018. Health risk assessment of drinking water in Bathinda district, Punjab, India. *Journal of Indian Water Resources Society*, 38, 34-41.

S. Kumar, A. A. Kazmi, N. C. Ghosh, **R. Singh**, 2017. Optimization of ballasted sand flocculation process for urban run-off treatment, *Journal of Indian Water Resources Society*, 37(4), 56-60.

R. Singh, B. Kanchan, P. Mondal, S. Singh. 2015. Water quality assessment of River Ganga - Health hazard identification and control. *International Journal of Scientific and Research Publication*, 5, 1-8.

R. Singh. 2014. Removal of oil from CO_2 compressor effluent of Ammonia Plan. *Journal of Indian Water Resources Society*, 34, 46-52.

B. A. Shah, A. V. Shah, **R. Singh**, N. B. Patel, 2011. Reduction of Cr (VI) in electroplating wastewater and investigation on the sorptive removal by WBAP. *Environmental Progress & Sustainable Energy*, 30, 59-69 (IF: 2.824).

B. A. Shah, A. V. Shah, **R. Singh**, 2009. Sorption isotherms and kinetics of chromium uptake from wastewater using natural sorbent material. *International Journal of Environmental Science & Technology*, 6, 77-90 (IF: 3.519).

B. A. Shah, A. V. Shah, **R. Singh**, N. B. Patel, 2009. Sorptive removal of nickel onto weathered basaltic andesite products: kinetics and isotherms. *Journal of Environmental Science & Health, Part A*, 44, 880-895 (IF: 2.269).

R. Singh, B. A. Shah, Sujata, 2008. SEM, TEM, PXRD, and equilibrium study of heavy metal sorption on weathered basaltic andesite products. *International Journal of Pure & Applied Chemistry*, 3, 192-200.

Singh R., Shah A. V., Shah B. A., 2007. Sorption Behaviour of Cu (II) from acidic solution using weathered basalt and e-site products. *E-Journal of Chemistry*, 4, 587-605 (IF: 3.241).

Patent Granted

R. Singh, 2022. Fluoride removal media developed from bagasse fly ash and a method for synthesis thereof. Indian Patents, Application Number – 2649/DEL/2015 dt. 26.08.2015, Patent No. 395135.

Book Chapters

O. Singh, R. Singh, K. Chhoden, N. R. Allaka, D. Singh, V. C. Goyal (2023). Rejuvenation of village ponds and performance evaluation of natural treatment system: Few case studies *(In. Water Management and Governance. Eds. A. Rawat, B. Sharma, O. P. Nautiyal), ABS Books, Delhi (ISBN: 978-93-94424-71-5).*

A. Patel, A. K. Singh**, R. Singh**, N. Puthiyottil, S. P. Rai (2023). Fluoride Mobilization and Provenance Identification in Semi-arid Conditions: A Hydrochemical and Isotopic Approach *(In. Surface and Groundwater Resources Development and Management in Semi-arid Region: Strategies and Solutions for Sustainable Water Management. Eds. C. B. Pande, M. Kumar, N. L. Kushwaha), Springer Nature, Switzerland AG (ISBN: 978-3-031-29394-8).*

S. Singh, N. Pawar, S. S. Kumar, **R. Singh**, G. Anand, A. Kumar, S. K. Malyan (2021). Aromatic oils from medicinal plants, and their role in nanoparticles synthesis, characterization, and applications (*In. Secondary metabolites from medicinal plants: Nanoparticles synthesis and their applications. Eds. R. K. Bachheti, A. Bachheti), CRC Press, Taylor & Francis Group, Boca Raton, FL (ISBN: 978-1-032-07515-0).*

S. K. Malyan, S. S. Kumar, L. Singh, **R. Singh**, D. A. Jadhav, V. Kumar (2021). Bioelectrochemical systems for removal and recovery of heavy metals. *In Bioremediation, Nutrients, and Other Valuable Product Recovery: Using Bioelectrochemical Systems (Eds. L. Singh, D. M. Mahapatra, M. L. Kansal, S. Thakr), Elsevier, Netherlands (ISBN: 978-0-12-821729-0).*

R. Singh, S. Kashyap, A. Pandey (2021). Water quality and human health. *In Climate Impacts on Water Resources in India: Environment and Health (Eds. A. Pandey, S. K. Mishra, M. L. Kansal, R. D. Singh, V. P. Singh), Springer Nature, Switzerland (ISBN: 978-3-030-51427-3).*

R. Singh, D. Kanbienna, A. Pandey (2021). Water quality status of upper Ganga canal. *In Climate Impacts on Water Resources in India: Environment and Health (Eds. A. Pandey, S. K. Mishra, M. L. Kansal, R. D. Singh, V. P. Singh), Springer Nature, Switzerland (ISBN: 978-3-030-51427-3).*

M. K. Sharma, **R. Singh**, O. Singh, D. G. Durbude (2021). Contamination in drinking water supply: A case study of Shimla city, Himachal Pradesh, India. *In Climate Impacts on Water Resources in India: Environment and Health (Eds. A. Pandey, S. K. Mishra, M. L. Kansal, R. D. Singh, V. P. Singh), Springer Nature, Switzerland (ISBN: 978-3-030-51427-3).*

R. Singh, S. Kumar, 2019. Impact of climate change on water quality. *In Climate Change and Its Impact on Water Resources of India (Eds. S. K. Jain, P. K. Singh), NIH Roorkee*, 178.

R. Singh, O. Singh, V. C. Goyal, N. Singh, 2018. Root Zone Wastewater Treatment for Rejuvenating Village Ponds. *In Indo-US Bilateral Workshop on Water-Food-Energy-Climate nexus: A perspective towards a sustainable future (Ed. Rajeev P. Singh), K.R. Publishers & Distributors, Varanasi (ISBN: 978-93-88179-09-6),* 23-26.

R. Singh, C. K. Jain, 2014. UASBR: An effective wastewater treatment option to curb greenhouse gas emission. *In Management of Natural Resources in the Changing Environment (Eds. Raju N. J., Gossel, W., Sudhakar, M.), Springer and Capital publishers (ISBN: 978-3-319-12559-6),* 125-134.

R. Singh, S. Kumar, M. Garg, 2014. Domestic Wastewater Treatment Using Tanfloc: A Tannin Based Coagulant. *In Geostatistical and Geospatial Approaches for the Characterization of Natural Resources in the Environment: Challenges, Processes and Strategies (Ed. Raju N. J.), Springer and Capital publishers, New Delhi (ISBN: 978-93-81891-25-4),* 202-205.

S. Kumar, N. C. Ghosh, R. P. Singh, **R. Singh**, S. Singh, 2014. Impact of Canal Recharge on Groundwater Quality of Kolayat Area, District Bikaner, India. *In Geostatistical and Geospatial Approaches for the Characterization of Natural Resources in the Environment: Challenges, Processes and Strategies (Ed. Raju N. J.), Springer and Capital publishers, New Delhi (ISBN: 978-93-81891-25-4),* 198-201.

R. Singh, V. K. Choubey, 2013. Evaluation of anaerobic biological treatment for wastewater of ion exchange (IX) resin manufacturing facility. *In Environmental Technology (Eds. Khanna D. R., Chopra A. K., Matta G., Bhutiani R. and Singh V.), Daya Publishing House (Astral International Pvt. Ltd.), New Delhi (ISBN: 9788170358237),* 15-23.

Non-refereed Articles

R. Singh, 2010. Is Sea Water Green? Water Digest, Nov-Dec., 2010, 26-32.

R. Singh, 2009. Water Recycling in Steel Plant. Steel World, Jan. 2009, 34-41.

R. Singh, 2009. Membrane Concentrate – Challenges in disposal and present practices. Everything about Water, Oct. 2009, 34-36.

Paper Published in Conferences

"Geospatial variability of major ion hydrochemistry and their interionic relationship control on water chemistry in the parts of Middle Ganga Plain" and "Hydrochemical analysis of groundwater in the vicinity of Rihand reservoir, India" in International Virtual Conference on Ground Water (ICGW-2021), 28 Oct. 2021

"Water quality status of upper Ganga canal", "Contamination in Drinking Water Supply: A case study of Shimla City, Himachal Pradesh", and "Greenhouse gases mitigation through industrial byproduct in rice soil" in STIWM-2018 organized by IIT Roorkee and IWRS at Roorkee, Feb. 16-19, 2018.

"Assessment of groundwater quality with special reference to arsenic in Ballia District, Uttar Pradesh, India" in Hydro-2018 organized by NIT Patna at Patna, Dec. 19-21, 2018.

"Hydrochemical characteristics of river Ganga in head water region between Gangotri & Haridwar, Uttarakhand, India" in RHAR-2019 organized by IIT BHU at Varanasi, Feb. 14-16, 2019.

"Source identification for arsenic in groundwater of South-western Nebraska" and "Evaluation of hydrogeochemistry and groundwater quality in Lalitpur district, Bundelkhand region, Uttar Pradesh, India" in IGWC-2017 organized by NIH, CGWB, and AGGS at New Delhi, Dec. 11-13, 2017.

"Investigating rural drinking water supply options- A case study for parts of Chitrakoot district in Uttar Pradesh" in 3rd India Water Week 2015 (Water Management for Sustainable Development organized by Ministry of Water Resources, River Development and Ganga Rejuvenation, Government of India, New Delhi, 13th – 17th January 2015.

"Assessment of hydro-geochemistry and the quality of River Ganga in a stretch from Gangotri to Haridwar", "Investigation of trace metals in groundwater of Moth Block, Jhansi, Uttar Pradesh, India", "Temporal variations in the physico-chemical characteristics of River Ganga at Haridwar", and "Groundwater quality evaluation of Shimla City" in Symposium on Hydrology – 2015 organized by Indian Association of Hydrologists, National Institute of Hydrology, and Central Water Commission at New Delhi, 22nd – 23rd December, 2015.

"Domestic Wastewater Treatment Using Tanfloc: A Tannin Based Coagulant" and "Impact of Canal Recharge on Groundwater Quality of Kolayat Area, District Bikaner, India" in IAMG 16th Conference (Geostatistical and Geospatial Approaches for the characterization of Natural Resources in the Environment: Challenges, Processes and Strategies) organized by Jawaharlal Nehry University, New Delhi, 17th – 20th October, 2014.

"UASBR: An effective wastewater treatment option to curb greenhouse gas (GHG) emissions" in International Humboldt Kolleg on Management of Water, Energy and Bio-resources in Changing Climate Regime: Emerging Issues and Environmental Challenges (IHK-2013)" organized by Jawaharlal Nehru University, New Delhi, 8th – 9th February, 2013

"Recycling and reuse of water in Steel industry" and "Estimation of re-aeration and de-oxygenation coefficients for self-purification capacity of the Hindon River" in Indian Desalination Congress on Water desalination, Treatment and Management (InDACON-2013)" organized by Malaviya National Institute and Technology, Jaipur, 21st–22nd February, 2013.

"Reduction of Cr (VI) ions in aqueous solution by hydrazinium sulfate: Kinetics and equilibrium studies" in NEA Conference (Harmony 2013) organized by DDU Gorakhpur University, Gorakhpur, 11th-13th November, 2013.

"Treatability study for organic and color removal from denim industry wastewater: An approach towards zero liquid discharge" in National symposium on "Water Resources Management in Changing Environment (WARMICE-2012)" organized by National Institute of Hydrology, Roorkee, 8th–9th February, 2012

"Evaluation of anaerobic biological treatment for wastewater of IX resin manufacturing facility" in International Conference on "World Congress for Man & Nature (Global Climate Change and Biodiversity Conservation)" organized by Gurukal Kangri Vishwavidyalaya, Haridwar, 11th–13th November, 2011

"Reduction of Cr (VI) in electroplating industry and investigation on the sorptive removal by WBAP" in International Conference on Water, Environment, Energy, & Society (WEES-2009) organized by National Institute of Hydrology, Roorkee (Uttaranchal), 12th–16th January, 2009

"A novel green method to synthesize zeolites from the bagasse fly ash (a sugar industry waste)" and "Sorptive removal of methylene blue" in International Conference on Water, Environment, Energy, & Society (WEES-2009) organized by National Institute of Hydrology, Roorkee (Uttaranchal), 12th–16th January, 2009

"Thermodynamics of Cu (II) sorption onto andesite from aqueous solution" in 2nd conference on Thermodynamics of Chemical and Biological Systems of "The Indian Thermodynamics Society" organized by Veer Narmad South Gujarat University, Surat (Gujarat), 30th October – 1st November, 2006 and awarded second prize for the best presentation

"Sorptive removal of Ni (II) from electroplating wastewater by andesite as the sorbent" in 25th conference of "Indian Council of Chemists" organized by Birla College, Kalyan, Mumbai (Maharashtra), 27th – 29th December, 2006

"Bentonite for harmful metal removal from aqueous solution" in 24th conference of "Indian Council of Chemists" organized by Bit, Mesra, Ranchi (Jharkhand), 16th – 18th December, 2005

"Presenting a novel design flow chart of effluent treatment plant for the power station at Hazira (GSEG)" in 22nd conference of "Indian Council of Chemists" organized by IIT, Roorkee (Uttaranchal), 17th – 19th October, 2003

"Minimization of copper from industrial effluent with the help of chelating resin" in TAGRSM-2003, Indian Chemical Society Vadodara Chapter, on 23rd February, 2003

Major Projects

Ongoing

- Water efficient irrigation by using SCADA system for medium irrigation project (MIP) Shahnehar - *PDS Study, NHP, MoWR RD & GR (Rs. 7.5 million)*
- Innovation centre for Eco-prudent wastewater solutions (IC-ECOWS) – *DST (WATER-IC) (Rs. 85.69 million)*
- Water quality assessment of Haridwar district - *NIH Roorkee (Rs. 1.71 million)*
- Understanding of hydrological processes in Upper Ganga basin by using isotopic techniques – *DST (NMSHE) (Rs. 22.5 million)*
- Integrated hydrological studies for Upper Ganga Basin upto Rishikesh - *DST (NMSHE) (Rs. 17.7 million)*

Completed

- Water quality assessment of southwest Punjab emphasizing carcinogenic contaminants and their possible remedial measures – *PDS Study, NHP, MoWR RD & GR (Rs. 6.56 million)*
- Hydro-geochemical evolution & occurrence of arsenic in aquifer of Central Ganges Basin – *PDS Study, NHP, MoWR RD & GR (Rs. 7.0 million)*
- In-situ bioremediation of non-aqueous phase liquids (NAPLs) pollution within the Baddi-Barotiwala Nalagarh (BBN) Industrial Area in Himachal Pradesh, India - *DST (UKIERI) (Rs. 1.67 million)*
- Conservation of ponds in Ibrahimpur-Masahi village and performance evaluation of natural treatment system - *NIH Roorkee & CEH, UK*

- Environmental flow assessment for Yamuna River from Hathnikund barrage to Okhla barrage - *NMCG, DoWR, RD & GR, MoJ (Rs. 10.46 million)*
- Preparation of strategic land and water management plan for rejuvenation of Rispana river system - *Uttarakhand Irrigation Department, Dehradun (Rs. 8.61 million)*
- Action research on IWRM plan for water security in identified villages of Western UP - *INCSW, DoWR, RD & GR, MoJ (Rs. 83 million)*
- Rejuvenation of Village Ponds in Identified Villages of Baghpat, Ghaziabad and Meerut Districts of Uttar Pradesh - *NIH Roorkee (Rs. 85.69 million)*
- Microbial dissolution of arsenopyrite ore - *IUSSTF, DST, & UNL (Rs. 3.32 million)*
- Hydro-geological investigations (under aquifer mapping) of Jhansi & Lalitpur districts of Bundelkhand region -*WAPCOS, MoWR RD & GR (Rs. 13.58 million)*
- Impact of sewage effluent on drinking water sources of Shimla and suggesting ameliorative measures - *PDS Study, HP-II, MoWR (Rs. 7.08 million)*
- Potential impact of pollution on water resources in Singrauli Area - *NGT, New Delhi*
- Himalayan river water quality assessment in a stretch from Gangotri to Haridwar - *NIH Roorkee (Rs. 2.35 million)*
- Development of low cost media for fluoride removal from drinking water of fluoride affected areas - *NIH Roorkee (Rs. 2.0 million)*
- Prioritization of pollution abatement activities in Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, & West Bengal for Nirmal Ganga - *MoWR, RD & GR, GOI*
- Pollution caused by leather tanning industry to the water bodies in Unnao district of Uttar Pradesh - *MoWR, RD & GR, GOI*
- Pilot study on groundwater pollution in Hindon-Kali-Krishni river catchment in Western Uttar Pradesh - *WSSO, UP (Rs. 2.01 million)*
- Assessment of ground water contamination due to past storage of spent wash in kachcha lagoons and suggesting remedial measures - *Saraya Distillery, Sardarnagar, Gorakhpur (Rs. 0.57 million)*

Invited Talks

- Invited talk titled "UASB Reactor for organics removal from industrial effluent" in Brainstorming session to discuss the findings and future work plan for the ongoing Ramanujan Project entitled "Bioremediation of LNAPL polluted land under (Semi)-arid coastal environmental conditions" at IIT Roorkee on Nov. 10, 2014.
- Invited talk titled "Water Chemistry & Characteristics" and "Wastewater treatment techniques" in training course entitled "Water supply management, treatment and rain water harvesting & recovery techniques" organized by Ordinance factories institute of learning, Dehradun during June 29 – July 03, 2015.
- Invited talk titled "Groundwater Quality and Control" in Workshop entitled "भूजल का विवेकपूर्ण उपयोग एवं जन सहभागिता – समय की मांग" organized by Groundwater Division, Muradabad on July 22, 2015.
- Invited talk titled "Basics of wastewater treatment" and "Membranes in water & wastewater treatment" in Short term (QIP) course on "Environmental Engineering and Practices" organized by Madhav Institute of Technology, Gwalior during March 08-18, 2016.
- Invited talk titled "Findings of Reconnaissance Survey of Jhansi & Lalitpur w.r.t. Hydogeochemical Parameters" in "Exploration of the Natural Resources in the Bundelkhand Region" organized by DST, New Delhi & Bundelkhand University, Jhansi organized during March 10-11, 2016.
- Invited talk titled "Treatment Techniques for Industrial Effluents Polluting Soil & Water Resources" in training course entitled "Investigation, Remediation & Management of Soil & Groundwater Contaminated Sites" organized by DOH, IIT Roorkee during Nov. 20-22, 2017.
- Invited talk titled "Reuse of Municipal Wastewater for Irrigation: A Solution to Water Scarcity" and "Ground water contaminant remediation with emphasis on arsenic" in short term course entitled "Strategies for sustainable development: Goals and Issues" organized by Madan Mohan Malaviya University of Technology, Gorakhpur during Feb. 19-25, 2018.
- Invited talk titled "Water quality testing methods" and "Treatment techniques for wastewater management and reuse in agriculture" for Ph.D. Course Work Program at Bundelkhand University, Jhansi during Dec. 10-11, 2018.
- Invited talk titled "Waste Water Treatment Techniques" and "Reuse of Municipal Wastewater for Irrigation: A Solution to Water Scarcity" in a three day training course on 'Water Security: Best Practices for Conservation, Safety and Sustainability' is being organized at Western Himalayan Regional Center (WHRC), Jammu during January 23-25, 2019.

- Invited talk titled “Water quality monitoring planning” and “Water quality testing methods” in a certificate course on ‘Monitoring of Environmental Parameters and Their Interpretation’ is being organized at Centre of Land and Water Resource Management (CLWRM), GBPNIHESD, Almora during Feb. 26 – March 14, 2019.
- Invited talk titled “Water Quality: Monitoring & Assessment” in a training course on ‘Water Audit & Rain Water Harvesting’ is being organized at Dept. of Water Resources Development & Management, IIT Roorkee during 18-22 February, 2019.
- Invited talk titled “Water Quality Laboratory Testing”, Protocol for Water Quality Sampling, Monitoring and Analysis”, and “Significance and Accuracy Check of Water Quality Parameters” in International Training Course on ‘Hydrology, Water Resources Management and Climate Change’ (for Pacific Island Countries) organized by NIH Roorkee during June 25 – July 20, 2018.
- Invited talk titled “Appropriate Techniques and Natural Treatment System (NTS) for Domestic Wastewater” in training course on “Water Conservation: Practices, Security and Sustainability - A Practitioners Approach” organized by NIH Roorkee during Dec. 26-28, 2018.
- Invited talk titled “Treatment technologies for urban wastewater management and reuse in agriculture” in international training course on “Soil – Water Conservation and Watershed Management” organized by ICAR-Indian Institute of Soil & Water Conservation, Dehradun during March 06-20, 2018.
- Invited talk titled “Water quality testing methods” and “Treatment techniques for wastewater management and reuse in agriculture” for Ph.D. Course Work Program at Bundelkhand University, Jhansi during Dec. 10-11, 2018.

- Invited talk titled “Water quality monitoring planning” and “Water quality testing methods” in a certificate course on ‘Monitoring of Environmental Parameters and Their Interpretation’ is being organized at Centre of Land and Water Resource Management (CLWRM), GBPNIHESD, Almora during Feb. 26 – March 14, 2019.
- Invited talk titled “Water Quality: Monitoring & Assessment” in a training course on ‘Water Audit & Rain Water Harvesting’ is being organized at Dept. of Water Resources Development & Management, IIT Roorkee during 18-22 February, 2019.

- Invited talk titled ‘Groundwater contaminant remediation with emphasis on arsenic’ in 5-days training course on ‘Groundwater Quality Monitoring & Assessment’ organized by NIH Roorkee during June 03-07, 2019.
- Invited talk titled ‘Analysis of pollution indicator parameters’, ‘Treatment technologies for wastewater treatment’, and ‘Arsenic and fluoride removal from drinking water’ in 5-days training course on “Water Quality Assessment and Management” organized by NIH Roorkee during June 17-21, 2019.
- Invited talk titled ‘Groundwater pollution due to arsenic and fluoride’ in 5-days TEQIP course “Applied Groundwater Flow and Contaminant Transport Modeling” organized by IIT Roorkee during June 24-28, 2019.
- Invited talk titled ‘Needs and expectations from the administrative authorities’ and ‘Treatment techniques for domestic wastewater’ in 2-days workshop on “Inception cum Need Assessment” under DST sponsored IC-EcoWS project during Aug. 8-9, 2019.
- Invited talk titled ‘Wastewater recycling’ in 1-day workshop on “Zero Waste Society” for women under Swachh Bharat Mission on Oct. 01, 2019.
- Invited talk titled ‘Instruments for trace metal analysis’ in 2-days workshop on “Opportunities and Trends in Modern Instrumentation for Science and Technology” organized by Graphic Era University, Dehradun and Indian Institute of Petroleum, Dehradun during Nov. 07-08, 2019.
- Invited talk titled ‘Raw water characterization and treatment for domestic supply’, ‘An introduction to wastewater treatment technologies’, and “Interaction with participants on few case studies’ in 4-days PHED Jaipur sponsored training course “Hydrology for Water and Sanitation Programmes’ organized by NIH Roorkee during Feb. 11-14, 2020.
- Invited talk titled ‘Water quality monitoring planning’ in 5-days CPCB sponsored training program on “Water Quality Monitoring of Surface, Ground, Wastewater/Effluents, Data Interpretation and Quality Assurance” organized by CPPRI Saharanpur during Feb. 24-28, 2020.
- Invited talk titled ‘Sample preparation and preservation for water quality’ in 5-days training course on ‘Data Processing for Water Quality’ organized by NIH Roorkee during Oct. 05-09, 2020.
- Invited talk titled ‘Water quality monitoring and assessment’ and ‘Gas chromatography mass spectrometry: Working principle and applications, sample preparation’ in 2-week ‘Mandatory training program for SRAs (CWC)’ organized by NIH Roorkee & NWA Pune during Oct. 19-30, 2020.
- Invited talk titled ‘Sample preparation and preservation for water quality’ in 5-days training course on ‘Data Processing for Water Quality’ organized by NIH Roorkee during Nov. 02-06, 2020.
- Invited talk titled ‘Wastewater treatment and management for water security’ in 5-days training course on “Water Security for resilience to deal with Disasters and Outbreaks” organized by NIH Roorkee under the aegis of INC-IHP during Nov. 02-06, 2020.

- Invited talk titled ‘Environment Conservation’ in a special NSS camp organized ar Jivan Jyoti Inter College, Roorkee on March 20, 2021.
- Invited talk titled ‘Sanitation facilities – Latrines, sewers, and septic systems’ in a 3-days training course on ‘Water, Sanitation, and Hygiene’ organized by IIT Roorkee during Aug. 24-26, 2021.
- Invited talk titled ‘Sustainable wastewater solution for rural India’ in ‘Indo-US Bilateral Workshop on Water and Air Research Initiative for Societal Health (WaARISH 2021)’ organized by SRM Institute of Science & Technology, Kattankulathur during Aug. 24-25, 2021.
- Invited talk titled ‘Grey water management’ in a 2-days training program on ‘Service delivery/ functionality of FHTCs’ for level 1 officers organized by Centre for Good Governance, Dr. R. S. Tolia, Uttarakhand Academy of Administration, Nainital during Oct. 12-13, 2021.
- Invited talk titled ‘Water quality monitoring and assessment’ and ‘Gas Chromatography - Mass spectrometry (GS-MS): Working principles and analytical applications, sample preparation’ in a 4-days training program for the CWC officials organized by NIH Roorkee during Oct. 20-23, 2021.
- Invited talk titled ‘Recent advances in water quality analysis’ in a ‘Water Education Lecture Series’ organized by USERC, Dehradun on Nov. 25, 2021.
- Invited talk titled ‘Treatment technologies in water pollution remediation’ in a 5-days training course on ‘Water quality assessment and management’ organized by NIH Roorkee during Dec. 06-10, 2021.
- Invited talk titled ‘Constructed wetlands: Sustainable wastewater management option for rural and peri-urban India’ in a 2-days ‘4th Industrial Water Treatment & Management Summit’ organized by Matcorr during Dec. 16-17, 2021.
- Invited talk titled ‘***जल गुणवत्ता विश्लेषण तकनीक मे नवीनतम प्रगति***’ in ‘Sir C. V. Raman Lecture Series’ organized under the ‘***विज्ञान महोत्सव***’ celebration by Bundelkhand University, Jhansi and Vigyan Bharti, Jhansi during Feb. 01-28, 2022.
- Invited talk titled ‘Wastewater treatment and management for water security’ in a 3-days training course on ‘Floods and drought risk mitigation under climate change’ organized by NIH Roorkee and NIDM, New Delhi during Feb. 02-04, 2022.
- Invited talk titled ‘Recent advances in water quality analysis’ in a 1-week training course on ‘Management of Forest for Water Quality Improvement’ organized by FRI Dehradun during March 07-11, 2022.
- Invited talk titled ‘Constructed wetlands: A sustainable and environmental friendly solution for treatment of sewage’ in the 'Water Strategy Class (Natural Resources)' at the University of Nebraska-Lincoln, Lincoln, Nebraska, USA on 14.04.2022.
- Invited talk titled ‘Basic concept of integrated water resorces management & new technologies in rain water harvesting for water conservation and rainwater harvesting structures in school, anganwadi, and other public instituttions’ and ‘Groundwater rechnarge technology for water resource management in rural region of Uttarkhand’ in in the training programme on ‘Orientation of Jal Jeevan Mission: Har Ghar Jal’ for level II officers being organized at Dr. R S Tolia Uttarakhand Academy of Administration, Nainital during 16-18 June 2022.

International/National conferences/meetings organized

- Joint organizing secretary for brainstorming session on “Hydrological aspects of cloudburst & flash floods in Himalayas” at Library building, CWC, New Delhi on Jan. 10, 2014.
- Joint Organizing Secretary for organizing “Symposium on Hydrology” organized by IAH, NIH, & CWC during Dec. 22-23, 2015 at New Delhi.

Important awards/distinctions/recognitions

- Chaired a technical session in International E-conference on ‘Water Source Sustainability’ organized by IIT Roorkee during June 18-20, 2021.
- Member of ‘Public Drinking Water Services Sectional committee, SSD 14’ constituted by BIS, New Delhi (2020-22).
- Member of Technical Advisory Board of Vulture Innovations Pvt. Ltd., Gurugram.
- Member of committee for ‘Preparation of Crisis Management Plan to deal with Contamination of Water Bodies (CMP-WB), NIDM-CPCB’ constituted by NIDM, New Delhi.
- Member of committee for evaluation of District Level Inspire Award Exhibition and Project Competition conducted by State Council of Education Research and Training, GoUK for year 2018-19 & 2019-20.
- Expert member for the development of wastewater and water conservation facilities for Nagar Panchayat, Jhabreda.

- Chaired a technical session in IGWC-2019 conference.
- Co-chaired a technical session in RWC-2020 conference.
- Co-chaired a technical session in छठवी राष्ट्रीय जल संगोष्ठी – 2019.
- Member of committee for organization of Poster Session during IGWC-2017 conference.
- Joint Secretary of Indian Association of Hydrologists, Roorkee since 2013.
- Member of committee for "Examining and recommending the proposals received for one day awareness workshop/seminar and to undertake the studies" constituted by IIT Roorkee.
- Member of judging committee for Biology Graduate Student Association (BGSA) Symposium – 2017, University of Nebraska-Lincoln, Lincon, Nebraska, US.
- Member of judging committee for poster evaluation in Water for Food Global Conference-2017, Daugherty Water for Food Global Institute, University of Nebraska-Lincoln, Lincoln, Nebraska, US.
- Nominated member of core-committee on "Monitoring of Potential Hazards of Industrial Development in Singrauli Area" constituted by Hon'ble NGT.
- Received prestigious Water Advanced Research and Innovation (WARI) Fellowship program supported by DST-GOI, UNL, DWFI, & IUSSTF for 2016-17.
- Member of Sub-committee – 2 on "Potential impact of pollution on water Resources" constituted by Hon'ble NGT during 2014-16.
- Member of Committee for "Preparation of a ready reckoner for water quality laboratory" constituted by MoWR, RD & GR.
- External expert of assessment committee to assess the progress of JRF, for upgradation to SRF, constituted by IIT Roorkee.

Synergistic Activities

- ***Ph.D. research mentor:*** Mentored 01 Ph.D. student (Er. Jhalesh Kumar - Registered in Indira Gandhi Krishi Vishwavidyalaya, Raipur) and Mentoring 01 Ph.D. student (Er. Kaptan Singh - Registered at Madan Mohan Malaviya University of Technology, Gorakhpur).
- ***Post-Graduate research mentor:*** 24 PG students mentored since arriving at NIH Roorkee in 2011.
- ***Postdoctoral fellow research mentor:*** Mentoring 03 postdoctoral research fellows.
- ***Women Scientist mentor:*** Mentored 01 Women Scientist (DST WOS-A) during 2018 - 2021.
- ***Assistant Executive Engineer (Civil):*** Maintenance, National Institute of Hydrology, Roorkee (2020-Present)
- ***Joint Secretary:*** Indian Association of Hydrologists, Roorkee (2013 – Present)
- ***Officer In-charge:*** Workshop, National Institute of Hydrology, Roorkee (2017-2019)
- ***Officer In-charge:*** Water Quality Laboratory, National Institute of Hydrology, Roorkee (2014-2016)
- ***Reviewer for journals*** such as *Journal of Indian Water Resources Society, Journal of Hydrology, Water Environment Research, Journal of Environmental Management, Groundwater for Sustainable Development, Current World Environment, Quaternary International, Environmental Science and Pollution Research*, जल चेतना

Graduate Advisors and Postdoctoral Sponsors: Graduate advisor: Dr. Bhavna A. Shah (Veer Narmad South Gujarat University, Surat, India); Postdoctoral Advisor: Dr. Karrie A. Weber (University of Nebraska-Lincoln, Nebraska)

Endorsement Certificate from the Mentor & Host Institute

This is to certify that:

I. The applicant, Dr. Daya Shankar Singh will assume full responsibility for implementing the project.

II. The fellowship will start from the date on which the fellow joins University/Institute where he/she implements the fellowship. The mentor will send the joining report to the SERB. SERB will release the funds on receipt of the joining report.

III. The applicant, if selected as SERB-N PDF, will be governed by the rules and regulations of the University/ Institute and will be under administrative control of the University/ Institute for the duration of the Fellowship.

IV. The grant-in-aid by the Science & Engineering Research Board (SERB) will be used to meet the expenditure on the project and for the period for which the project has been sanctioned as indicated in the sanction letter/ order.

V. No administrative or other liability will be attached to the Science & Engineering Research Board (SERB) at the end of the Fellowship.

VI. The University/ Institute will provide basic infrastructure and other required facilities to the fellow for undertaking the research objectives.

VII. The University/ Institute will take into its books all assets received under this sanction and its disposal would be at the discretion of Science & Engineering Research Board (SERB).

VIII. University/ Institute assume to undertake the financial and other management responsibilities of the project.

IX. The University/ Institute shall settle the financial accounts to the SERB as per the prescribed guidelines within three months from the date of termination of the Fellowship.

Dated: 07.08.23

Signature of the Mentor:

Name & Designation: Dr. RAJESH SINGH, SCIENTIST 'D', EHD

Dated:

Signature of the Registrar of University/Head of Institute

Seal of the Institution

डॉ. सुधीर कुमार/Dr. Sudhir Kumar
निदेशक/Director
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee-247 667

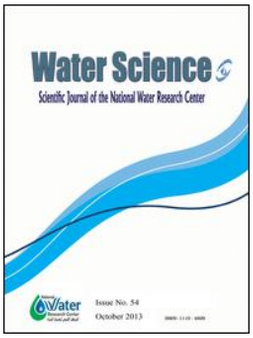
Undertaking by the Fellow

I, Dr. Dayashankar Singh, Son/Daughter/Wife of Shri. Uday Bhanu Singh, resident of Department of Geology, LKO 226007 have been awarded SERB N-PDF . I accept the award and undertake that:

1. I shall abide by the rules and regulations of SERB during the entire tenure of the fellowship.
2. I shall also abide by the rules, discipline of the institution where I will be implementing my fellowship
3. I shall devote full time to research work during the tenure of the fellowship
4. I shall prepare the progress report at the end of each year and communicate the same to SERB through the mentor
5. I shall send two copies of the consolidated progress report at the end of the fellowship period.
6. I further state that I shall have no claim whatsoever for regular/permanent absorption on expiry of the fellowship.

Date: 8 Aug 2023

Signature



Water Science

ISSN: (Print) 1110-4929 (Online) Journal homepage: https://www.tandfonline.com/loi/twas20

Determination of silt thickness in Durga Kund for its de-isolation at Varanasi U.P. India

Daya Shankar Singh, Rakesh Singh & Ajai Mishra

To cite this article: Daya Shankar Singh, Rakesh Singh & Ajai Mishra (2020) Determination of silt thickness in Durga Kund for its de-isolation at Varanasi U.P. India, Water Science, 34:1, 13-17, DOI: 10.1080/11104929.2019.1709293

To link to this article: https://doi.org/10.1080/11104929.2019.1709293

© 2020 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.

Published online: 17 Jan 2020.

Submit your article to this journal

Article views: 169

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=twas20

WATER SCIENCE
2020, VOL. 34, NO. 1, 13–17
https://doi.org/10.1080/11104929.2019.1709293

OPEN ACCESS Check for updates

Determination of silt thickness in Durga Kund for its de-isolation at Varanasi U.P. India

Daya Shankar Singh [a], Rakesh Singh [b] and Ajai Mishra [a]

[a]Department of Geology, University of Lucknow, Lucknow, India; [b]Central Ground Water Board, Bhopal, India

ABSTRACT
In this study, we are focused on the re-connection of Kund to the water table. Kunds are the best ancient architectural construction that was connected to the underground water table and works upon the principle of the Capillary action. But due to the dumping of the sacristy in the Kund, they have been disconnected from the subsurface water source/water table. For the rejuvenation of the Kunds, it should be cleaned through which they could again connect to the water table. For the re-connection of Durga Kund to the water table, first, we have to calculate the silt thickness and cleaned it. So, in this process for the delineation of silt thickness, there are two methods, which have used. The first is based upon the hydrogeological conceptual method and the second is based upon the geophysical method. After applying both the methods, the results were almost same, the estimated thickness of silt was about 3.5 to 4 meters. Now, this result has been established that both the conceptual and practical results are same. It means in this technical time, the Conceptual results are as much reliable as instrumental results.

KEYWORDS
Traditional values; survival; contamination; capillary; underground water

Introduction

There are a lot of Kunds in India. Durga Kund is one of them. It is situated in the southern portion of the Varanasi District. It is situated adjacent to the Durga Temple. Durga Mandir was built in the 18th century by the queen of Bengal. This temple is dedicated to the Goddess Durga. This Kund is most important for their religious, traditional, and scientific values.

In ancient times, they were the main source of water for the survival of human civilization except to the bank of rivers (Gajic, Dugalic, & Diurovic, 2006). Generally, they are used for drinking purposes and cultural activities. But nowadays, due to the pollution and open structure design of Kund, they are not used for drinking purposes however they are used for the cultural and traditional activities which allow people to pour their incense waste. With the beautiful example of freshwater sources, these kunds are the heritage of our society and future. So, we have to preserve it for our future generation.

This present study is totally based upon the concept of capillary action and it works upon the principle of attraction forces between soil and water molecules (DeBano, 2000; Doerr, Shakesby, & Walsh, 2000). Finally, this attraction decides the amount of retention curve for soil-water (Comegna, Sommella, & Geoderma, 1998; Strand & Wang, 2003) and the height of the water level in that capillary tube. This height also depends upon the sediment size/grain size (Cisar, Williams, Vivas, & Haydu, 2000; Kostka, 2000) while, Gillham (1984) has estimated the height of the capillary fringe to range from 0.01 m for medium sand to greater than 10 m for clay. In Durga Kund area, it has a homogeneous alluvial sedimentary basement. So the water level will be the same in all the surrounding area but the pressure head will differ with respect to the aperture/opening of the structure and the grain size (Abu-Zreig, Rudra, & Dickinson, 2003; Mingorance, Fernández-Gálvez, Peña, & Barahona, 2007; Wiel-Shafran, Ronen, Weisbrod, Adar, & Gross, 2006).

However, for the first time, we have tried to compare the results of conceptual and instrumental methods and the results were almost same.

Study area

Adjacent to the Durga temple, there was a Kund, which is known as Durga Kund. It was believed that this Kund was earlier connected to the Ganga River. Durga Kund is located in the Kashi Vidhyapeeth Block of Varanasi district, Uttar Pradesh. It is located near the Ganga River with the 25° 29” N latitude and 82° 97” E longitudes. The elevation of this place from the Mean Sea Level (MNS) is about 80.8 meters. On the way forward from Assi Chauraha to Ravindrapuri, Durga Kund is situated adjacent to Durga Mata Temple as shown in Figure 1. The name of ‘Durga Kund’ comes in important from Kund.

CONTACT Daya Shankar Singh daya.singhudai@gmail.com Department of Geology, University of Lucknow, UP, India
Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/twas.

© 2020 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.
This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

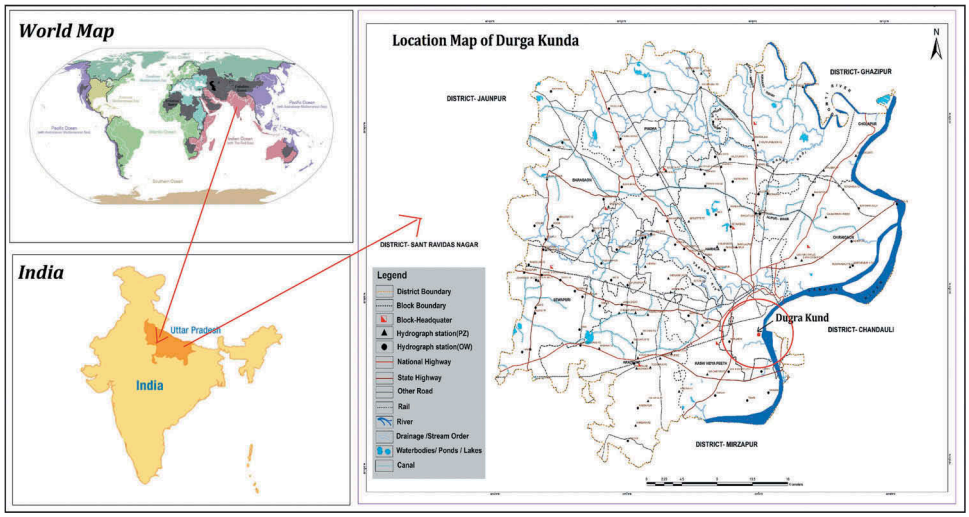


Figure 1. Location map of Durga Kund.

Durga Kund is the safest and the most existent kund among other kunds till now.

Methodology

There were two methods that were executed for this problem. One is based on the hydrogeological conceptual method and the other is based on the Geophysical method. Both methods were applied in September 2017.

Table 1. Lithological succession of Durga Kund Dug well.

S. No.	Location	Depth From	Depth Up to	Lithology
1-	Durga Kund	80.8m (surface level)	52.8m	Fine sand and silt
		52.8	19.8	Course sand
		19.8	13.8	Clay
		13.8	−102.2	Course sand

Hydrogeological method

For the hydrological method, we have to take a nearby dug well of Durga Kund for the comparative study of the water table. The lithological order (shown in Table 1) of the stratum has been taken from the borewell which is constructed by UP Jal Nigam, nearby Kund. Figure 2 shows that the thickness of the uppermost succession is 28 meters, which is formed by fine sand and silt and this type of sediments support to the best aquifer type. This type of aquifers also supports capillary action, so when the precipitation or evaporation takes place then the response of the water table can be easily seen (Commander & Hauck, 2000; Gerla, 2002; Singh & Mondal, 2004).

According to Bernoulli's equation,

$$\mathbf{P} + \frac{1}{2} \times \boldsymbol{\rho} \times \mathbf{v}^2 + \boldsymbol{\rho} \times \mathbf{g} \times \mathbf{h} = \mathbf{Constant} \quad (1)$$

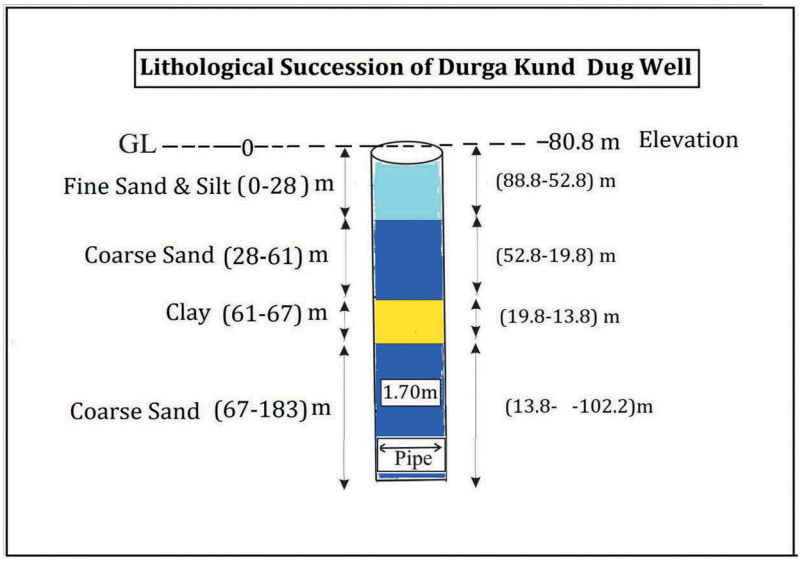


Figure 2. Lithological succession of Durga Kund dug well.

So,

$$\mathbf{P} + \frac{1}{2} \times \frac{\mathbf{m}}{\mathbf{V}} \times \mathbf{v}^2 + \frac{\mathbf{m}}{\mathbf{V}} \times \mathbf{g} \times \mathbf{h} = \mathbf{Constant}$$

Then,

$$\mathbf{P} + \frac{1}{2} \times \frac{\mathbf{m}}{(\pi \times \mathbf{r}^2 - \mathbf{l})} \times \mathbf{v}^2 + \frac{\mathbf{m}}{(\pi \times \mathbf{r}^2 - \mathbf{l})} \times \mathbf{g} \times \mathbf{h} = \mathbf{Constant} \quad (2)$$

where,

P =pressure
v =speed
V = Volume
h =height of the fluid (WATER)
ρ = density of water
g = gravitational acceleration
l =length of that area
r =Radius of a cylindrical area
So, from Equations (1) and (2),

$$\textbf{Radius of a cylindrical area or well } (\mathbf{r}) \ \alpha \ \frac{1}{\mathbf{h}} \quad (3)$$

From Equation (3), radius of the cylindrical area or opening of a tube is indirectly proportional to the height of the fluid or water. Now, the radius of the well is small in comparison to the kund, then according to Equation (3); the height of water should be shallow in the well (Bredehoeft, 1967). The water level of the Kund is shallow (Mould, Frahm, Salzmann, Miegel, & Acreman, 2010). Due to garbage deposition in the Kund, its water is not properly connected to the water table (about 6 meters near Durga Kund Area by Ground Water Department and UP Jal Nigam) so the percolation could not take place (Fernandez Galvez & Mingorance, 2010). Now, Figure 3 is showing that the water level of the Kund from the ground level is 1.51 meters while the thickness of the water column is 6 meters up to the silt in the bottom. Adjacent to the Kund, there is a dug well, in which the water level is 5.59 meters below to the ground level having a water column thickness of 8.26. According to Capillary Height Formula/Jurin's law (Kholodov et al., 2015)

$$\mathbf{H} = \frac{(2 \times \boldsymbol{\gamma} \times \cos\boldsymbol{\theta})}{(\boldsymbol{\rho} \times \mathbf{g} \times \mathbf{r})} \quad (4)$$

where,

H= the height of water in the column,
γ= the water–air surface tension = 0.07199 N m^{-1}
ρ= the density of water = 996.2 Kg/m^3
r= the radius of Dug Well = 1.70/2 m, Durga Kund = 5/2 m
g= the acceleration due to gravity = 9.8 m/s
θ= the angle of contact for water and sandy soil = 64°

Geophysical method

In the geophysical method, the Echo Sounding method was applied. SyQuest Digital Hydro-box Echo Sounder was used for sounding operations at very low and high frequency. The principal sounding lines, using single beam Echo Sounders were run at a spacing of 8 meters. The lines were planned North-South of the Kund. Single Beam at low and High-Frequency Sounding. SyQuest Hydro-box echo sounder operated at 33 kHz and at 210 kHz was used for sounding by the Survey Boat. The speed of advance for sounding operations was restricted up to 1 knot. The data was logged directly into the HYPACK software (Ver.2009) and the digital data display of the Echo Sounder was closely monitored.

(Gribovszki, Kalicz, Szilagyi, & Kucsara, 2008; Gribovszki, Szilagyi, & Kalicz, 2010)

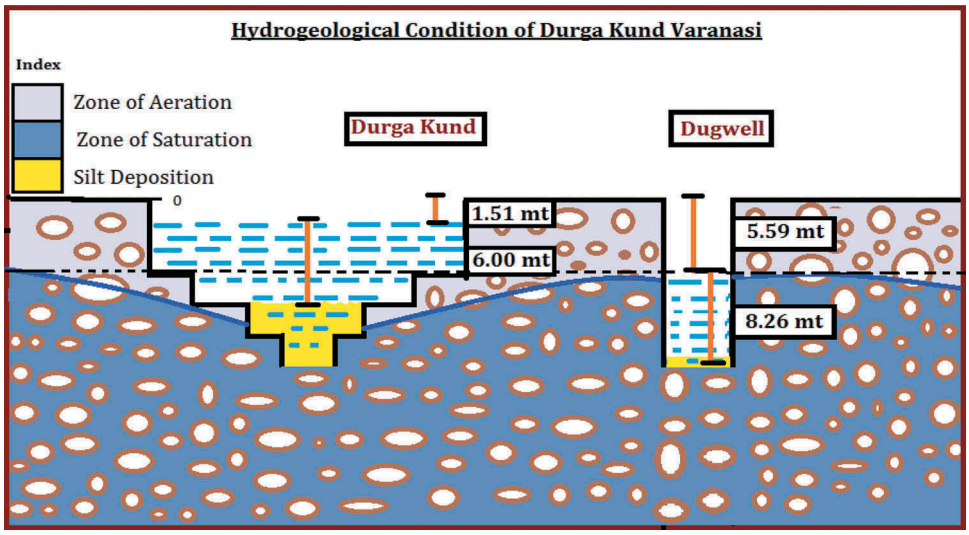


Figure 3. Hydro-geological condition of Durga Kund Varanasi.

Table 2. Results on different depth levels.

S. No.	Water level (meter)	Volume of water (cubic meter)	Dredging/silt volume (cubic meter)
1.	0.00 (Water Level)	26,509.8	0.0
2.	1	20,793.9	0.0
3.	2	15,171.9	93.8
4.	3	10,012.4	650.3
5.	4	5364.9	1718.7
6.	5	1342.6	3412.2
7.	6	0.0	7785.5
8.	7	0.0	13,501.4
9.	8	0.0	19,217.3
10.	9	0.0	24,933.2

Result and discussion

In the hydrogeological method, the result is totally dependent upon the concept of Capillary action (Gribovszki et al., 2008, 2010). If a well is dug initially, then the water level will be decided by the capillary height. If the water level is more than the capillary height, it will be just because of garbage/silt thickness. Let us assume that there is a glass filled with water to a certain height, and if a pebble is put into the glass, then the water level in the glass will increase. This increase in the glass will be equal to the volume of the pebble. In the same way, garbage is acting just like a pebble.

In the case study, the physically measured height includes the actual capillary height and height just because of garbage/silt thickness.

So, in the case of Dug well,

Physically measured water height = 8.26 meters

Calculated water height = 7.60 meters

So, the thickness of garbage/Silt deposits for Well

= physically measured Height – Calculated Height {**From Equation (4)**}

= (8.26–7.60) meter

= **0.66 meters.**

For Durga Kund,

Physically measured water height = 6 meters

Calculated water height = 3.5 meters

The thickness of garbage/Silt deposits for Durga Kund

= physically measured Height – Calculated Height {**From Equation (4)**}

= (6–2.58) meter

= **3.42 meters.**

So, in Durga Kund, silt thickness is about 3.5.

At both the places, the difference between the calculated and physically measured height will be equal to the thickness of garbage/Silt deposits. At the dug well, the thickness of garbage is about to match with physically measured garbage thickness which was about to 0.5 meters. In the same way, the garbage thickness is about 3.5 meters in Durga Kund.

In the geophysical method, the Dredging quantity was calculated on the basis of sounding data. It was calculated by HYPACK software for the desired survey area and a report with respect to different depth levels was obtained. The results are summarized in Table 2.

As shown in Table 2, after the depth of 1 meter, we started detecting silt and at 5-meter depth, we did not detect the water. According to Figure 4, the volume of water and silt volume curves are intersecting each other between 3.5 and 4 meters of the water level. Now it should be the final depth up to where silt and water mixture is reported and after this depth, only silt is reported. Then, this is about 3.5 to 4 meters of the zone where the silt with water is reported which is garbage or silt.

Conclusion

Aquifers are the natural tankers for the holding of freshwater which are formed by the natural eroded and transported sediments. With the help of pore spaces, they are capable to hold and percolate the water. When the precipitation takes place, these pore spaces filled with water and start percolating; it reverses during extraction. These processes are responsible for the fluctuation in the water level. But, due to any reasons when these pore spaces chock or

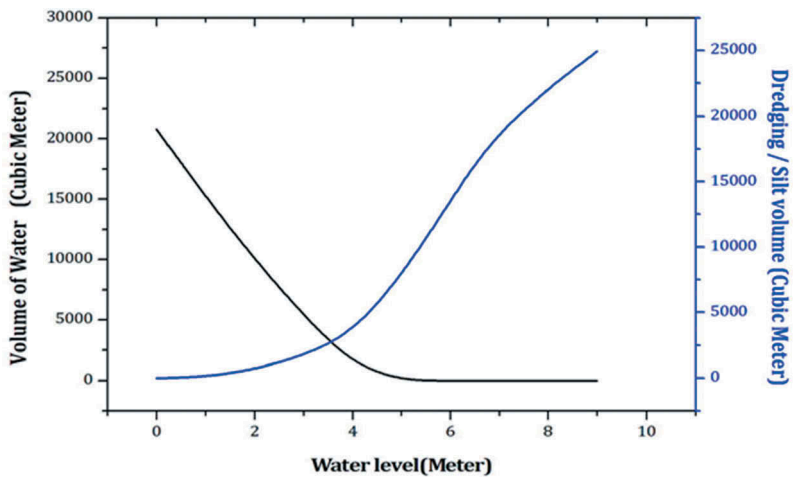


Figure 4. Graph between the volume of water and of silt volume.

block then they disconnected for the response. The same problem was reported from Durga Kund by pouring the sacristy in the Kund.

So, for the delineation of silt thickness both the methods were applied and the results are the same. The silt or garbage thickness is about 3.5 to 4 meters thick. In this technical time, we can still believe in the hydrogeological concepts.

If we remove this garbage, then Durga Kund will be connected to the natural water level and attain the natural water level head.

Disclosure Statement

No potential conflict of interest was reported by the authors.

ORCID

Daya Shankar Singh http://orcid.org/0000-0002-3062-8662
Rakesh Singh http://orcid.org/0000-0002-1268-1697
Ajai Mishra http://orcid.org/0000-0001-5282-8879

References

Abu-Zreig, M., Rudra, R. P., & Dickinson, W. T. (2003). Effect of application of surfactants on hydraulic properties of soils. *Biosystems Engineering*, *84*, 363–372.

Bredehoeft, J. D. (1967). Response of well-aquifer systems to earth tides. *Journal of Geophysical Research*, *72*, 3075–3087.

Cisar, J. L., Williams, K. E., Vivas, H. E., & Haydu, J. J. (2000). The occurrence and alleviation by surfactants of soil–Water repellency on sand-based turfgrass systems. *Journal of Hydrology*, *231–232*, 352–358.

Comegna, V., Sommella, P., & Geoderma, A. (1998). Use of a fractal model for determining soil water retention curves. *Geoderma*, *85*, 307–323.

Commander, P., & Hauck, E. (Ed.). (2000). How our ground water has changed. In a series outlining observed climate changes or variations over recent decades in south-west Western Australia. *Climate Note*, *8*, 1–2.

DeBano, L. F. (2000). Water repellency in soils: A historical overview. *Journal of Hydrology*, *231–232*, 4–32.

Doerr, S. H., Shakesby, R. A., & Walsh, R. P. D. (2000). Soil water repellency: Its causes, characteristics and hydro-geomorphological significance. *Earth-Science Reviews*, *51*, 33–65.

Fernandez Galvez, J., & Mingorance, M. D. (2010). Vapor and liquid hydrophobic characteristics induced by presence of surfactants in an agricultural soil. *Geoderma*, *154*, 321–327.

Gajic, B., Dugalic, G., & Diurovic, N. (2006). Comparison of soil organic matter content, aggregate composition and water stability of Gleyic Luvisol from adjacent forest and cultivated areas. *Agronomy Research*, *2*(4), 499–508.

Gerla, P. J. (2002). The relationship of water table changes to the capillary fringe evapotranspiration and precipitation in intermittent wetlands. *Wetlands*, *12*, 91–98.

Gillham, R. W. (1984). The capillary fringe and its effect on water table response. *Journal of Hydrology*, *67*, 307–324.

Gribovszki, Z., Kalicz, P., Szilagyi, J., & Kucsara, M. (2008). Riparian zone evapotranspiration estimation from diurnal groundwater level fluctuations. *Journal of Hydrology*, *349*, 6–17.

Gribovszki, Z., Szilagyi, J., & Kalicz, P. (2010). Diurnal fluctuations in shallow groundwater levels and stream flow rates and their interpretation-A review. *Journal of Hydrology*, *385*, 371–383.

Kholodov, V. A., Yaroslavtseva, N. V., Yashin, M. A., Frid, A. S., Lazarev, V. I., Tyugai, Z. N., & Milanovskiy, E. Y. (2015). Contact angles of wetting and water stability of soil structure. *Eurasian Soil Science*, *48*, 600–607.

Kostka, S. J. (2000). Amelioration of water repellency in highly managed soils and the enhancement of turfgrass performance through the systematic application of surfactants. *Journal of Hydrology*, *231–232*, 359–368.

Mingorance, M. D., Fernández-Gálvez, J., Peña, A., & Barahona, E. (2007). Laboratory methodology to approach soil water transport in the presence of surfactants. *Colloids and Surfaces A*, *306*, 75–82.

Mould, D. J., Frahm, E., Salzmann, T., Miegel, K., & Acreman, M. C. (2010). Evaluating the use of diurnal groundwater fluctuations for estimating evapotranspiration in wetland environments: Case studies in southeast England and northeast Germany. *Ecohydrology*, *3*, 294–305.

Mondal, N. C., & Singh, S. K. (2004). Analysis of unconfined aquifer response to delineate potential groundwater recharge zone in hard rock terrain, groundwater group, National Geophysical Research Institute, Hyderabad, Andhra Pradesh, India. *Earth Proceeding Model*, 1, 1–5.

Strand, T. E., & Wang, H. F. (2003). *Soil-moisture retention curves, capillary pressure curves, and mercury porosimetry: A theoretical and computational investigation of the determination of the geometric properties of the pore space*. American Geophysical Union, Fall Meeting 2003, Nice, France.

Wiel-Shafran, A., Ronen, Z., Weisbrod, N., Adar, E., & Gross, A. (2006). Potential changes in soil properties following irrigation with surfactant-rich greywater. *Ecological Engineering*, *26*, 348–354.