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DETERMINATION OF GROUND WATER QUALITY INDEX AND MAPPING USING GIS TECHNIQUES FOR SOUTH GUWAHATI, KAMRUP METROPOLITAN, ASSAM

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Abstract:

Groundwater is a primary source of drinking and domestic water in South Guwahati due to rapid urban expansion, increasing population density, and inadequate municipal water supply. This paper assesses the groundwater quality in South Guwahati using samples from ten representative locations. The Weighted Arithmetic Water Quality Index approach was used to compute the Water Quality Index (WQI) providing a clear understanding of the water quality status and its suitability for drinking purposes. Spatial distribution maps for each parameter and the overall WQI map were generated using GIS-based Inverse Distance Weighting (IDW) interpolation, enabling visualization of spatial variability and identification of potential contamination hotspots. The results reveal that although most parameters fall within permissible limits, elevated concentrations of iron, hardness, fluoride, turbidity, and TDS are observed in several locations, particularly Lalmati, Hatigaon, Basistha Chariali, and Tetelia. WQI classifications range from excellent to poor, highlighting clear spatial variation in groundwater quality. The findings bring out the need for continuous monitoring, improved local water treatment practices, and sustainable groundwater management strategies to ensure safe and reliable access to groundwater in South Guwahati.

Keywords — **Groundwater quality, South Guwahati, Water Quality Index, Spatial Distribution map, IDW interpolation, GIS**

I. INTRODUCTION

Groundwater in Guwahati, especially South Guwahati, is a vital water source due to limited municipal supply. Rapid urbanization, population growth affects its quality, with contaminants like iron, fluoride and arsenic. Regular monitoring of physical and chemical parameters is essential for safe domestic use and informed mitigation strategies. Islam et al. (2014), Singh et al. (2017), Sarmah & Sarma (2024), and Hinge et al. (2022) assessed groundwater quality in Guwahati, revealing spatial variations and elevated iron, fluoride, and hardness levels. Studies emphasize health risks, the need for regular monitoring, GIS-based mapping, and practical treatment strategies to ensure safe drinking water. The Water Quality Index (WQI) is a comprehensive and effective tool used to evaluate the combined influence of multiple chemical parameters on the suitability of groundwater for various uses. It simplifies complex and extensive groundwater quality data into a single, easily interpretable numerical value.

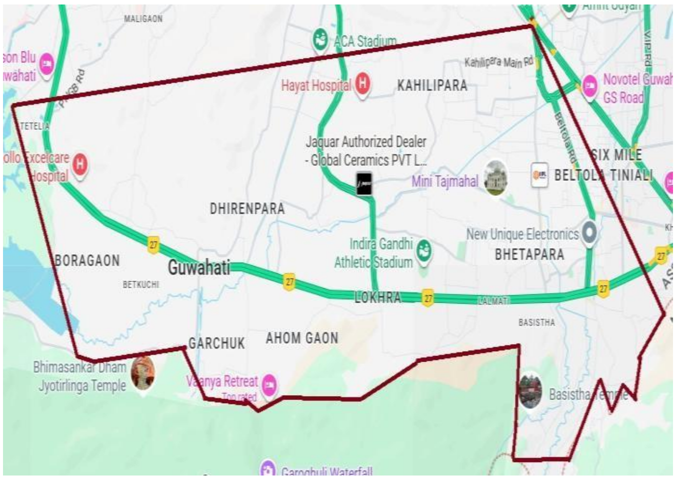

Fig 1. South Guwahati Region
(Source:Islam, Farheena & Choudhury, Navanita& Saikia, Jyotisman& Dey, Yudhajit. (2014). Quality Analysis of Ground Water In Greater Guwahati. 40-44. Adapted from Google Maps.)

II. STUDY AREA

Sampling locations were strategically selected in South Guwahati considering rapid infrastructure expansion and areas of high population density. Ten representative locations were selected for groundwater sampling.

Table 1: Sampling Sites and Corresponding Locations

Site	Name of the location
1	Tetelia
2	Kahilipara
3	Lalmati
4	Lokhra
5	Ahom Gaon
6	Hatigaon
7	Basistha Ch.
8	Dhirenpara
9	Bhetapara
10	Lalganesh

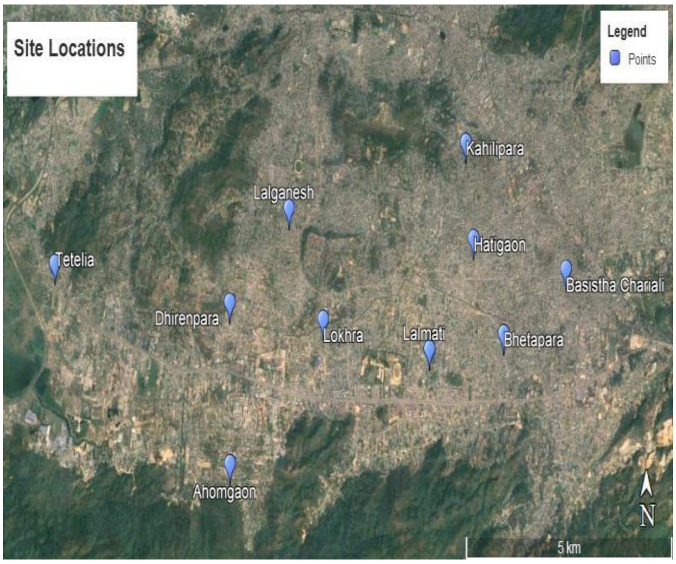

Fig 2. Sampling sites shown in Google Earth Pro

III. METHODOLOGY

The methodology involves a systematic approach to assess and map water quality. Water samples from the ten sampling locations are collected for laboratory analysis. The laboratory results are used to compute the Water Quality Index (WQI) for each sampling point using the Weighted Arithmetic Water Quality Index (WAWQI) method which involves three major stages (Konkey et al., 2014).

A. Stage 1-

In this stage, each of the twelve selected water quality parameters is assigned an individual weight (w_i) according to its relative significance in determining drinking water quality. The weights range from 1 to 5, representing the degree of impact of each parameter on overall human health. Arsenic (As) is assigned the highest weight of 5 due to its serious health and environmental risks, whereas Calcium and Magnesium are given the lowest weight of 1 because of their comparatively lesser influence. The weights assigned to the remaining parameters are summarized in the corresponding table.

Table 2: Assigned Weights and Health Impact of different water quality parameters

Parameter	Health Impact Classification	Assigned Weight (W_i)
Total Arsenic	Primary Toxic Hazard / Carcinogen	5
Nitrate	Critical Acute Health Risk (Infants)	5
Fluoride	Serious Long-Term Health Risk	4
pH	Indirect Health Risk / Primary Standard	4
Turbidity	Critical Indirect Health Risk	3
Total Iron	Aesthetic / Secondary Health Risk	3
Sulphate	Secondary Health Risk / Aesthetic	2
Chloride	Aesthetic / Corrosive	2
TDS	Aesthetic / Indicator	1
Total Hardness	Aesthetic / No Health Risk	1
Alkalinity	No Health Risk / Operational	1
Calcium, Magnesium	No Health Risk / Beneficial	1

B. Stage 2-

In this stage, the relative weight (W_r)of each water quality parameter is calculated as follows:

$$W_r = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (1)$$

where w_i is the assigned weight of the i^{th} parameter and n represents the total number of parameters.

C. Stage 3-

This stage involves assigning the quality rating (Q_i) for each parameter as follows:

$$Qi = \frac{C_i}{S_i} \times 100 \quad (2)$$

where C_i is the measured concentration of the i^{th} parameter in and S_i denotes the corresponding Indian drinking water standard.

The sub-index (SI_i) for each parameter is then calculated by multiplying its relative weight with the quality rating:

$$SI_i = W_r \times Qi \quad (3)$$

Finally, the overall Water Quality Index (WQI) is obtained by summing the sub-indices of all considered parameters, as expressed in Equation

$$\mathbf{WQI = \Sigma SI_i \ (i = 1 \ to \ n)} \quad (4)$$

Based on the computed Water Quality Index (WQI) values, the groundwater quality is classified into different water quality status categories. Accordingly, groundwater is categorized as excellent, good, poor, very poor, or unsuitable for drinking. The corresponding WQI ranges for each water quality status and their possible usages are presented in a tabulated form.

Table 3: Water Quality Status and Possible Usages
(Source: Kumbhar, Shridhar & Jamale, Prajkta)

WQI Range	Status	Possible Usages
< 50	Excellent	Drinking, Irrigation & Industrial
50–100	Good Water	Domestic, Irrigation & Industrial
100–200	Poor Water	Irrigation & Industrial
200–300	Very Poor Water	Restricted use for Irrigation
> 300	Unfit for Drinking	Proper treatment required before use

The laboratory results along with WQI values are used to prepare spatial map distribution. For this, a base map of Guwahati is obtained in the form of a shapefile, from which the South Guwahati area is extracted using clipping techniques in ArcGIS. The sampling locations are geo-referenced on the map, and spatial interpolation is carried out using the Inverse Distance Weighting (IDW) tool in ArcGIS to analyse the spatial distribution of water quality.
Areas that are within the permissible limit have been shown in different shades of green and the areas where the parameter crossed the permissible limit have been displayed in yellow, orange, and red, with red showing the highest level of contamination. This colour scheme helps quickly identify both safe areas and locations that need more attention.

IV. RESULTS

Based on the equations, Water Quality Index (WQI) values and their respective Water Quality Status (WQS) across ten sites are summarized into the following table.

Table 4: WQI values for all sampling sites

Site	Location	WQI	WQS
1	Tetelia	51.75	Good Water Quality
2	Kahilipara	46.92	Excellent Water Quality
3	Lalmati	153.54	Poor Water Quality
4	Lokhra	67.66	Good Water Quality
5	Ahomgaon	22.88	Excellent Water Quality
6	Hatigaon	119.06	Poor Water Quality
7	Basistha Ch.	129.22	Poor Water Quality
8	Dhirenpara	59.91	Good Water Quality
9	Bhetapara	64.40	Good Water Quality
10	Lalganesh	43.44	Excellent Water Quality

The results indicate that groundwater quality in South Guwahati varies significantly. Excellent water quality is observed at Ahomgaon, Kahilipara, and Lalganesh, indicating minimal contamination. Moderate WQI values at Tetelia, Lokhra, Dhirenpara, and Bhetapara suggest good water quality suitable for drinking with minor treatment. High WQI values at Lalmati, Hatigaon, and Basistha Chariali indicate poor water quality, making the water unsuitable for direct consumption without treatment.
The WQI spatial distribution map illustrates groundwater quality variations, where red indicates poor water quality, yellow represents good water quality, and green denotes excellent water quality.

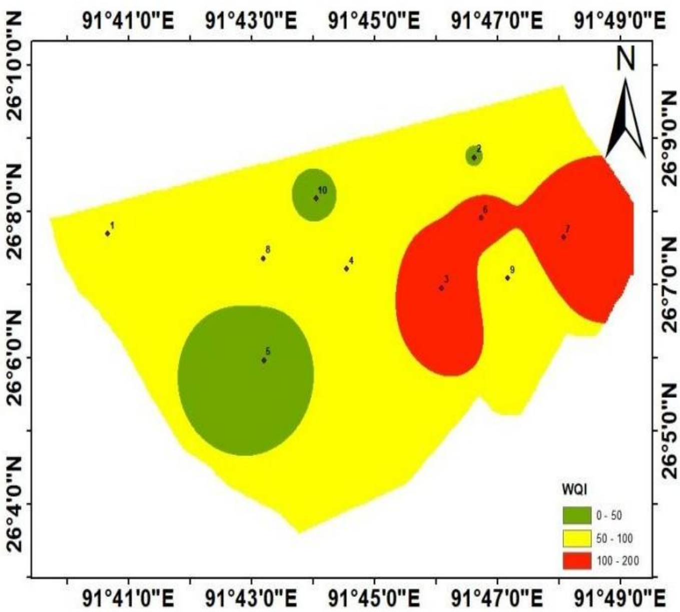

Fig 3. WQI Spatial Distribution Map

Although most parameters fall within permissible limits, elevated concentrations of iron, turbidity, TDS, hardness, calcium, and magnesium significantly contributed to higher WQI values at several locations particularly Lalmati, Hatigaon, Basistha Chariali, and Tetelia. Furthermore, the presence of fluoride in Hatigaon and trace amounts of arsenic at Lokhra and Dhirenpara highlights the need for regular monitoring.

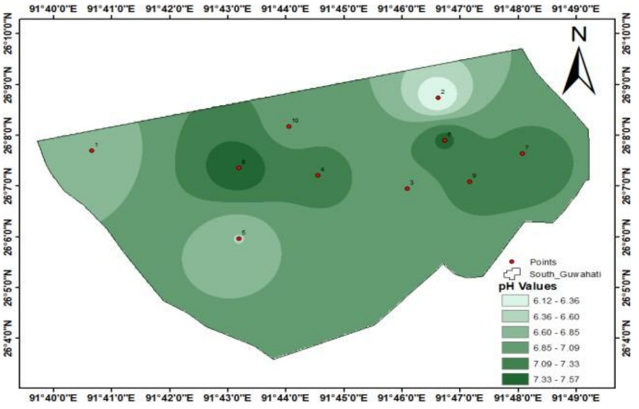

Fig 4. pH Spatial Distribution Map

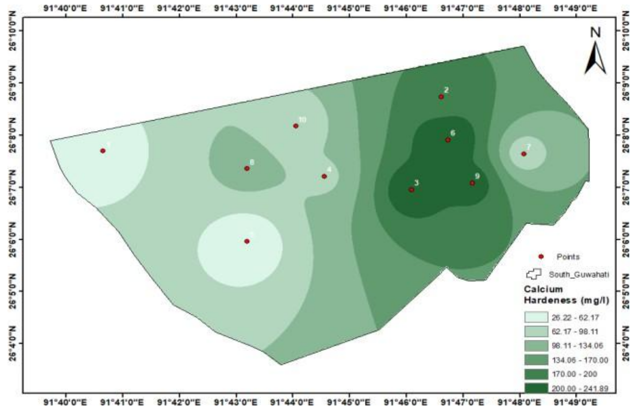

Fig 8. Calcium Hardness Spatial Distribution Map

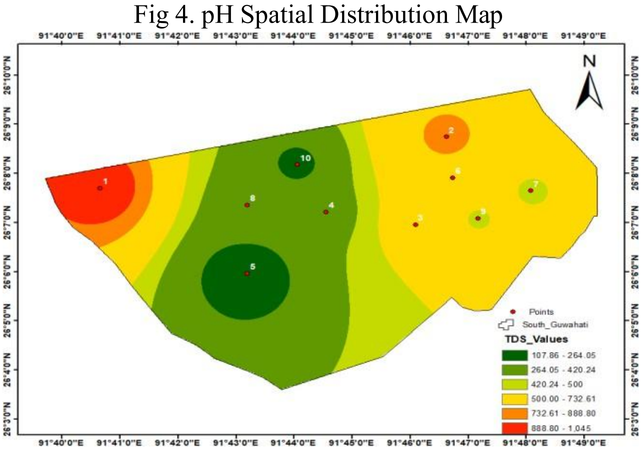

Fig 5. TDS Spatial Distribution Map

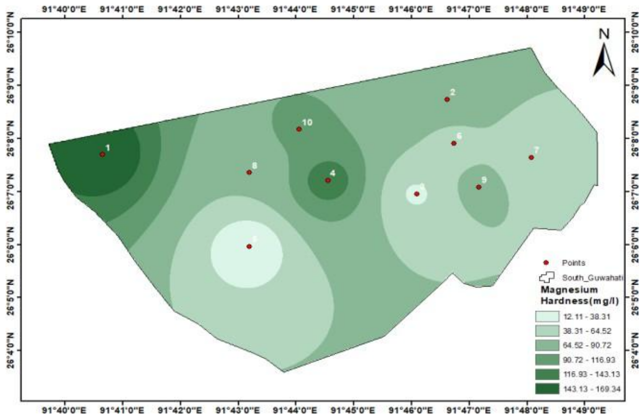

Fig 9. Magnesium Hardness Spatial Distribution Map

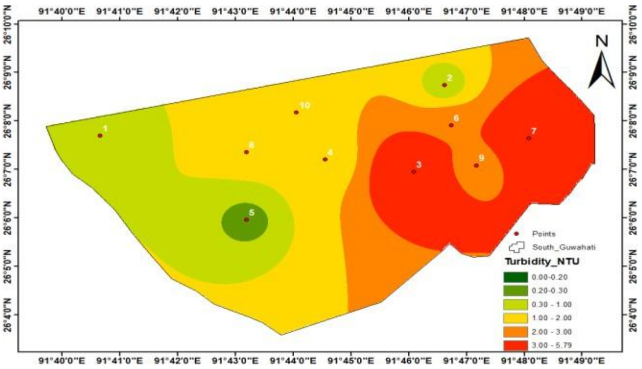

Fig 6. Turbidity Spatial Distribution Map

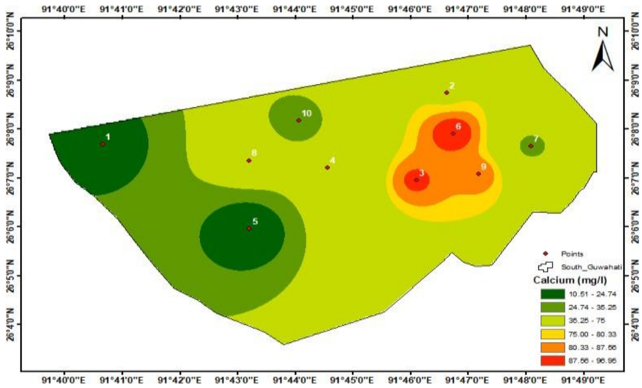

Fig 10. Calcium Spatial Distribution Map

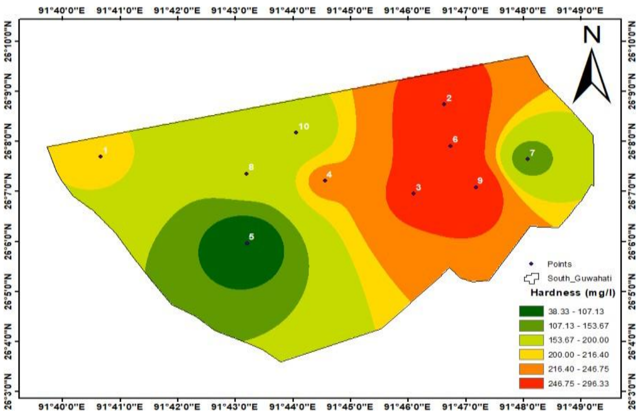

Fig 7. Hardness Spatial Distribution Map

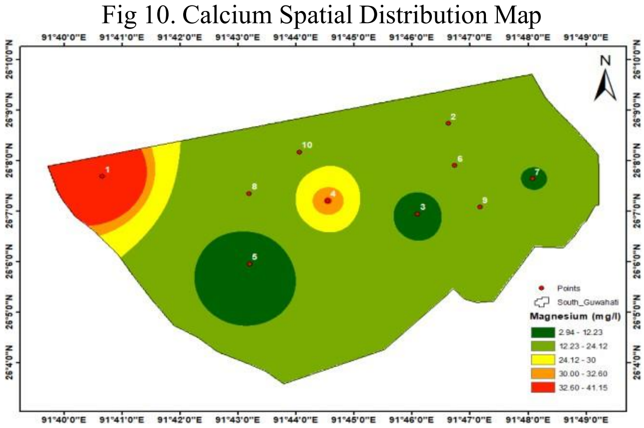

Fig 11. Magnesium Spatial Distribution Map

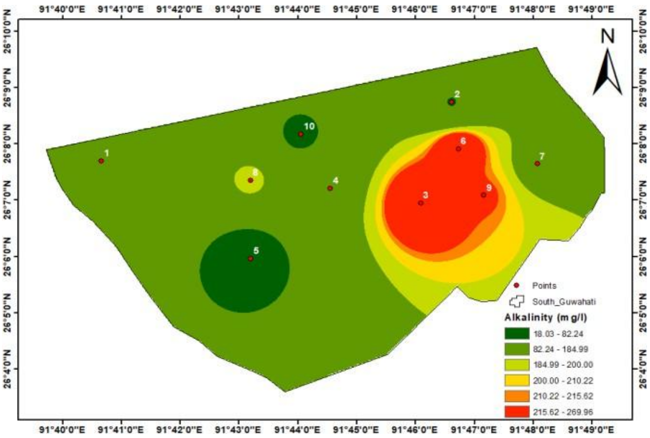

Fig 12. Alkalinity Spatial Distribution Map

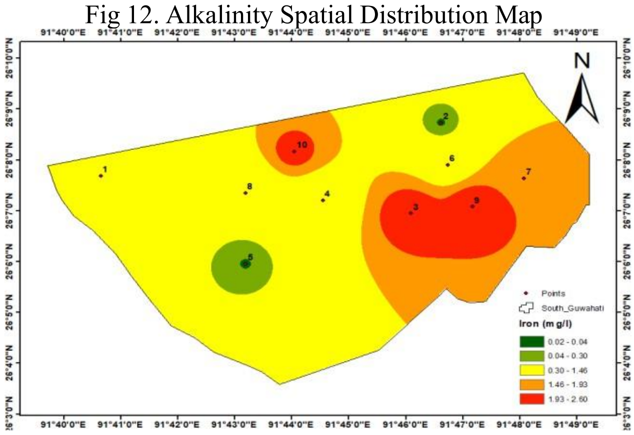

Fig 13. Iron Spatial Distribution Map

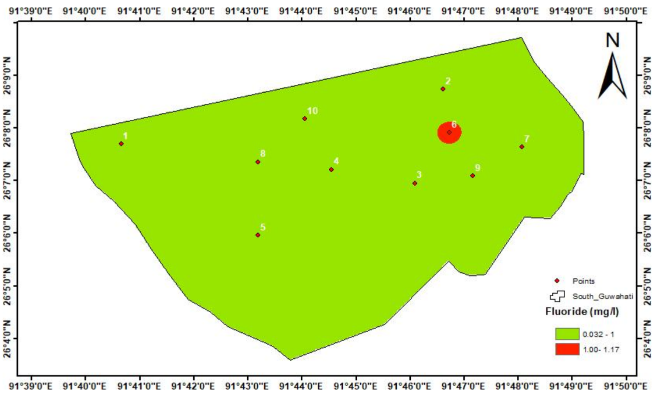

Fig 14. Fluoride Spatial Distribution Map

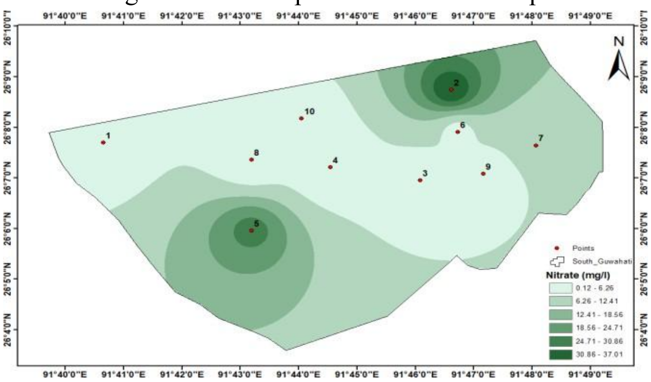

Fig 15. Nitrate Spatial Distribution Map

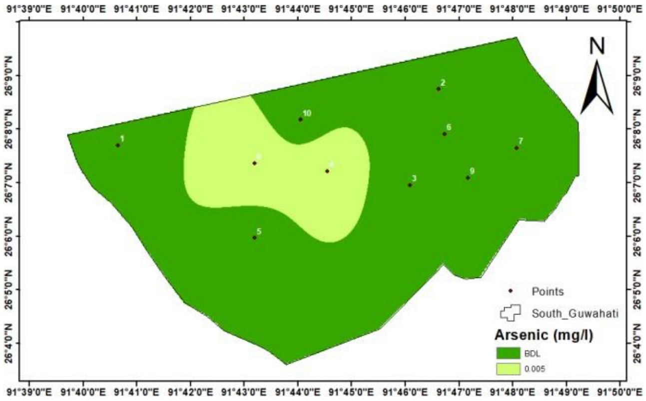

Fig 16. Arsenic Spatial Distribution Map

V. CONCLUSION

This study successfully shows the effectiveness of combining WQI assessment with GIS techniques to evaluate and map groundwater quality in a complex urban environment. The study contributes scientific data on the current status of groundwater in South Guwahati. The insights gained can support policymakers, environmental agencies, and urban planners in formulating strategies for sustainable groundwater management, ensuring long-term environmental and public health security for the region.

REFERENCES

1. *APHA,* Standard Methods for the Examination of Water and Wastewater, *23rd ed. Washington, DC, USA: American Public Health Association, 2017.*

2. *Bureau of Indian Standards,* IS 10500: Drinking Water—Specification*. New Delhi, India: BIS, 2012.*

3. *K. P. Dandge, "Spatial distribution of groundwater quality index using remote sensing and GIS techniques,"* Applied Water Science*, vol. 12, Art. no. 7, 2022.*

4. *K. K. Fatah, M. Hamed, M. H. Saeed, and R. Dara, "Evaluation of groundwater quality by using GIS and water quality index techniques for wells in Bardarash area, Northern Iraq,"* Iraqi Geological Journal*, vol. 53, no. 2C, pp. 87–104, 2020.*

5. *G. Hinge, B. Bharali, A. Baruah, and A. Sharma, "Integrated groundwater quality analysis using water quality index, GIS and multivariate technique: A case study of Guwahati City,"* Environmental Earth Sciences*, vol. 81, p. 412, 2022.*

6. *F. F. Islam, N. Choudhury, J. Saikia, and Y. Dey, "Quality analysis of groundwater in Greater Guwahati,"* Journal of Civil Engineering and Environmental Technology*, vol. 1, no. 4, pp. 40–44, 2014.*

7. *S. Konkey, U. B. Chitranshi, and R. D. Garg, "Groundwater quality analysis and mapping using GIS techniques,"* International Journal of Engineering Science and Technology (IJEST)*, vol. 6, no. 8, pp. 474–477, 2014.*

8. *J. N. Marfo, J. A. Quaye-Ballard, S. O. Kwakye, K. Obeng, A. Arko-Adjei, and R. N. A. Quao, "Groundwater quality and potential analysis using geospatial techniques: The case of Ashanti Region in Ghana,"* Heliyon*, vol. 10, Art. no. e27545, 2024.*

9. *B. Nas and A. Berktay, "Groundwater quality mapping in urban groundwater using GIS,"* Environmental Monitoring and Assessment*, vol. 160, pp. 215–227, 2010.*

10. *T. Rajavarshini, M. Baskar, S. J. Rajammal, S. Rathika, M. Nagarajan, and R. L. Meena, "Delineation and mapping of groundwater quality assessment in Salem District, Tamil Nadu, India using GIS techniques,"* International Journal of Environment and Climate Change*, vol. 14, no. 11, pp. 487–502, 2024.*

11. *R. K. Sarmah and S. Sarma, "Groundwater quality assessment in the southwestern peri-urban Guwahati City,"* Naturalista Campano*, vol. 28, no. 1, pp. 1656–1661, 2024.*

12. *S. Singh, M. R. Ranjan, A. Tripathi, and R. Ahmed, "Assessment of groundwater quality of Greater Guwahati with reference to iron and fluoride,"* International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, vol. 5, no. 11, pp. 2315–2318, 2017.*

13. *S. Kate, S. Kumbhar, and P. Jamale, "Water quality analysis of Urun-Islampur City, Maharashtra, India,"* Applied Water Science*, vol. 10, Art. no. 95, 2020.*