RESEARCH PAPER

ASSESSMENT OF POST MONSOON GROUND WATER QUALITY OF GABHANA TEHSIL, DISTRICT ALIGARH, UTTAR PRADESH WITH SPECIAL REFERENCE TO PHYSIOCHEMICAL PARAMETERS

Chhaya Tiwari[1*], Ravi Kant[2]

1PhD Scholar, Department of Chemistry, Mangalayatan University, Aligarh, Extended NCR, 33rd Milestone, Mathura Road, Beswan, Aligarh, Uttar Pradesh - 202146, India

2Dean (Research and Development), Department of Chemistry, Mangalayatan University, Aligarh, Extended NCR, 33rd Milestone, Mathura Road, Beswan, Aligarh, Uttar Pradesh - 202146, India

***Corresponding Author: Ms. Chhaya Tiwari**

Email: tchhaya173@gmail.com

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ABSTRACT

Background: Groundwater is the principal source of drinking and irrigation water in the rural belt of Gabhana Tehsil, Aligarh district, Uttar Pradesh, an area where unregulated agricultural runoff and diffuse anthropogenic activity threaten aquifer quality. Objective: The present study was undertaken to assess the post-monsoon physicochemical and trace-metal quality of groundwater from Gabhana Tehsil and to evaluate its suitability for drinking and irrigation purposes with reference to Indian Standard IS 10500:2012. Methods: Groundwater samples were collected from fourteen bore-well sites (S1-S14) selected across representative villages of the tehsil during the post-monsoon season. Physical parameters (pH, electrical conductivity), major chemical parameters (total dissolved solids, total hardness, alkalinity, chloride, calcium, magnesium, sulphate, nitrate, nitrite, fluoride, sulphide, phenol and anionic surfactants) and twenty trace/toxic elements were analysed using standard titrimetric, spectrophotometric and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) methods as prescribed by APHA (24th edition, 2023) and relevant IS 3025 protocols. Results: pH (7.499-8.058), total hardness, chloride, calcium, magnesium, sulphate and sulphide remained within desirable limits at all sites. However, total dissolved solids, alkalinity, nitrate, nitrite, fluoride and sodium exceeded BIS desirable limits at multiple sites, and mercury and antimony exceeded acceptable limits at isolated locations. Most trace metals (Cr, Fe, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sn, Ba, Pb, Al, B, Mn) remained within desirable limits throughout. Conclusion: The groundwater of Gabhana Tehsil is largely suitable for drinking and irrigation, but localised contamination from agricultural and anthropogenic sources -- particularly elevated nitrate, sodium, alkalinity and TDS -- warrants periodic monitoring and targeted remediation at the affected sites.

Keywords: *Groundwater quality; Physicochemical parameters; Heavy metals; ICP-MS; Gabhana Tehsil; Aligarh; Post-monsoon; IS 10500:2012*

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1. INTRODUCTION

Water is an indispensable natural resource and is often described as the elixir of life; its quality is directly linked to public health, agricultural productivity and ecological balance.1 In large parts of rural and semi-urban India, groundwater remains the primary and, in many cases, the sole source of water for drinking, domestic and irrigation purposes.2 The quality of this resource is, however, increasingly threatened by industrial effluents, indiscriminate use of agrochemicals, uncontrolled disposal of domestic waste and geogenic factors, all of which can alter the physicochemical and trace-element composition of the aquifer.3

Aligarh district, situated in the doab between the Ganga and Yamuna rivers in western Uttar Pradesh, is an agriculturally advanced and industrially active region, well known for its lock and hardware manufacturing units. The district hosts more than 5,500 industrial units, and the resultant anthropogenic pressure has been reported to degrade groundwater quality in and around Aligarh city and its adjoining blocks.4-8 Gabhana Tehsil, an essentially rural tehsil of the district comprising about 155 villages, has, however, received comparatively little attention in the groundwater-quality literature despite being entirely dependent on bore-well and hand-pump sources for drinking and irrigation water.

A review of the available literature on groundwater quality in and around Aligarh district, including studies from Aligarh city, Beswan, Iglas, Firozabad and neighbouring Agra district, indicates a research gap with respect to a systematic physicochemical and toxic-element characterisation of groundwater specific to Gabhana Tehsil.9-13 Given the reliance of the local rural population on untreated groundwater, an area-specific assessment covering both conventional physicochemical parameters and trace/toxic elements was considered necessary.

The present study was therefore designed with the following objectives: (i) to analyse groundwater samples from Gabhana Tehsil for physical, chemical and trace-metal parameters using standard methods prescribed by the American Public Health Association (APHA, 24th edition, 2023) and relevant Bureau of Indian Standards (BIS) procedures, and to compare the results with the drinking-water specification IS 10500:2012; and (ii) to generate baseline data that can inform public awareness regarding groundwater quality and the health risks associated with contaminated water in the study area.

2. MATERIALS AND METHODS

2.1 Study Area

Gabhana Tehsil lies in Aligarh district, Uttar Pradesh, and covers a total area of approximately 473 km2, of which 468.70 km2 is rural and 3.80 km2 is urban. As per the most recent administrative records, the tehsil has a population of approximately 3,08,802, distributed across 155 villages. Aligarh district as a whole lies between latitude 27 deg 54' and 28 deg N and longitude 78 deg and 78 deg 5'E, within the central Ganga basin, and experiences a monsoon-influenced humid subtropical climate with a normal annual rainfall of approximately 760 mm. The spatial distribution of the fourteen sampling sites (S1-S14) across the tehsil is shown in Figure 1.

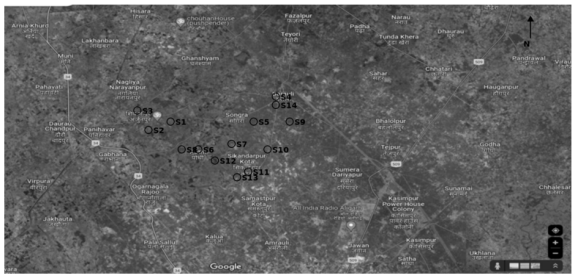

Figure 1. Location map of groundwater sampling sites (S1-S14) in Gabhana Tehsil, Aligarh district, Uttar Pradesh (base imagery: Google Maps/Google Earth, sampling points overlaid by authors)

2.2 Sample Collection

The study was carried out in two phases. In the first phase, a preliminary reconnaissance survey was followed by a detailed field survey to finalise the sampling network on the basis of drainage pattern, land use and the overall objectives of the study. Groundwater samples were collected from fourteen bore-well sites (Table 1) distributed across representative villages of Gabhana Tehsil during the post-monsoon season. Samples were collected in pre-rinsed, clean polythene bottles without entrapped air bubbles, sealed tightly immediately after collection, labelled in the field and transported to the laboratory at room temperature prior to analysis.

Table 1. Details of groundwater sampling locations, Gabhana Tehsil, Aligarh district

S. No.	Site Name	Site Code	Source	Location Description
1	Sumera Jhaal Jawan	S1	BW	Near T-junction at Anup Shehar-Barauli Road, Jawan
2	Dabthala	S2	BW	Opposite Langotia Baba Temple
3	Nagla Banjara	S3	BW	Opposite first temple in Baazgarhi
4	Barauli By-pass	S4	BW	Opposite river bridge, Barauli
5	Barauli	S5	BW	Opposite Shri Hotilal Maheshwari Inter College
6	Rigaspuri	S6	BW	Premises of primary school
7	Pokharghari	S7	BW	Near Gaushala of Ponkargarhi
8	Songra	S8	BW	On entry Y-point of Songra
9	Hursaina	S9	BW	Farming land on road towards Hursaina to Barauli, Gabhana
10	Pratappur	S10	BW	Farming land roads towards Barauli from Pratappur, Gabhana
11	Barauli Khass	S11	BW	Farming land roads towards Barauli from Madangarhi, after a sharp turn
12	Ponkargarhi	S12	BW	Farming land, Ponkargarhi
13	Ramnagar	S13	BW	Opposite Navjyoti Higher Secondary School

S. No.	Site Name	Site Code	Source	Location Description
14	Shyampur	S14	BW	Farming land Shyampur, opposite Ponkargarhi entry gate

2.3 Analytical Methods

In the second phase, all fourteen samples were analysed for physical, chemical and trace/toxic-element parameters following standard methods recommended by the Bureau of Indian Standards (IS 3025 series) and the American Public Health Association (APHA, 24th edition, 2023). pH was measured using a Mettler Toledo SevenCompact pH/Ion S220 digital pH meter; electrical conductivity was determined electrometrically; TDS was determined gravimetrically; total alkalinity, total hardness and chloride were determined by standard titration; sulphate, nitrate, sulphide and fluoride were determined spectrophotometrically (UV-Vis); and twenty trace and toxic elements (Na, K, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sn, Sb, Ba, Hg, Pb, Al and B) were quantified using an Agilent Technologies 7800 Inductively Coupled Plasma Mass Spectrometer (ICP-MS), calibrated against a multi-element standard (Merck) diluted in 1% nitric acid. All results were compared against the acceptable/permissible limits prescribed under IS 10500:2012 (Table 2).

Table 2. Parameters analysed and corresponding analytical methods/instruments

S. No.	Parameter	Method/Reference	Instrument
1	pH	IS 3025 (Part 11)	pH meter
2	Electrical Conductivity	Electrometric method	Conductivity meter
3	Total Dissolved Solids	IS 3025 (Part 16)	Gravimetric method
4	Total Alkalinity (as CaCO3)	IS 3025 (Part 23)	Standard titration
5	Total Hardness (as CaCO3)	IS 3025 (Part 21)	Standard titration
6	Chloride (as Cl)	IS 3025 (Part 32)	Standard titration
7	Sulphate (as SO4)	IS 3025 (Part 24)	UV-Vis spectrophotometer
8	Nitrate (as NO3)	APHA 4500-NO3, 2017	UV-Vis spectrophotometer
9	Sulphide	IS 3025 (Part 29), methylene blue method	UV-Vis spectrophotometer
10	Fluoride	APHA 4500-F:D, 23rd ed., 2017	UV-Vis spectrophotometer
11	Heavy/trace elements (Na, K, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Sn, Sb, Ba, Hg, Pb, Al, B)	APHA 3125, 24th ed., 2023	ICP-MS (Agilent Technologies 7800)

3. RESULTS

3.1 Physical Parameters

The pH of the groundwater samples ranged from 7.499 to 8.058, well within the desirable limit of 6.5-8.5 prescribed under IS 10500:2012, indicating a near-neutral to mildly alkaline character across the study area. Electrical conductivity ranged from 314.88 microS/cm (S4) to 1844.91 microS/cm (S9), with the highest values recorded at S9, S6, S13, S12 and S5 (Table 3; Figure 2), reflecting elevated dissolved-ion concentrations at these sites relative to the prescribed limit of 1000 microS/cm.

Table 3. Site-wise electrical conductivity of groundwater samples

Sample Code	Conductivity (microS/cm at 25C)	Limit (microS/cm)
S1	402.21	
S2	334.92	
S3	413.84	
S4	314.88	
S5	1260.32	Max 1000
S6	1293.92	
S7	1000.00	
S8	489.48	
S9	1844.91	

Sample Code	Conductivity (microS/cm at 25C)	Limit (microS/cm)
S10	1216.71	
S11	1394.07	
S12	1415.21	
S13	1428.57	
S14	800.30	

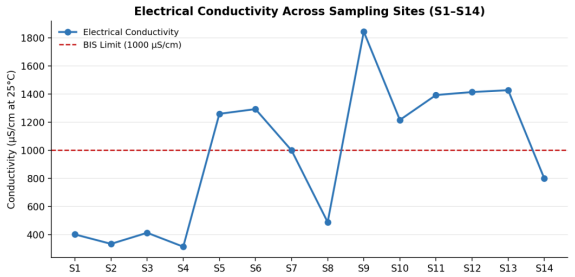

Figure 2. Site-wise variation of electrical conductivity relative to the BIS limit (1000 µS/cm)

3.2 Chemical Parameters

Total dissolved solids ranged from 220.42 to 342.64 mg/L at sites S1-S4 and S8, well within the desirable limit of 500 mg/L; however, sites S5, S6, S7, S9, S10, S11, S12, S13 and S14 recorded elevated TDS of 882.23, 905.75, 700.18, 1291.44, 851.70, 975.85, 990.65, 1000.66 and 560.21 mg/L respectively, exceeding the desirable limit but remaining within the permissible limit of 2000 mg/L (Figure 4).

Total hardness (70.35-146.73 mg/L), chloride (nil-49.8 mg/L), calcium (21.75-55.78 mg/L), magnesium (0.49-2.94 mg/L; Figure 3), sulphate (8.1-71.7 mg/L) and sulphide (0.0065-0.0086 mg/L) remained within their respective desirable limits (200, 250, 75, 30, 200 and 0.05 mg/L) at all sampling sites. Phenolic compounds and anionic surfactants (as MBAS) were recorded below the limit of quantification throughout.

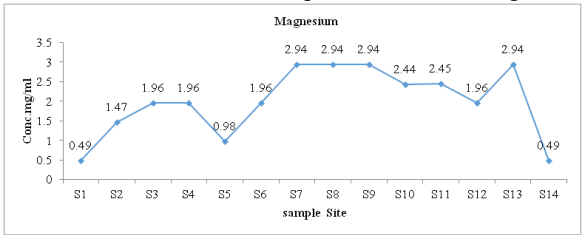

Figure 3. Site-wise magnesium concentration (mg/L), all values within the BIS desirable limit of 30 mg/L

Total alkalinity ranged from 70.62 to 107.0 mg/L at sites S1-S4, within the desirable limit of 200 mg/L; sites S5, S6, S7, S8, S9, S10, S11, S12, S13 and S14, however, recorded elevated alkalinity of 258.94, 383.06, 363.8, 214.0, 481.5, 321.0, 395.90, 449.4, 428.0 and 299.6 mg/L respectively, exceeding the desirable limit but within the permissible limit of 600 mg/L (Figure 4).

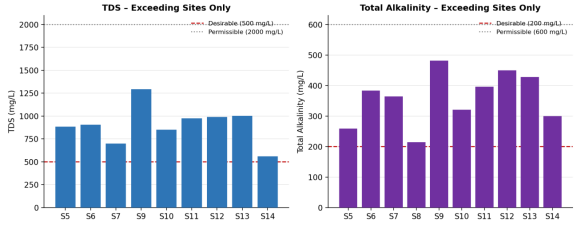

Figure 4. TDS and total alkalinity at sites exceeding the respective BIS desirable limits

Nitrate concentrations ranged from 2.14 to 37.69 mg/L at most sites, within the desirable limit of 45 mg/L (for which IS 10500:2012 permits no relaxation); sites S5, S7, S9, S11, S12 and S13, however, recorded elevated nitrate of 172.81, 110.79, 104.16, 52.46, 50.96 and 51.65 mg/L respectively, exceeding the prescribed limit (Figure 5). Nitrite was within the desirable limit (0.0-12.1 microg/L) at most sites but reached 45.4 microg/L at S1, exceeding the 20 microg/L limit (no relaxation permitted). Fluoride ranged from 0.0 to 0.9038 mg/L at most sites but reached 1.5862 mg/L at S1, marginally above the desirable limit of 1.0 mg/L and close to the permissible limit of 1.5 mg/L.

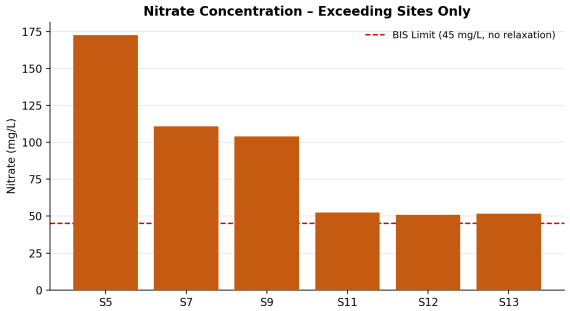

Figure 5. Nitrate concentration at sites exceeding the BIS limit of 45 mg/L

3.3 Trace and Toxic Elements

Twenty trace/toxic elements were quantified by ICP-MS across all fourteen sites (Table 4). Sodium concentrations ranged from 19.7844 to 187.532 mg/L at most sites, within the desirable limit of 200 mg/L; sites S5, S6, S9, S10, S11, S12 and S13, however, recorded markedly elevated sodium of 237.534, 297.163, 675.083, 355.492, 491.776, 484.422 and 486.235 mg/L respectively, exceeding the prescribed limit, with S9 showing the highest concentration recorded in the study (Figure 6). Mercury ranged from nil to 0.00152 mg/L, marginally exceeding the desirable limit of 0.001 mg/L at S3. Antimony ranged from nil to 0.0253 mg/L, exceeding the desirable limit of 0.005 mg/L at S1 (Figure 7). Manganese, recorded up to 0.09597 mg/L at S3, remained below the desirable limit of 0.1 mg/L. All remaining trace elements -- chromium, iron, nickel, copper, zinc,

arsenic, selenium, molybdenum, silver, cadmium, tin, barium, lead, aluminium and boron -- were recorded within their respective desirable limits at every sampling site, with lead, tin and boron below the limit of quantification throughout.

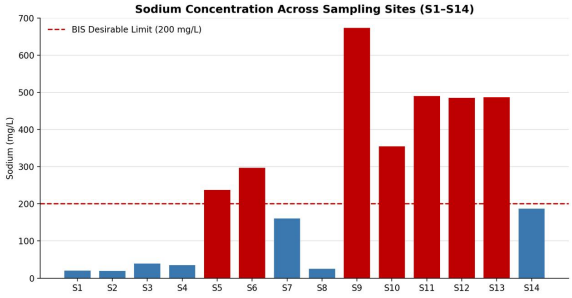

Figure 6. Site-wise sodium concentration relative to the BIS desirable limit (200 mg/L); bars in red indicate exceedance

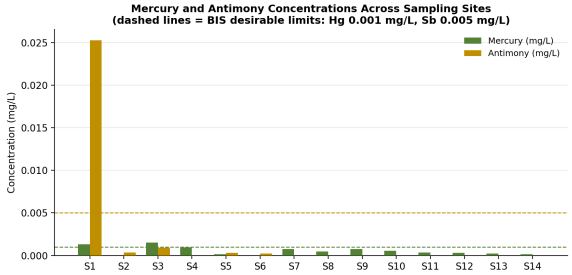

Figure 7. Site-wise mercury and antimony concentrations relative to their respective BIS desirable limits

Table 4. Trace and toxic element concentrations (mg/L) in groundwater samples, sites S1-S14

Table 4a. Sites S1-S7

S. No.	Parameter	Limit (mg/L)	S1	S2	S3	S4	S5	S6	S7
1	Sodium (as Na)	200.0 max	19.897	19.784	39.179	35.181	237.534	297.163	160.450
2	Potassium (as K)	-	12.687	12.118	9.761	8.121	27.961	31.447	33.019
3	Total Chromium (as Cr)	0.05 max	0.0003	<0.00000	<0.00000	<0.00000	0.0002	0.0004	0.0002
4	Manganese (as Mn)	0.1 max	0.0102	0.0304	0.0959	0.0817	0.005	<0.000	0.001
5	Iron (as Fe)	0.1 max	0.00271	0.00206	0.00124	0.00169	0.00243	0.00019	0.00134
6	Nickel (as Ni)	0.02 max	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000	0.00087
7	Copper (as Cu)	0.05 max	<0.00000	0.00006	0.00004	<0.00000	<0.00000	0.00137	0.02183
8	Zinc (as Zn)	5.0 max	0.00602	0.04405	0.00889	0.03284	0.00089	0.01366	0.00988
9	Total Arsenic (as As)	0.01 max	0.00251	0.00023	0.00043	0.00368	0.00016	0.00076	0.00090
10	Selenium (as Se)	0.01 max	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000
11	Molybdenum (as Mo)	0.07 max	0.00252	0.00223	0.00340	0.00180	0.00166	0.00054	0.00160
12	Silver (as Ag)	0.01 max	0.00009	0.00005	0.00007	0.00009	0.00002	0.00001	0.00003
13	Cadmium (as Cd)	0.003 max	0.00003	0.00001	0.00001	<0.00000	0.00002	<0.00000	<0.00000
14	Tin (as Sn)	-	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000
15	Antimony (as Sb)	0.005 max	0.0253	0.00034	0.00090	<0.00000	0.00030	0.00023	<0.00000
1	Barium	0.7	0.0	0.0	0.0	0.0	0.1	0.2	0.0

S. No.	Parameter	Limit (mg/L)	S1	S2	S3	S4	S5	S6	S7
6	m (as Ba)	max	4853	1318	7989	3222	7420	3289	7988
17	Mercury (as Hg)	0.001 max	0.00131	<0.000000	0.00152	0.00096	0.00016	<0.000000	0.00075
18	Lead (as Pb)	0.01 max	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000
19	Aluminium (as Al)	0.03 max	0.00022	0.00125	0.00002	0.00307	<0.000000	0.00010	0.00080
20	Boron (as B)	5.0 max	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000

Table 4b. Sites S8-S14

S. No.	Parameter	Limit (mg/L)	S8	S9	S10	S11	S12	S13	S14
1	Sodium (as Na)	200.0 max	26.689	675.083	355.492	491.776	484.422	486.235	187.532
2	Potassium (as K)	-	13.863	31.413	37.837	27.547	27.326	27.987	20.502
3	Total Chromium (as Cr)	0.05 max	<0.00005	0.00003	0.00002	0.00007	0.00005	0.00009	0.00004
4	Manganese (as Mn)	0.1 max	0.00000000	0.00020	0.00017	0.00016	0.00012	0.00011	0.00004
5	Iron (as Fe)	0.1 max	0.00015	<0.0000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000
6	Nicke l (as Ni)	2 max	000000	0000	000000	000000	000000	000000	000000
7	Copper (as Cu)	0.05 max	0.00024	<0.00000	<0.000000	0.00002	<0.000000	<0.000000	<0.000000
8	Zinc (as Zn)	5.0 max	<0.000000	<0.00000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000
9	Total Arsenic (as As)	0.01 max	0.00070	0.00065	0.00073	0.00111	0.00121	0.00109	0.00103
10	Selenium (as Se)	0.01 max	0.00009	0.00065	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000
11	Molybdenum (as Mo)	0.07 max	0.00182	0.00517	0.00414	0.00584	0.00568	0.00581	0.00954
12	Silver (as Ag)	0.01 max	0.00003	0.00001	0.00001	0.00002	0.00002	0.00002	0.00002
13	Cadmium (as Cd)	0.003 max	<0.000000	<0.00000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000
14	Tin (as Sn)	-	<0.000000	<0.00000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000
15	Antimony (as Sb)	0.005 max	<0.000000	<0.00000	<0.000000	<0.000000	<0.000000	<0.000000	<0.000000
16	Barium (as Ba)	0.7 max	0.060059	0.155559	0.126111	0.137335	0.12900	0.150665	0.104118
17	Mercury (as Hg)	0.001 max	0.00046	0.00075	0.00055	0.00034	0.00030	0.00023	0.00013
1	Lead	0.0	<0.	<0.	<0.	<0.	<0.	<0.	<0.

S. No.	Parameter	Limit (mg/L)	S8	S9	S10	S11	S12	S13	S14
8	(as Pb)	1 max	00000	0000	00000	00000	00000	00000	00000
19	Aluminium (as Al)	0.03 max	0.00088	0.00015	0.00003	0.00065	0.00001	0.00025	0.00001
20	Boron (as B)	5.0 max	<0.00000	<0.0000	<0.00000	<0.00000	<0.00000	<0.00000	<0.00000

4. DISCUSSION

The overall physicochemical profile of groundwater in Gabhana Tehsil indicates near-neutral pH and desirable levels of hardness, chloride, calcium, magnesium, sulphate and sulphide across all fourteen sampling sites, suggesting that the aquifer is not subject to widespread geochemical or industrial degradation. This is broadly consistent with earlier physicochemical investigations of groundwater in Aligarh district and its neighbouring blocks, which have similarly reported major ions largely within BIS limits alongside localised exceedances.9-13

However, the elevated TDS, alkalinity, nitrate, nitrite, sodium, mercury and antimony recorded at specific sites point to localised contamination rather than a uniform aquifer-wide problem. The clustering of elevated TDS, alkalinity and sodium at sites S5, S6, S9, S10, S11, S12 and S13 -- largely village sites located amid farming land -- is consistent with leaching of agrochemical residues and evaporative concentration of salts in an area of intensive irrigation, a pattern reported in comparable studies from the central Ganga plain and adjoining districts of western Uttar Pradesh.5,9,13 The exceedance of nitrate at S5, S7, S9, S11, S12 and S13 is of particular concern given that IS 10500:2012 permits no relaxation for this parameter; excessive nitrate in drinking water is commonly associated with the use of nitrogenous fertilisers and can pose a health risk, particularly methaemoglobinaemia in infants, if the water is consumed without treatment.

The marginal exceedance of mercury at S3 and the localised elevation of antimony at S1 warrant further monitoring, although the corresponding limits under IS 10500:2012 are stringent (0.001 mg/L and 0.005 mg/L respectively) and the observed exceedances were confined to single sites rather than being widespread. The remaining sixteen trace elements analysed -- including chromium, iron, nickel, copper, zinc, arsenic, selenium, molybdenum, silver, cadmium, tin, barium, lead, aluminium, boron and manganese -- were within desirable limits at all fourteen sites, which is a reassuring finding given that several of these elements (arsenic, lead, cadmium in particular) are associated with serious chronic health effects even at low concentrations.

Taken together, the findings suggest that groundwater in Gabhana Tehsil is largely suitable for drinking and irrigation use, but that a subset of villages served by sites S1, S3, S5, S6, S7, S9, S10, S11, S12 and S13 require closer monitoring and, where necessary, household-level treatment (e.g., for nitrate and TDS) before the water is used for drinking. Continued seasonal monitoring, particularly comparison between pre- and post-monsoon periods, would help establish whether the observed exceedances are transient (associated with monsoon-driven leaching) or indicative of a persistent contamination trend, an aspect identified as a limitation of the present single-season study.

5. CONCLUSION

The present investigation provides baseline post-monsoon physicochemical and trace-element data for groundwater across fourteen representative sites of Gabhana Tehsil, Aligarh district, Uttar Pradesh. pH, total hardness, chloride, calcium, magnesium, sulphate and sulphide were within desirable limits at all sites, while TDS, alkalinity, nitrate, nitrite, fluoride and sodium exceeded desirable limits at multiple, geographically clustered sites, and mercury and antimony exceeded limits at isolated locations. The majority of trace/toxic elements screened by ICP-MS were within safe limits throughout the tehsil. These findings indicate that while groundwater in Gabhana Tehsil is generally of acceptable quality, targeted monitoring, public awareness and, where required, point-of-use treatment are recommended for the affected villages, particularly with respect to nitrate and salinity-related parameters. The data generated fill an identified gap in the groundwater-quality literature for this specific tehsil and can serve as a baseline for future seasonal and long-term monitoring studies.

AUTHOR CONTRIBUTION STATEMENT

S. No.	Name of Author	Contribution
1	Ms. Chhaya Tiwari	Conceptualization, Investigation, Original draft preparation, Plagiarism check
2	Prof. (Dr.) Ravi Kant	Supervision, Formal analysis, Review and editing

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest associated with this study.

REFERENCES

1. American Public Health Association, American Water Works Association, Water Environment Federation. Standard Methods for the Examination of Water and Wastewater. 24th ed. Washington DC: APHA; 2023.
2. Bureau of Indian Standards. Indian Standard Drinking Water Specification (Second Revision) IS 10500:2012. New Delhi: Bureau of Indian Standards; 2012.
3. Foster SSD, Chilton PJ. Groundwater: the processes and global significance of aquifer degradation. Philosophical Transactions of the Royal Society B: Biological Sciences. 2003;358(1440):1957-1972. DOI: 10.1098/rstb.2003.1380
4. Anjum R, Ali SA, Siddiqui MA, Parvin F, Khan Z, Khan N, et al. Hydro-geochemical assessment of ground water for drinking and agricultural purposes and potential human health risk in Aligarh city, India. Chemical Engineering Journal Advances. 2023;16:100547. DOI: 10.1016/j.ceja.2023.100547
5. Umar R, Ahmed F, Alam M, Khan AM. Hydrochemical characteristics and seasonal variation in groundwater quality of an alluvial aquifer in parts of central Ganga plain, western Uttar Pradesh, India. Environmental Geology. 2009;58:1295-1300. DOI: [to be verified by author]
6. Umar R, Umar A, Khurshid S, Ahmed I. Microbial contamination in the groundwater of Aligarh City. Journal of the Geological Society of India. 2001;58:321-326. DOI: [to be verified by author]
7. Irfan A, Khurshid S. Evaluation of groundwater quality of Aligarh city (India): using statistical techniques approach. International Journal of Economic and Environment Geology. 2018;9(3):63-70.
8. [Author(s) to be completed]. Assessment of physicochemical characteristics of groundwater quality used for drinking water supply of Firozabad city, India using index method. Journal of Applied Sciences and Environmental Management. [Year;Vol(Issue):Pages - to be verified by author]
9. [Author(s) to be completed]. Physico-chemical analysis of groundwater quality in Beswan and Iglas, Aligarh district, Uttar Pradesh, India. International Journal of Environmental Sciences & Natural Resources. [Year;Vol(Issue):Pages - to be verified by author]
10. Khan AA, Khan MN. Physico-chemical study of groundwater at Shahjahanpur city, Uttar Pradesh, India. Research Journal of Chemical Sciences. 2015;5(1):55-59.
11. [Author(s) to be completed]. Groundwater quality assessment using water quality index and principal component analysis in the Achnera block, Agra district, Uttar Pradesh, northern India. Scientific Reports. 2024. DOI: [to be verified by author]
12. Trivedy RK, Goel PK. Chemical and Biological Methods for Water Pollution Studies. Karad, India: Environmental Publications; 1984.
13. Singh IB, Bajpai VN. Significance of syndepositional tectonics in the facies development of the Gangetic alluvium near Kanpur, Uttar Pradesh. Journal of the Geological Society of India. 1989;34:61-66.