

An impact of Industrial Effluents on Groundwater Quality of Siltara Industrial area, Raipur, (C.G)

Ghanshyam Shakar¹Bhumika Das²

¹Research Scholar, Associate Professor , MATS University Raipur, India

ABSTRACT: Water is the most important element on earth for the life of human beings. Groundwater is the purest source of water available to meet our everyday demands. This is why the reliance on groundwater has risen to such an extent that it has contributed to groundwater overexploitation. In terms of groundwater, several cities in India have already reached zero levels. Its output is declining due to overexploitation and lack of groundwater recharge. In addition to over-exploitation, humans have also altered the natural groundwater recharge system by constructing homes, road networks, factories, and other services. Industrial waste is not adequately disposed of by the factories and is mostly flown through the open land and river / nala channels. This resulted in groundwater as well as surface water pollution. Both overexploitation and industrial waste would be devastating in the coming days.

Keywords: *Groundwater, Industrial effluents, Overexploitaion, Recharge, Contamination*

1.0 INTRODUCTION

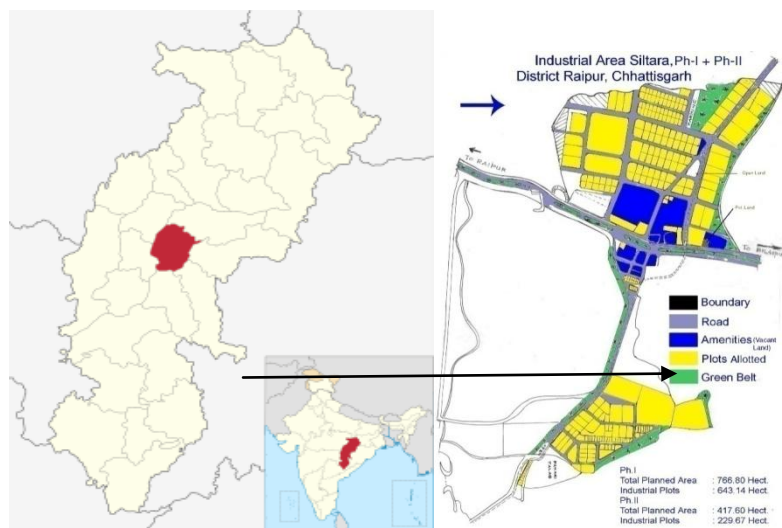
One of the most critical global environmental, social and political problems (APHA, 21st edition) is the quality, quantity and availability of drinking water. Ground water is one of the key sources of potable water and, because of its relative inaccessibility, it is much more difficult to clean up until this groundwater is polluted (BIS, 2012). In addition to affecting water quality, toxic waste also threatens human health, economic growth and social stability (Punamia BC, 1977). The quality of groundwater has become a matter of significant concern because of heavy metal pollution due to recent industrialization and ever growing urbanisation. A significant health concern is contamination of water by trace metals. Studies have shown that cardiovascular, neurological and renal disorders contribute to heavy metal toxicity (Bartram J & Balance R, 1996). The key health threats posed by chemical water contamination are the presence of fluoride nitrates, arsenic, cadmium , lead and other toxic metals (CGWB, 2010). The rapid growth of industrialization and urbanisation has produced an unconstructive effect on the environment in the last two decades. The leaching process has been tainted by commercial, municipal and agricultural waste containing pesticides, insecticides, fertiliser residues and heavy metals containing groundwater water. These contaminants are introduced to the groundwater and soil system through multiple human activities and rapid industrialization growth that directly or indirectly affect human health (Sharma Supriya, et.al , 2016).

1.2 Study area

Chhattisgarh is one of the 29 states of India, located in the centre-east of the country. It is the tenth-largest state in India, with an area of 135,191 km² (52,198 Sq. Mi.). With a population of 25.5 million, Chhattisgarh is the 17th-most populated state in the country. A resource-rich state, it is a source of electricity and steel for the country, accounting for 15% of the total steel produced. Chhattisgarh is one of the fastest-developing states in India. The northern and southern parts of the state are hilly, while the central part is a fertile plain. The highest point in the state is the Gaurkata. Deciduous forests of the Eastern Highlands Forests cover roughly 44% of the state. The state animal is the *van bhainsa*,

or wild Asian buffalo. The state bird is the *Pahari myna*, or hill myna. The state tree is the Sal (Sarai) found in Bastar division. The climate of Chhattisgarh is tropical. It is hot and humid because of its proximity to the Tropic of Cancer and its dependence on the monsoons for rains. Summer temperatures in Chhattisgarh can reach 45 °C (113 °F). The monsoon season is from late June to October and is a welcome respite from the heat. Chhattisgarh receives an average of 1,292 millimeters (50.9 in) of rain. Winter is from November to January and it is a good time to visit Chhattisgarh. Winters are pleasant with low temperatures and less humidity.

Raipur is a city in the Raipur district of the Indian state of Chhattisgarh. It is the capital of the state of Chhattisgarh. The Raipur district covers an area of 12,461.9 sq. km. It is situated in the central part of Chhattisgarh state. It falls in the Survey of India's topo Sheet Nos. **64 G/11** and **64 G/12** (1: 50000 Scale). The district is bounded by Baloda Bazar district in the north, Durg district in the west, Raigarh district in the Mahasamund district and Dhamteri district in the south. Raipur is located near the center of a large plain, sometimes referred as the "rice bowl of India", Where hundreds of varieties of rice are grown. The Mahanadi River flows to the east of the city of Raipur, and the southern side has dense forests. The Maikal Hills rise on the north-west of Raipur; on the north, the land rises and merges with the Chota Nagpur Plateau, which extends north-east across Jharkhand state. On the south of Raipur lies the Deccan Plateau. Raipur has a tropical wet and dry climate, temperatures remain moderate throughout the year, except from March to June, which can be extremely hot. The temperature in April–May sometimes rises above 48 °C (118 °F). These summer months also have dry and hot winds. In summers, the temperature can also go up to 50 °C. The city receives about 1,300 millimeters of rain, mostly in the monsoon season from late June to early October. Winters last from November to January and are mild, although lows can fall to 5 °C (41 °F) making it reasonably cold. Siltara is a village panchayat located in the Raipur district of Chhattisgarh state, India. The latitude 21.3811556 and longitude 81.6637765 are the geo coordinate of the Siltara. The nearest railway station to Siltara is Mandhar which is located in and around 6.4 kilometer distance. Siltara's nearest airport is Swami Vivekananda Airport situated at 23.1 KM distance.



Map not to Scale (source - CSIDC)

2.0 Geology

The Chhattisgarh Basin covers an area of approximately 36,000 km² that overlaps the Bastar Craton's granite-gneiss and volcanic basement (Ramakrishnan and Vaidyanadhan, 2008). The basin's southern and eastern margins have depositional interaction with the basement, while the basin's western and northern margins are fault-limited. The basin succession (~2500 m thick) consists primarily of subordinate conglomerate sandstones, shale, and carbonates and tuffs at different stratigraphic levels. Chattisgarh Supergroup is the succession, which is further divided into various groups (Murti, 1987; Das et al . 1992; Patranabis-Deb and Chaudhuri, 2008). However, the layers dip gently at an angle of 2-10° along the NS faults; the dip ranges from 20-25°. Structural disturbances along the western, northern and eastern margins are seen in the Chattisgarh Basin. NNE-SSW and E-W delimit the western and northern edges of the basin to the ENE-WSW faults, respectively. The deformation in the eastern part of the basin is expressed by strong open warps and large scale faults trending NNW-SSE, NNE-SSW, E-W and NE-SW within the strata. The rejuvenated basin opening faults (Chaudhuri et al . 2002) are assumed to be such large-scale faults. It was inferred that the basin formed as an intracratonic rift on the basis of sedimentary assemblages, facies and stratigraphic architecture (Chaudhuri et al . 1999; 2002; Roy and Prasad, 2001; Patranabis-Deb and Chaudhuri, 2002 and Patranabis-Deb and Chaudhuri, 2008). Using the K-Ar dating process, Kreuzer et al. (1977) dated the authigenic glauconites from the Chapradih Formation of the Chandrapur Group and inferred the age as 700-750 ma and regarded the succession as Neoproterozoic.

Age	Supergroup	Group	Formation	Lithology
QUATERNARY	Recent to sub-recent		Alluvium and Laterite	Sand, Silt, Clay and lateritic Soil
PROTEROZOIC	Chhattisgarh Supergroup	Raipur Group	Maniyari formation	
			Hirri formation	
			Taranga formation	
			Chandi formation	Limestone, Sandstone & Shale
			Gunderdehi formation	Shale
			Charmuria formation	Limestone & Shale
		Chandrapur Group	Kanspathar formation	Sandstone, Siltstone, Shale & Conglomerate
			Choparadih formation	
			Lohardi formation	
ARCHAEAN	Basement crystallines- Granite, gneisses, granulite and Amphibolite			

Table: 1. Stratigraphic succession Chhattisgarh Supergroup (Das, et.al. 1992; 2003)

2.1. Local Geology

It falls under the Proterozoic Chandi formation of the Raipur Group of the Chhattisgarh Super Group, as per the local geology of the Siltara district. Limestone, shale, sandstone and dolerite intrusion are the main rock types that occur in this region in some areas.

Age	Supergroup	Group	Formation	Lithology
Proterozoic	Chhattisgarh Supergroup	Raipur Group	Chandi Formation	Limestone, Sandstone & Shale

Table: 2. Stratigraphic Succession of the Study Area

3.0 Methodology

3.1 Sample Collection

Samples from various sources such as dug wells, bore wells, ponds and nala parts (pre-monsoon and post-monsoon) need to be collected in order to research the impact of industrial effluent on the groundwater. The liquid samples should be collected shortly after collection in detergent-washed 1L fresh polyethylene bottles and acidified (5 ml per litre) with pure anal grade HNO₃. Effluent samples for the assessment of BOD and COD must be obtained separately and not acidified. Until it is acidified, the electrical conductivity (EC) and pH of liquid samples can be measured in the region. Five folds should be obtained for each specimen type. Samples should be taken to the laboratory and placed in a refrigerator before further testing is carried out.

3.2 Sample preparation

While preparing the samples of groundwater it should be filtered using whatman 41 filter paper to remove any suspended solid particles. For heavy metal analysis using TXRF technique, 10 ml of each type of sample should be taken in a plastic vial and must be further acidified with 0.5 ml analar grade HNO₃. It should be kept under action for 16 hours for complete dissolution of inorganic salt contained in smaller solid particles that might be present in the sample even after filtration. Then 3 ml of the each type of sample should be internally standardized with 6 ml of commercially available standard yttrium solution (E.Merck, Germany).

3.3 Physical Characteristics

Included in the analysed physical characteristics were: appearance, colour, pH, temperature, odour, electrical conductivity (EC), total suspended solids (TSS), total dissolved solids (TDS), total hardness and turbidity. With a pH / temperature metre, the pH and temperature can be evaluated in situ. It is possible to assess the colour by stirring the composite samples until the sediments are freely suspended and can then be adjusted using a colour disc. The Jenway M470 Portable Conductivity / TDS metre (Gowon P.A., et.al 2014) can be used to assess TDS, TSS, EC and turbidity in situ.

3.4 Chemical and Organic Characteristics, heavy metals

Alkalinity, acidity, nitrate, chloride, sulphate, phosphate, DO, BOD, COD, phenol compounds, oil and grease, As, Al, Zn, Fe, BP, Cu, Ni, Mn, Cr, Cd, Mg, Ca and Cyanide were included in the chemical and organic characteristics. Following the definition provided in APHA, DO can be analysed using the Winkler method with azide modification. By subtracting the value of the final DO concentration (after 5 days of incubation at 20°C) from the initial DO concentration, the BOD can be analysed. COD can be calculated by the technique of dichromate reflux because it has an advantage over oxidants due to its oxidising strength and its applicability to a wide range of samples. It is possible to spectrophotometrically test nitrate, phosphate, and sulphate. Titrimetrically, chloride can be measured. It is possible to test oil and grease, phenol compounds, alkalinity, acidity and cyanide using methods adapted from traditional water and wastewater analysis methods (APHA, 1992). For the determination of heavy metals and certain trace metals, including Cd, Cr, Mn, Ni, Cu, Pb, Fe, Zn, Al, As, Ca and Mg, an Atomic Absorption Spectrophotometer (Boston, MA 02118-2512, USA) may be used (Ogwo P.A., et.al 2014).

3.5 Bacteriological Characteristics

Analysis of bacteriological features involves total plate count, total coliform, and E coli. It is possible to estimate the total plate count using the heterotrophic plate count approach introduced by the American Public Health Association. Using the Most Probable Number (MPN) method, complete coliform and E coli analysis can be performed. The procedure included three successive steps: a presumptive test, a verified test and a full test that recognises coliform bacteria as a faecal contamination indicator (APHA, 1998). Results obtained can be analyzed statistically and compared with WHO, (Ogwo P.A., et.al 2014).

Physical and chemical properties of tube well water as per IS 10500-2012¹⁸

S.No.	Parameter	Unit	Accept. Limit	Permi. Limit
1	Colour	Hazen Unit	5	15
2	Odour		Agreeable	Agreeable
3	pH		6.5-8.5	No relaxation
4	Turbidity	NTU	1	5
5	Total Dissolved Solids	mg/l	500	2000
6	Ammonia	mg/l	0.5	No relaxation
7	Boron	mg/l	0.5	1
8	Calcium	mg/l	75	200
9	Chloride	mg/l	250	1000
10	Fluoride	mg/l	1	1.5
11	Magnesium	mg/l	30	100
12	Nitrate	mg/l	45	No relaxation
15	Total Alkalinity	mg/l	200	600
16	Sulphate	mg/l	200	400
17	Total Hardness	mg/l	200	600
18	Temperature	°C	-	
19	Sodium	mg/l	-	
21	Iron	mg/l	0.3	No relaxation
22	Cadmium	mg/l	0.003	No relaxation
23	Chromium	mg/l	0.05	No relaxation
24	Zinc	mg/l	5	15
25	Manganese	mg/l	0.1	0.3
26	Nickel	mg/l	0.02	No relaxation

3.6 Sample collection and preparation

During January-February 2020, a systematic sampling was conducted. In pre-washed polythene, narrow mouth, well and bore-well bottles, a total of 15 groundwater samples were gathered. Prior to sampling, the bottles were rinsed twice. Special attention was taken to those areas where the contamination of fluoride was expected. Based on this report, representative wells were selected. The water samples from the bore-wells were obtained after pumping out water for about 10 minutes extract stagnant water from the bore-well.

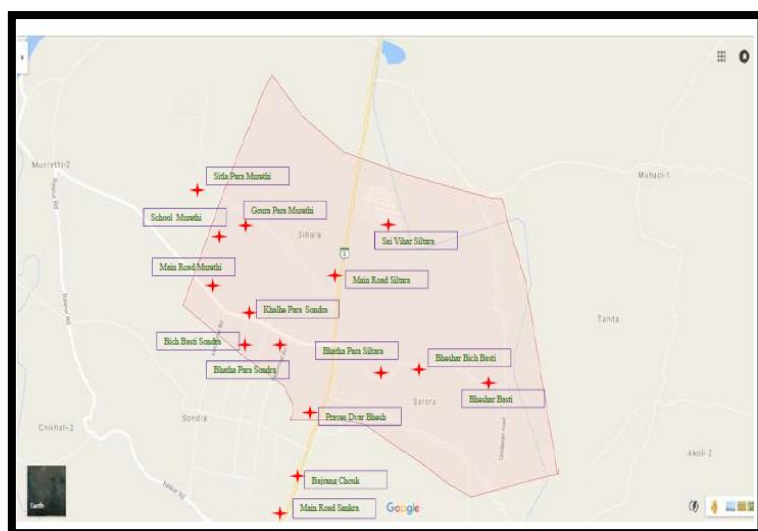


Fig2: Sampling location map

4.0 Analysis

Hanna metres were used to calculate some significant physical parameters such as temperature, pH, reduction potential (RP), electrical conductivity (EC), total dissolved solid (TDS) (model no. HI 8424, HI 9142, HI 991300). Groundwater hardness measured as Total hardness using EDTA (0.01 M) complex matrix titration with Eriochrome Black-T (EBT) and pH 10 buffer solution as indicator and groundwater alkalinity measured using H₂SO₄ (0.02 N) titration with 1 ml NaOH & 3 drop phenolphthalein indicator. The concentration of calcium and magnesium ions was measured using the EDTA titration method with (1N) NaOH and the P&R indicator pinch. The fluoride ion concentration was determined using by ion selective electrode method (Metrohm ion meter - 781) with 1:1 total ion strength adjustment buffer (TISAB). The buffer preparation was added by 58g NaCl + 5g CDTA (trans-2, 2, NNNN, cyclodiamine tetra acetic acid) + 57ml glacial acetic acid and adjusted to near 5.5 pH with 8 molar NaOH then made up with 1 liter ultra pure distilled water. The concentration of fluoride ions was measured using the ion selective electrode method (Metrohm ion metre-781) with a 1:1 total ion intensity adjustment buffer (TISAB). 58 g NaCl + 5 g CDTA (trans-2, 2, NNNN, cyclodiamine tetra acetic acid) + 57ml glacial acetic acid and changes of near 5.5 pH with 8 molar NaOH were applied to the buffer preparation and then 1 litre of ultra pure distilled water was added. NO₃- and NH₄⁺ measurements were calculated using the ion selective electrode (Metrohm ion metre-781) 1:1 buffer (1 mol / L (NH₄)₂ SO₄ and NaOH) process.

The concentration of Na⁺ and K⁺ ions was measured by a flame photometer (SYSTRONIC Flame photo meter-130). The SO₄²⁻ ions were calculated as a pinch of BaCl₂ by the turbidity metre (digital turbidity metre, Model No.331). The chloride ion was calculated by chromate indicator with Mohr solution.

S.no	Location	Age	Depth in Feet
1	Pravesh Dvar Bheshar	10	110
2	Bheshar Basti	10	100
3	Bheshar Bich Basti	20	30
4	Khalhe Para Sondra	35	150
5	Bich Basti Sondra	90	40
6	Bhatha Para Sondra	17	200
7	Bajrang Chouk Sankra	15	205
8	Main Road Sankra	6	200
9	Bhatha Para Siltara	20	250
10	Sai ViharSiltara	6	65
11	Main Road Siltara	20	215
12	Main Road Murethi	1	324
13	School Murethi	30	306
14	Goura Para Murethi	10	207
15	Sitla Para Murethi	10	297

5.0 RESULT

5.1 Physical parameter analysis

S.NO	Location	T °C	pH	EC (µs)	TDS (mg/l)	RP (MV)	TH (mg/l)	Alkalinity (mg/l)	Mg ⁺ (mg/l)
1	Praves Dvar Bheshar	26.4	6.30	1374	683	250.4	235	730	18.36
2	Bheshar Basti	25.9	6.24	1308	652	237.7	275	720	17.32
3	Bheshar Bich Basti	25.5	6.58	1747	872	215.3	230	850	30.58
4	Khalhe Para Sondra	25.4	6.26	1366	681	222.1	245	650	12.90
5	Bich Basti Sondra	25.5	6.24	1439	717	245.8	250	730	17.06
6	Bhatha Para Sondra	25.3	6.25	1041	518	253.9	255	550	10.56
7	Bajrang Chouk Sankra	25.3	6.45	707	352	246.5	110	610	15.50
8	Main Road Sankra	25.3	6.01	1222	611	285.5	165	720	22.78
9	Bhatha Para Siltara	25.3	6.05	1208	602	272.3	225	600	14.98
10	Sai Vihar Siltara	25.4	6.09	874	437	274.1	265	600	15.76
11	Main Road Siltara	25.5	6.42	1021	509	259.9	170	650	17.32
12	Main Road Murethi	25.4	6.22	4.53	2.26	274.5	180	750	12.38
13	School Murethi	25.7	6.13	932	463	274.5	230	850	26.94
14	Goura Para Murethi	25.5	6.34	1011	509	262.4	200	680	17.84
15	Sitala Para Murethi	26.0	6.13	1667	831	264.3	345	850	17.84

5.2 Chemical parameters analysis

	Location	NO_3^-	PO_4^{3-}	F^-	Cl^-	Na^+	Ca^{2+}	K^+	SO_4^{2-}	NH_4^+
1	PravesDvarBheshar	6.48	0.51	4.9	896	75.6	16.1	1.59	60.1	16.2
		5	0	0		1	1		5	
2	BhesharBasti	9.02	0.56	4.6	854	71.3	15.1	1.59	54.3	16.2
		3	7	6		3	0		7	
3	BhesharBichBasti	19.9	0.87	7.4	874	125.	17.6	12.4	100.	14.3
		5	0	0		9	2	6	1	
4	Khalhe Para Sondra	20.0	0.56	3.8	836	53.1	15.1	41.9	100.	17.4
		8	7	0		2	0	1	5	
5	BichBasti Sondra	19.9	0.78	3.2	754	70.2	17.6	47.9	101.	15.1
		8	4	6		6	2	4	8	
6	Bhatha Para Sondra	13.9	0.82	3.2	658	43.4	13.0	0.25	123.	15.8
		5	2	0		9	8		6	
7	BajrangChoukSankra	13.5	0.72	4.6	516	63.8	13.5	5.76	39.9	11.9
		3	8	4		3	9		4	
8	Main Road Sankra	20.1	0.60	3.1	680	93.8	15.1	17.8	60.5	17.2
		8	5	2		1	0	1	6	
9	Bhatha Para Siltara	19.5	0.55	2.7	738	61.6	15.6	1.08	59.3	12.6
		8	8	2		9	0		2	
10	Sai ViharSiltara	20.0	0.60	3.2	726	64.9	17.1	2.41	122.	15.5
		1	5	4		0	1		0	
11	Main Road Siltara	4.41	0.60	3.1	658	71.3	10.0	0.25	92.3	11.8
		6	5	2		3	6		2	
12	Main Road Murethi	8.81	0.56	4.0	472	50.9	16.1	2.26	91.0	8.16
		3	7	6		8	1		8	
13	School Murethi	19.5	0.61	4.1	668	110.	15.1	1.59	58.0	10.1
		7	4	8		9	0		9	
14	Goura Para Murethi	18.9	0.66	4.1	762	73.4	14.0	0.41	93.1	13.4
		5	2	2		7	9		5	
15	Sitala Para Murethi	19.9	0.61	4.8	101	73.4	24.6	64.6	171.	11.1
		3	4	0	8	7	6	7	9	

WHO prescriptions against observed value of physical and chemical species

S. No.	Species	WHO prescriptions, mg/l	Observed value, (Low to High value mg/l)	Average value
1.	Temperature	7 °C -11 °C	25 °C - 26.4 °C	25.6033
2.	pH	6.5-8.5	6.01 - 6.68	6.275
3.	EC	500	4.53 -1973	1056.551
4.	TDS	600	2.26 – 985	527.508
5.	RP	-	208.7- 285.5	251.87
6.	TH	100-500	110-450	227.5
7.	Mg ⁺	30	2.5-30.58	14.68
8.	Alkalinity	300	490- 850	653.33
9.	NO ₃ ⁻	45	4.416-20.45	16.98
10.	PO ₄ ³⁻	5	0.51-0.87	0.616
11.	F ⁻	1.5	2.58-7.4	3.528
12.	Cl ⁻	250	280-1404	749.4
13.	Na ⁺	20	10.3-125.94	60.45
14.	Ca ²⁺	75	9.57-36.75	18.04
15.	K ⁺	25	0.26-64.68	7.60
16.	SO ₄ ²⁻	200	5.70-171.93	73.33
17.	NH ₄ ⁺	-	8.16-22.30	13.30

5.3 Correlation matrix of ions for Siltara

	TC	pH	EC (μs)	TDS (mg/l)	RP (MV)	TH	Alkalinity	NO ₃ ⁻	PO ₄ ³⁻	F ⁻	Cl ⁻	Na ⁺	Mg ²⁺	Ca ⁺	K ⁺	SO ₄ ²⁻	NH ₄ ⁺
TC	1																
pH	0.34	1															
EC (μs)	0.23	0.10	1														
TDS (mg/l)	0.23	0.10	1.00	1													
RP(MV)	0.21	0.43	0.43	-0.43	1												
TH	0.29	0.14	0.72	0.72	-0.35	1											
Alkalinity	0.20	0.00	0.11	0.10	0.16	0.15	1										
NO ₃ ⁻	0.22	0.26	0.28	0.28	-0.03	0.19	-0.03	1									
PO ₄ ³⁻	0.28	0.33	0.18	0.18	-0.19	0.07	0.23	0.11	1								
F ⁻	0.14	0.27	0.23	0.22	-0.18	0.02	0.65	0.20	0.46	1							
Cl ⁻	0.29	0.08	0.88	0.88	-0.45	0.83	-0.10	0.20	-0.06	0.04	1						
Na ⁺	0.04	0.11	0.59	0.59	-0.11	0.21	0.61	0.13	0.34	0.55	0.41	1					
Mg ²⁺	0.04	0.11	0.59	0.59	-0.11	0.21	0.61	0.13	0.34	0.55	0.41	1	1				
Ca ⁺	0.18	0.12	0.61	0.61	-0.33	0.83	-0.24	0.36	-0.18	0.14	0.80	0.13	0.13	1			
K ⁺	0.04	0.17	0.39	0.39	-0.04	0.22	0.44	0.25	0.22	0.26	0.18	0.20	0.20	0.09	1.00		
SO ₄ ²⁻	0.10	0.08	0.51	0.51	-0.12	0.47	0.31	0.16	0.33	0.20	0.47	0.44	0.44	0.26	0.52	1.00	
NH ₄ ⁺	0.05	0.17	0.43	0.43	-0.35	0.32	-0.11	0.17	0.05	0.01	0.25	0.24	0.24	0.15	0.11	0.28	1

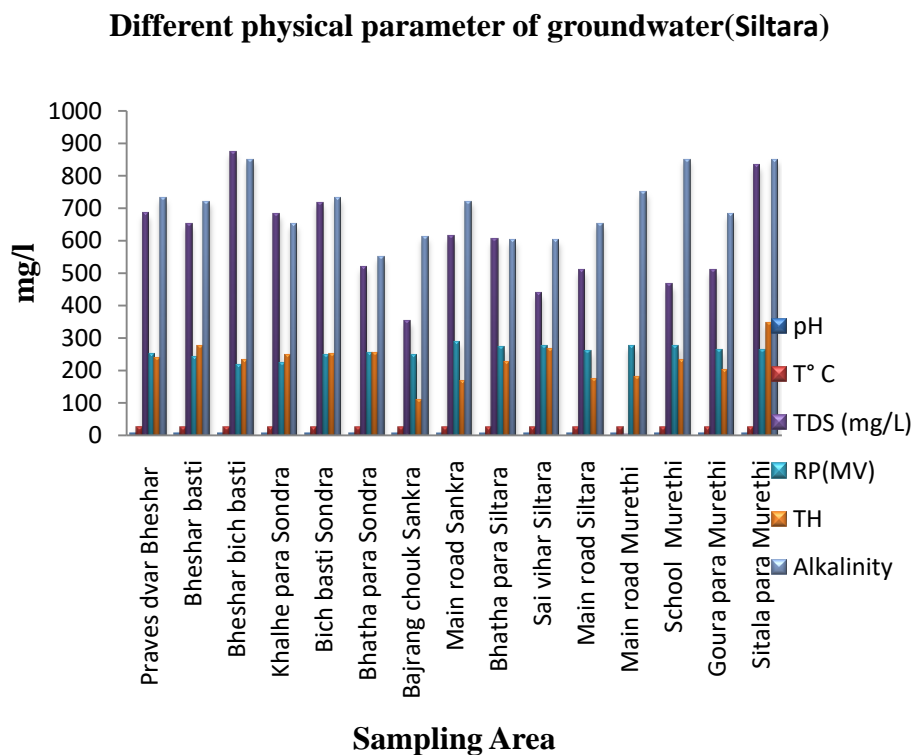


Figure: Physicochemical parameter (pH, Tem, EC,TDS, RP, T-H, H,T-A)of Ground water graph around the Siltara area.

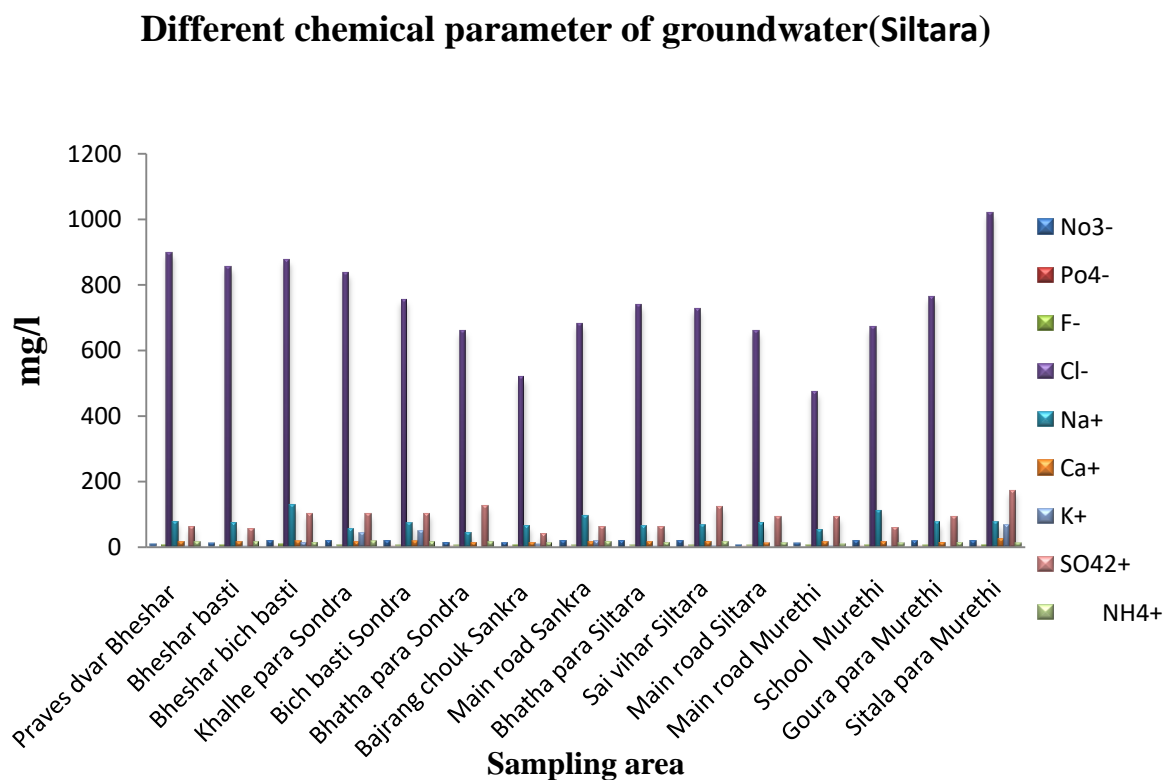


Figure: Physicochemical parameter (NO_3^- , PO_4^{3-} , F^- , Cl^- , Na^+ , Ca^{2+} , K^+ , SO_4^{2-} , NH_4^+) of Groundwater graph around the Siltara area.

6.0 CONCLUSION

The hydrochemical analysis shows that, with the exception of the few areas, the current status of groundwater in Siltara is not appropriate for drinking purposes, but could deteriorate in the future, as is evident from the very high percentage of water tested, the desirable limits according to WHO standards and almost approach the maximum permissible level. In the case of Urla, however, it is not suitable for drinking in the entire area.

For such areas, adequate effluent treatment techniques and appropriate methods of disposal are needed. Both areas demonstrate significant leaching into the groundwater of various chemical components leading to enrichment of various anions and cations, which ultimately suggests contamination from foreign sources. Therefore, it is time for the new definition of "water supply management" to shift to "water demand management." The key driver for improved groundwater quality in India should be effective management of effluent treatment and solid waste management, rather than the provision of various subsidies.

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