



Drinking Water Quality Assessment of Ground Waters of Bhachau - Kachchh, Gujarat, India with special reference to major Anions and Cations

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Abstract

The major objective of the present study is to assess the quality of the groundwater in Bhachau district which is the only source of drinking water in arid and semi arid zones. To collect the information on the level of pollution 34 water samples were collected from various village of Bhachau districts, Gujarat during February 2013. The Physico-chemical parameters analyzed were based on their clinical significance. Parameters like color, odor, pH, electrical conductivity, turbidity, salinity, total dissolved solids, total hardness, calcium and magnesium hardness, fluoride, potassium, sulphate, lithium, bromide, ammonium, calcium were analyzed. Most of the parameters are exceeding the permissible limit recommended by BIS. Fluoride content in the water sample ranged from 3.20 to 5.37 mg/L. Analysis of various water quality parameters indicated the contamination of groundwater in the selected sites.

Keyword: Water quality, ground water, physico-chemical, fluoride, bhachau taluka.

Introduction

Water is indispensable and one of the precious natural resources of this planet and groundwater is an important source of water supply throughout the world¹. Water is a prime need for human survival and industrial development and it is also considered as the only source of drinking water in many rural and small communities^{2,3}. The chemical constituents in groundwater is one of the major factors which decides the water for suitability for various purposes such as domestic, industrial, agricultural. Groundwater is getting polluted due to urbanization and industrialization in the recent times. Though this water contributes about 0.6% of the total water resources on earth, it accounts for rural domestic water needs (80%) and urban water needs (50%) in developing countries⁴. Geology of an area has great influence on water quality because in general ground water carries higher mineral contents than surface water and the quality of such waters also varies due to a change in chemical composition of the underlying sediments and aquifers^{2,3}. Groundwater quality determination assumes significance in the field of water quality management because of its inconsistent variation with groundwater table, geological and soil conditions and contamination through percolation and seepage etc⁵. The villages located near Bhachau are reported to encompass certain clinical problems such as kidney disorders, eye problems and cancers. Hence the present study was designed with this as a background since the villages subjected for study used ground water for drinking. Moreover there are no proper reports available regarding the groundwater quality of this particular area. Hence the water samples were collected from 7 different villages near Bhachau and were subjected for analysis of various anions and cations.

Material and Methods

Study area: The study area is Bhachau taluka, Kachchh district of Gujarat state, India. Its geographical co-ordinates is Latitude 23°17'0" north and Longitude 70°20'0"east. There are 72 villages situated in Bhachau taluka and total population is around 25,389 according the census report of 2001. The drinking water source of Bhachau taluka is ground water mainly they were consider the groundwater for their drinking purposes and for day today activities. Bore well is the only supply of ground water in Bhachau taluka which is distributed through pipeline. Hence the study was designed to evaluate the parameters significant for potability purpose and the concentration in the water was compared with the standards prescribed by WHO (World Health Organization) and BIS (Bureau of Indian Standards).

Sample collection: A total of 34 samples were collected from different villages located in Bhachau during the month of February 2013. Samples were collected and preserved in a pre-cleaned, sterilized polyethylene bottles. After collection, the samples were transported to the laboratory within 6 hrs and subjected to analysis for various parameters such as color, odor, pH, electrical conductivity, turbidity, salinity, total dissolved solids, total hardness, calcium hardness, magnesium hardness, fluoride, potassium, sulphate, lithium, bromide, ammonium, calcium, alkalinity, chlorides, magnesium, nitrite, nitrate, phosphate, sodium and lithium. Samples were estimated in the Laboratory by using Standard Procedures 6, 7. Fine grade chemicals were used throughout the study. All the reagents and standards required for the study was prepared using Millipore water.

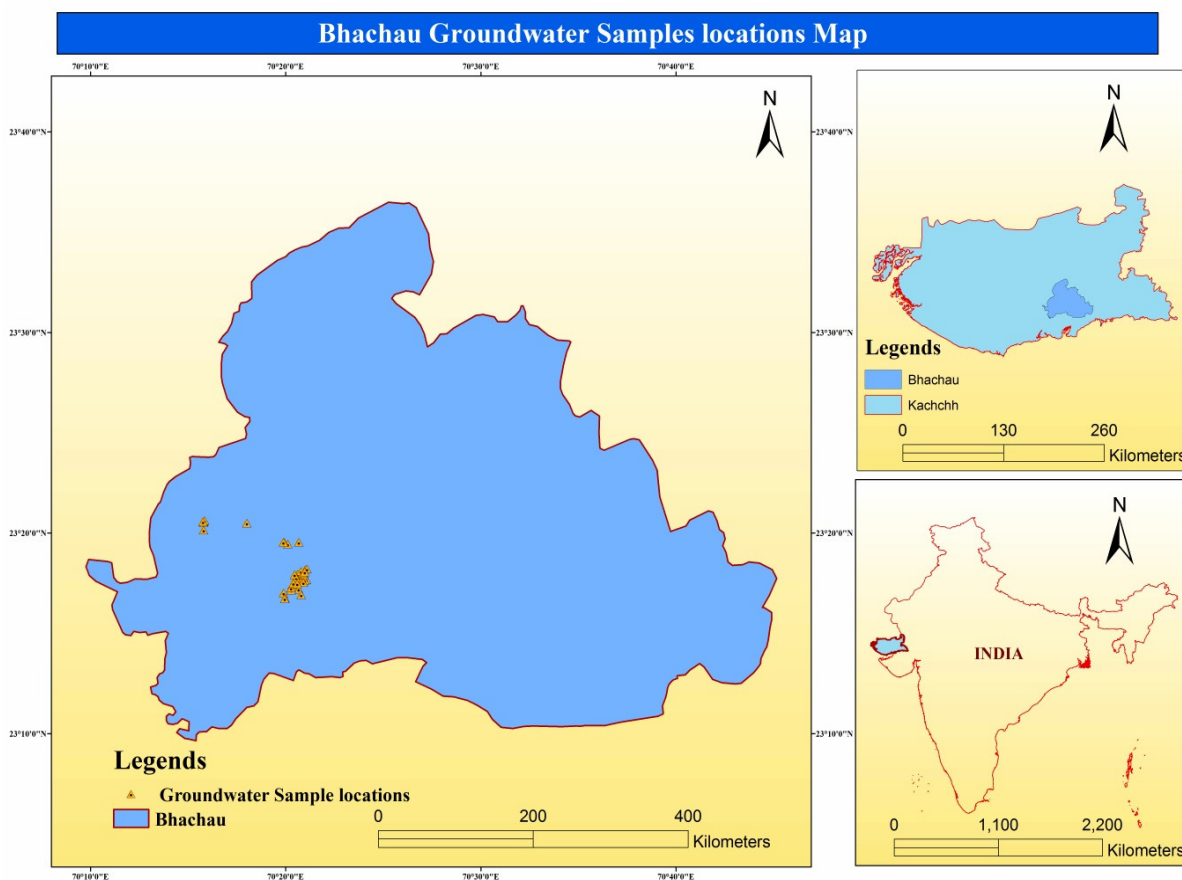


Figure-1
Map showing the study area in Kachchh district, Gujarat

Results and Discussion

Color: Color units of the water samples was recorded to be 10 in all 34 samples in the study area and which was exceeding the permissible limit of 5 (Pt.Co.units) recommended by BIS⁸ and there is no objectionable smell in the groundwater samples except the sample number 25 which shows a chlorinated smell. All samples were in the range of 10. In natural waters, color may occur due to the presence of humic acids, fulvic acid, metallic ions, suspended matter, industrial effluents⁶.

pH: The parameter pH generally indicates the acid or alkaline nature of any solution and usually does not bear any direct impact on consumers.. The data revealed that the pH value is ranged from 7.0 to 8.5. The maximum range found in the sample 14 and the minimum was observed in sample 26 and the average of the pH value found as 7.59. The pH value of all the samples does not exceed the recommended limit (6.5-8.5) of BIS⁸ whereas the water samples were slight alkaline in characteristic. Similar pH value 7.1 -8.4 for the ground water of selected area of Mysore city, Karnataka and they have stated that the reason for such conditions may due to different types of

buffers that may present in the ground water and presence of weak basic salt in the soil⁹.

Electrical Conductivity: In case of electrical conductivity, the value ranged between 298.50 μS to 3283.50 μS . The maximum value of EC observed in the sample 22 and the minimum value found in the sample 6 and 7, and the average of the electrical conductivity shown in the range 1574.45 μS . Around 52% of the sample which exceeds the permissible limits 1400 recommended by BIS⁸. Patil and Patil¹⁰ also found that high range of electrical conductivity was observed in Amalner Town ground waters in the range of 398 μS to 2827 μS .

Total Dissolved Solids: The Total Dissolved Solids ranged between 200mg/L to 2200mg/L. The maximum level found in the sample 22 and the minimum found in sample 28, 25, 20. Average TDS value is 1056 mg/L. About 76% of the sample which exceeds the BIS limit of 500 mg/L because incidence of higher level of TDS is considered to be objectionable. In general, salinity behavior of any water samples is characterized by total dissolved solids content. As per the classification¹¹, total dissolved solids for the water samples around 17 samples were found to be slightly saline. Similarly high level of TDS

ranging from 700 to 3200 mg/L groundwater samples in Kotputli Town, Jaipur, Rajasthan¹². This parameter in general gains its entry in to ground water through various means such as sea water intrusion, sewage, urban runoff, industrial wastewater¹³.

Turbidity: The maximum Turbidity found in the range of 3.0 – 8.0 NTU in sample 16 and the minimum value found in the range of 3 NTU in sample 1, the average value found in the range of 5 NTU. Almost 100% of the samples are in the prescribed limit of BIS. Turbidity nature of the water may be attributed due to colloidal and extremely fine dispersion of sediments, microorganisms and organic matter¹⁴. Similar values (0.3 to 1.4 NTU) of turbidity found in the study of Groundwater samples near Industrial Area, Cuddalore District, Tamilnadu¹⁵.

Total hardness: The Total Hardness is an important parameter of water quality whether it is to be used for drinking and Hardness of such water mainly depends upon the amount of calcium or magnesium salts or both¹⁶. The maximum Total hardness is found to be 630 mg/L in sample 10 and the minimum is observed as 104 mg/L in the sample 14. The maximum value observed for calcium hardness is 349 mg/L in the sample 16 and the minimum value 67 mg/L found in the sample 14. Similarly the maximum magnesium hardness 332 mg/L was seen in the bore well sample 10 and the minimum value 30 mg/L found in the sample 19 and 20. The average value of Total Hardness, Calcium Hardness and Magnesium Hardness was recorded in the range of 346 mg/L, 201 mg/L and 149 mg/L respectively. Around 48% of the samples were crossing the permissible limit recommended by BIS⁸ which 300 mg/L which may be due to presence of carbonate and bicarbonate hardness. Based on the classification¹⁷ for total hardness of the water, around 25 samples are very hard water and 3 samples are hard water and 6 samples are moderately hard water. Such a high concentration of total hardness observed in the Ground Water of Alathur Block –Perambalur, Tamilnadu, India¹⁸ they observed values recorded in the range 259 to 697 mg/L.

Salinity: In case of Salinity, maximum level found in the range of 2 ppt in the sample 8 and most of the sample having minimum level of 0.1 ppt. Around 50% of the sample shows a slightly saline characteristic in the water sample.

Ammonia: Ammonia concentration found as maximum of 0.52 mg/L in the sample 26 and the minimum as found as 0.1 mg/L found in sample number like 15, 16 and 27. Average concentration found as 0.13 mg/L. Most of the samples are below detectable limit and average level as 4.26 mg/L. The presence of Ammonia in any aquatic environment may be due to its release as an end product of decomposition of organic matter and industrial effluents. A contrary result where found in the study near municipal solid waste dumping sites in Jabalpur and the concentration found to the maximum of 4.3 mg/L¹⁹.

Bromide: Maximum level of bromide found in the range of 2.46 mg/L in sample number 1 and the minimum value range in 0. mg/L. Average bromide of the sample was found as 0.746 mg/L.

Fluoride: Fluoride in groundwater has drawn worldwide attention due to its considerable impact on human physiology^{20,21}. In general, incidence of fluoride depends on the geological, chemical and physical characteristic of aquifer, and also on the porosity and acidity of the soil and rocks. Similarly, industries and agricultural activities also act as secondary sources²². Though fluoride is considered essential at very lower concentrations for human beings, whereas higher concentration will lead to health defects. The maximum level of fluoride 5.37 mg/L found in the sample 31 and the minimum value found in the range of 3.20 mg/L in the sample 4. The average values detected as 4.43 mg/L. All the sample is not within the limit 1 mg/L recommended by BIS⁸. Researchers²³ also reported quite higher values of this element's contamination (0.03 - 16.6 mg/L) in the ground waters of Hisar region of Haryana.

Potassium: Potassium is an essential nutrient for both plant and human life which has its natural occurrence in ground water by weathering of rocks and minerals. The potassium values ranged between 1 mg/L (sample no. 5) to 33 mg/L (Sample no. 34) and the average potassium concentration was in the range of 14 mg/L. As per the studies conducted¹², higher values of potassium were observed (78 mg/L) in the groundwater Samples of Kotputli Town Jaipur, Rajasthan. Calcium ion is commonly present in the water.

Calcium: The maximum level of calcium occurred in the sample 16 in the range of 272 mg/L and the minimum value occurred 16.7 mg/L in samples 6 and 29. The average value of calcium in the water sample was recorded as 95 mg/L and it is found that 59% of the sample exceeds the permissible limits recommended by BIS⁸. It is found in great abundance in all natural waters and its source lies in the rocks which it is leached its concentration varies greatly in natural waters depending upon the nature of the basin⁶.

Magnesium: Magnesium in ground water samples ranged between from 7.4 mg/L - 80.6 mg/L. The minimum value was observed in sample No. 19 and 20 and the maximum in the sample No.10. The average magnesium concentration was found to be 35.7 mg/L. Magnesium is considered to be a essential metal at lower concentrations whereas it becomes toxic when it is at higher range and also gives unpleasant taste in the drinking water. Similar range of magnesium 28 to 81 mg/L in the Alathur block, Perambalur, Tamilnadu, India were also reported¹⁸.

Calcium and Magnesium Hardness: Calcium hardness is ranged between 67 to 349 mg/L. Magnesium hardness found to be between 30 to 332 mg/L A study carried out²⁴ in the

groundwater of Barpeta District, Assam, India showed high values of calcium and magnesium.

Sulphate: Sulphate is naturally occurring element result from leaching of gypsum and other common minerals. Maximum Sulphate concentration found in the range of 342.6 mg/L and a minimum of 0.001 mg/L. The recommended BIS limit for

sulphate in drinking water is 150 mg/L and only 9% of the sample exceeds the permissible limit. A contrary result found in the study conducted in the groundwater samples near an Industrial vicinity of Cuddalore District, Tamilnadu, India¹⁵ where the values were reported in the rang between 18 to 119 mg/L.

Table-1
Physico-chemical characteristics of ground water samples of Bhachau taluka, Kachchh, Gujarat

Sam	pH	EC	TDS	Co l	Tu r	T. H	Ca.H	mg.H	Sal	NH ₄	Br	F	K	Ca	S	T.A	Cl	Mg	NO ₃	NO ₂	P	Na
1	7.5	2338.05	1600	10	3	602	291.9	310.1	0.2	0.02	2.46	4.53	11.7	188	342.6	428	382.93	75.4	6.7	BDL	0.78	705.6
2	7.7	1940.30	1300	10	4	422	199.5	302.5	0.1	BDL	1.4	4.50	3.7	117	BDL	332	312.02	54.1	3.8	BDL	BDL	446.4
3	7.9	298.50	200	10	7	126	77.7	48.3	0	BDL	0.03	3.90	16.3	17.2	0.03	180	14.18	11.7	1.5	0.01	0.03	76.8
4	7.1	2686.6	1800	10	4	582	308.7	273.3	0.2	0.25	BDL	3.20	10.8	164	BDL	434	368	66.4	7.4	0.01	0.004	532.8
5	8	1194.0	800	10	4	272	144.9	127.1	0	BDL	0.8	4.30	1	86.2	0.01	212	191.46	30.9	3.6	0.02	0.002	288
6	8.1	298.50	200	10	6	134	77.7	56.3	0	BDL	0.05	3.30	14.8	19.6	BDL	166	21.27	13.7	1.2	0.03	BDL	68.8
7	8.2	298.50	200	10	5	128	81.9	46.1	0	BDL	0.04	4.58	14.2	17.2	0.01	160	14.182	11.2	1.4	0.07	0.001	51.2
8	7.6	2238.80	1500	10	6	570	268.8	301.2	2	0.08	0.15	4.15	12	140	BDL	368	375.84	73.2	8.7	0.09	BDL	454.2
9	7.2	2238.80	1500	10	6	588	291.9	296.1	0.2	BDL	0.10	4.48	8.2	145	0.001	414	354.57	72.0	6.9	BDL	0.001	529.6
10	7.5	2388.05	1600	10	6	630	298.2	331.8	0.2	BDL	1.05	4.51	9.2	149	BDL	432	375.84	80.6	7.7	BDL	0.001	451.2
11	7.3	1194.0	800	10	5	564	308.7	255.3	0.1	BDL	BDL	4.49	7.3	145	12.57	420	361.66	62.0	6.3	0.01	0.47	500.8
12	7.2	2686.60	1800	10	4	594	272.2	321.8	0.1	BDL	BDL	4.53	8.4	140	BDL	412	361.66	78.2	10.6	0.001	BDL	529.6
13	7.3	2388.1	1600	10	6	442	262.5	179.5	0	BDL	1.38	3.51	5.5	137	8.74	408	397.11	43.6	3.6	0.001	2.40	627.2
14	8.5	895.52	600	10	6	104	67.2	36.8	0	BDL	BDL	4.38	3.7	17.2	0.07	160	28.36	8.9	1.4	0.01	0.30	94.4
15	7.3	1492.53	1000	10	4	266	195.3	70.7	0.1	0.01	BDL	4.72	5.3	88	0.12	342	191.46	17.2	3.4	0.004	BDL	248
16	7.1	2985.0	2000	10	8	512	348.6	163.4	0.1	BDL	BDL	4.61	6	272	2.27	358	546.03	39.7	5.0	0.01	BDL	596.8
17	7.2	1791.0	1200	10	6	290	199.5	90.5	0	0.01	BDL	4.47	13.5	87.7	1.01	352	234	22.0	3.3	0.001	3.04	216
18	7.3	1492.50	1000	10	7	290	199.5	90.5	0	BDL	BDL	4.58	6.4	87.6	0.11	348	198.6	22.0	3.1	BDL	1.73	296
19	7.9	298.50	200	10	7	108	77.7	30.3	0	BDL	BDL	4.62	18	16.7	0.06	166	21.27	7.4	10.8	0.001	0.30	52.8
20	8.2	298.50	200	10	7	108	77.7	30.3	0.1	BDL	BDL	4.61	23.2	16.7	0.06	160	21.27	7.4	1.1	0.001	0.51	84.8
21	8	895.50	600	10	6	108	75.6	32.4	0	BDL	BDL	4.66	17.8	16.7	0.08	164	14.18	7.9	1.5	BDL	BDL	54.4
22	7.4	3283.50	2200	10	7	512	304.5	208	0.2	BDL	BDL	4.10	8	90.9	3.20	430	453.8	50.4	11.4	0.001	BDL	661
23	7.3	2985.00	2000	10	4	510	285.6	224	0.3	0.05	BDL	4.01	6	130	2.64	422	293.8	54.5	10.5	0.003	BDL	794
24	7.8	2985.00	2000	10	7	510	296.1	214	0.1	0.27	BDL	3.77	6.5	127	0.33	404	375.8	52.0	9.5	0.01	0.23	635
25	7.8	298.50	200	10	5	108	75.6	32.4	0	BDL	BDL	4.38	18.2	16.7	0.56	156	21.27	7.9	1.8	0.01	0.07	114
26	7	1791.00	1200	10	6	302	212.1	89.9	0	0.52	BDL	3.97	14.1	88.9	0.04	516	234	21.8	1.1	0.004	BDL	176
27	7.2	1492.50	1000	10	4	362	224.7	137	0	0.1	BDL	3.93	2.6	85.8	0.72	390	198.6	33.4	7.5	BDL	BDL	251
28	7.6	298.50	200	10	4	488	317.1	171	0.2	0.10	BDL	4.97	14.8	128	1.16	368	404.2	41.5	5.7	0.01	0.13	302
29	8.1	2985.00	2000	10	7	120	81.9	38.1	0	BDL	BDL	4.80	23.1	17.2	BDL	156	28.36	9.3	2.3	BDL	0.35	189
30	7.5	1194.00	800	10	4	284	193.2	90.8	0	0.18	BDL	4.94	31.6	78.1	0.74	352	163.1	22.1	4.2	0.003	BDL	248
31	7.8	1194.00	800	10	5	244	151.2	92.8	0.1	0.11	BDL	5.37	30.6	72.5	0.90	310	148.9	22.6	5.2	0.1	0.07	173
32	7.4	895.50	600	10	4	274	189	85	0	0.03	BDL	5.24	33	76	BDL	346	148.9	20.7	3.9	BDL	0.12	355
33	7.3	597.00	400	10	6	282	161.7	120	0	0.13	BDL	5.34	29.8	74.8	256.2	350	134.9	29.2	3.5	0.001	BDL	304
34	7.6	1194.00	800	10	4	294	189	105	0.1	BDL	BDL	5.30	32.6	76.8	278.3	350	163.1	25.5	3.9	BDL	0.49	347
Min	7	298.5	200	10	3	104	67.2	30.3	0	0.01	0	3.2	1	16.7	0.001	156	14.18	7.4	1.1	0.001	0.001	51.2
Max	8.5	3283.5	2200	10	8	630	348.6	331.8	2	0.52	2.46	5.37	33	272	342.6	516	546.03	80.6	11.4	0.1	3.04	794
Mean	7.58	1574.45	1055.88	10	5.41	345	200.21	147.12	0.12	0.13	0.74	4.43	13.76	92.07	35.09	322.52	222.19	35.18	4.98	0.017	0.52	336.89

Alkalinity: Alkalinity nature of the samples are generally attributed due to the presence of carbonates and bi-carbonates. Though alkalinity if not harmful to human health, its presence in the water imparts unpleasant taste. Alkalinity of water is due to the presence of bicarbonate, carbonate and strong bases. In case of Alkalinity, the samples subjected in the present study revealed the maximum alkalinity value of 516 mg/L and the minimum alkalinity of 156 mg/L. All the samples were compared with the BIS⁸ and found that 32% of the samples are exceeding the permissible limit of 400 mg/L. A study conducted in the bore well samples along the Vrushabhavathi river stream reported a similar total alkalinity values ranging between 68 to 660 mg/L²⁵.

Chloride: The chloride concentration was recorded maximum of 546 mg/L in sample No.16 and minimum 14 mg/L in the sample No. 21, 7 and 3. The average concentration of the chloride was found to be 225 mg/L. When the samples are compared with the BIS standard around 38% of the samples are exceeding the permissible limit 250 mg/L. Chloride in ground water gains its entry from various sources such as agricultural activities, industrial activities, geological formation, domestic water contamination and sea water intrusion in case on coastal stretches. Values of chloride ranged from 7.10 to 8.45 mg/L in the ground water samples of Bichi, Kano state of Nigeria as reported²⁶.

Nitrate: The major source of nitrate in ground water is due to excessive use of nitrogenous fertilizers, sewage, plant and animal matters etc and nitrate at higher levels in the drinking water may cause adverse effects on human and animal health. The concentration of nitrate in ground water samples ranged from 1.1 mg/L -11.4 mg/L. The minimum value was observed in the sample No. 20 and 26 and the maximum in sample No. 22. The average concentration of the nitrate was found to be 5.0 mg/L. All the samples are compared with the BIS standard and are found within the permissible limit 45 mg/L. Sivasankaran²⁷ reported that the ground water samples from Pondicherry region has high concentration of nitrate. Nitrate values from 1.10 to 5.70 mg/L in the water samples of Nujendla area in Guntur District, Andhra Pradesh, India has been reported²⁸.

Nitrite: Nitrite is the partially oxidized form of nitrogen found in very low concentration in natural waters. It occurs as an intermediate form during denitrification and nitrification reactions and presence of even minute quantity of nitrite in water is indicative of organic pollution⁶. The concentration of nitrite was found to be the maximum of 0.09 mg/L in the sample No.8 and the minimum of 0.001 mg/L in some samples. The average concentration of nitrite was found to be 0.02 mg/L.

Phosphate: Phosphate in the ground water samples was observed the maximum of 3.40 mg/L in the sample No. 13 and the minimum of 0.001 mg/L in some samples. The average of the phosphate was found to be 0.525 mg/L. Lower distribution

of phosphate concentrations in the ground waters of Tirupur was also reported²⁹.

Sodium: Sodium in the ground water samples was observed to the maximum of 794 mg/L and the minimum of 51 mg/L. Average sodium values were found to be 342 mg/L. Rout and Sharma³⁰ reported that the range of sodium varied from 5.25 to 35.49 mg/L in the Ambala cantonment area, Haryana, India. Reports on health effects at higher concentration of sodium ions in drinking water were also reported.

Conclusion

As a whole, this study concluded that most of the parameters exceed the permissible limits of BIS standards. Parameters such as Fluoride were found to be beyond the permissible levels (3.2-5.3 mg/L). Similarly, some significant parameters for potability such as total hardness, total dissolved solids, chloride, Total hardness etc. were also recorded at higher range. Thus from the present study it is very evident that the groundwater source is the only reliable source of drinking water for the residents in the study area. Among the various parameters studies, most of the chemical constituents do not comply with the water quality standards prescribed by BIS. People should be aware about the quality of water they are drinking and this problem will be more aggressive when similar water sources are used for drinking purpose for a longer period (Chronic) because of the possible clinical problems associated with these chemicals in the drinking water.

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