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Assessment of Physico-Chemical Quality of Ground Water in Some Rural Areas Receiving Industrial Wastewater Discharges in Nagpur District, Maharashtra State, India

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Abstract:
Water is a vital natural resource of the earth. Life is not possible on this planet without water. Due to increased human population, industrialization, use of fertilizers and manmade activity water is polluted to the marked extent with different harmful pollutants. Contaminated water cause severe ill effects on human health hence, it is necessary to check the quality of drinking water at regular intervals in terms of physico-chemical parameters such as pH, TDS, TH, Alkalinity, Chloride, Sulphate, Nitrate, Fluoride etc. The study was conducted for (12) different water quality parameters for six ground water samples collected from open wells and hand pump in some rural areas on and around Nagpur-Raipur National Highway No-6, in Nagpur District, M.S. India. In this area different types of industries are located, such as pulp and paper, food processing, oil Processing mills etc. The untreated effluents from these industries are directly discharged in nearby water bodies; due to this all water bodies in this area are getting polluted. The study includes analysis of physico-chemical parameters of groundwater samples and the values were compared with BIS (1992) and WHO. The results showed that, some of the parameters exceed the prescribed value of BIS and WHO, and hence the water in this area is not safe for human consumption without proper treatment.

Keywords: *Groundwater, Open wells, Industries, Physico-chemical parameters, BIS, WHO.*

1. Introduction

As per the United Nations Report published on 22 March 2010, contaminated and polluted water kill more people than all forms of violence including war. (United Nations, 2010) The crucial role ground water plays as a decentralized source of drinking water for millions of rural and urban families cannot be over-stated. According to some estimates, it accounts for nearly 80% of the rural domestic water needs, and 50% of the urban water needs in India. (Nayar and Tiwari, 2008). Ground water is generally less susceptible to contamination and pollution when compared to surface water bodies, but once contaminated, it is difficult to restore its quality. (Sasane and Patil, 2013, Hadithi, 2012). Rapid industrialization especially in developing countries like India, has affected the availability and quality of ground water due to over exploitation and improper disposal of waste. Hence, there is always a need for and concern over the protection and management of groundwater quality. (Patil *et al*, 2001). Industrial development results in the generation of industrial effluents, and if untreated, results in water, sediment and soil pollution. (Patil *et al*, 2012).Considering the above aspects of groundwater contamination, the present study was undertaken to investigate the possible impact of groundwater quality of some open wells and hand pump in rural areas on and around Nagpur-Raipur National Highway No.6 in Nagpur District, Maharashtra State, India.In this particular area, different industries are located like paper and pulp, food processing, oil processing mills etc. All these industrial effluents produce a wide variety of water pollutants that are directly discharged without any treatment in Nag-Nullah which originates from Nagpur city carrying waste water and domestic sewage. This Nag-Nullah flows through the study area contaminating the surface and ground water bodies before meeting a perennial river Kanhan at Sawangi village. Most rural people living in this area use ground water directly from available sources without any treatment and hence are exposed to a variety of water-borne diseases, and therefore it is necessary to assess the amount of water pollution.

The main objectives of the study include:

- Collection of ground water samples from open wells and hand pumps in rural areas on and around Nagpur- Raipur National Highway No-6, in Nagpur District, M.S. India.
- To assess the quality of groundwater consumed by rural people by Physical, Chemical parameters.

- To find the possible impacts of ground water pollution.

2. Materials and Methods

2.1. Study Area

Study area is located in Nagpur district, Maharashtra state, India. (Figure-1). The area covered is from Kadholi village to Mathani village about 30-35 km. east from Nagpur (Longitude 79^0 25'E and Latitude 21^0 10' N), A perennial River Kanhan and a sewage carrying Nag-Nullah flows through the area. People in this area use available ground water for drinking and daily needs. The literature survey reveals that no water quality management studies were made in this region so far hence; the present study was planned and undertaken. For the present study, six sampling sites are selected and labeled as S1, S2, S3, S4, S5, and S6.

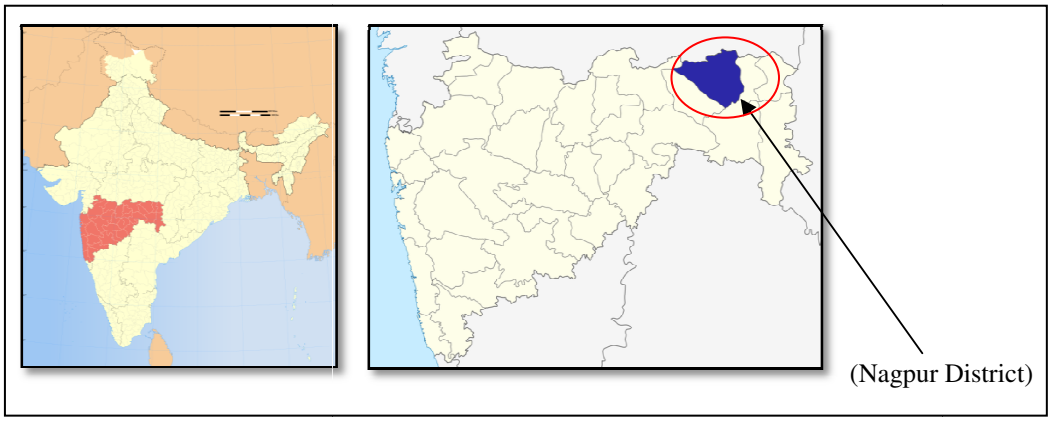

Figure 1: Location Map of the Study Area.

Site S1 is an open well near food processing mill near Kadholi village, Site S2 is an open well located at oil processing mill near Kadholi village, Site S3 is an open well near oil processing mill at Wadoda village (Wadoda village is in between Kadholi village and Mathani village),Site S4 is an open well near pulp and paper industry near Mathani village, Site S5 is an open well at Mathani village and Site S6 is a hand pump located near the Nag-Nullah carrying sewage at Borgaon Chikhana village.(Figure-2).

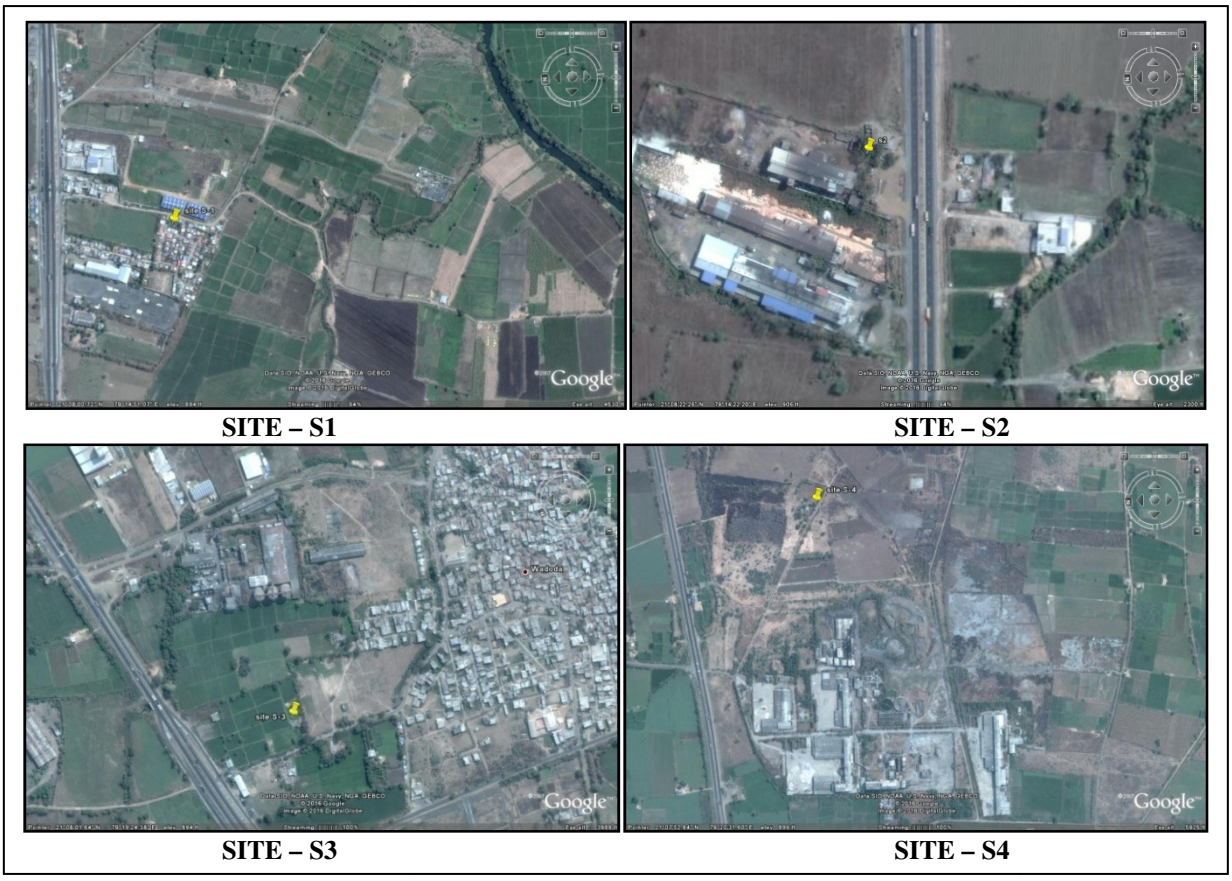

Figure2: Sampling Locations

2.2. Sample Collection

The ground water samples were collected from open wells and hand pump at different villages on and around Nagpur-Raipur National Highway No.6 in Nagpur District, Maharashtra State, India. The sites are represented in Table 1. The samples were collected in clean plastic cans of three-liter capacity for physicochemical analysis. Temperature, pH, were determined within the field of collection, the other parameters like EC, TDS, TH, Ca^{2+}, Mg^{2+}, TA, NO_3^-, SO_4^{2-}, chlorides, fluorides etc. were analyzed in the laboratory within the stipulated period. The collected samples were transferred to the laboratory by following all the precautions laid by standard methods (APHA, 1995). The samples were kept in refrigerator maintained at 4^0C until used. Physical and chemical parameters are analyzed as per the standard methods. (APHA, 1989, Trivedy and Goel, 1986).

S.N.	Name of Sampling Area	Sample Code	Source	Longitude
1	Kadholi village	S1	Open well	N 21^0 08'00.72" E 79^0 14'51.07"
2	Kadholi village	S2	Open well	N 21^0 08' 22.26" E $79^0$14'22.20"
3	Wadoda village	S3	Open well	N $21^0$08'01.64" E $79^0$19'24.38"
4	Mathani village	S4	Open well	N $21^0$07'52.84" E $79^0$20'31.60"
5	Mathani village	S5	Open well	N $21^0$08'15.30" E $79^0$21'09.70"
6	BorgaonChikhana village	S6	Hand pump	N $21^0$05'49.83" E $79^0$23'15.35"

Table 1: Sampling location.

2.3. Analysis

A total of six samples were collected and analyzed from January 2008 to December 2008 as presented in Table1. The temperature was determined using a thermometer on the spot, and the pH was measured by pH meter (Hanna Instrument pH ep (K) pocket sized pH meter.) Electrical conductivity was measured by using a digital conductivity meter (Century make). The conductivity meter was calibrated using 0.1 N KCL solution. Nephelo/Turbido meter was used for turbidity determination. Total Alkalinity (TA) was estimated by neutralizing with standard HCl acid. Total hardness (TH) and calcium (Ca^{2+}) as $CaCO_3$ were determined titrimetrically, using standard EDTA. The calculation of magnesium (Mg^{2+}) was done by subtracting the Ca^{2+} from TH value. The fluoride was estimated by SPANDS Spectrophotometric method (Systronic make). Turbidimetric method was employed for the estimation of sulphate (SO_4^{2-}); nitrate amount was estimated by using the Brucine method. Chloride was estimated by using Titration method. The reagents used for the analysis were AR grade and double distilled water was used for preparation of solutions.

All the results were compared with the BIS (1992) and WHO standards for drinking water quality. The result and comparison of sample parameters with the BIS (1992) and WHO standards of drinking water quality are presented in the following table 2.

S.N.	Parameters	S1	S2	S3	S4	S5	S6	ISO (10500:2004) (Desirable limit)	*WHO (Maximum allowable limit)
1	pH	8.13	8.08	7.69	8.04	8.12	7.89	6.5-8.5	6.5-8.5
2	EC (µS/cm)	667	689	665	1052	840	568	300-400	-
3	TDS (mg/L)	942	982	914	721	646	432	500	-
4	TURBIDITY(NTU)	8.69	9.28	4.43	5.37	4.26	1.97	5-10	-
5	TH (mg/L)	236	240	298	267	254	213	300	-
6	CALCIUM (mg/L)	211	213	270	237	231	195	75	75
7	MAGNESIUM(mg/L)	25	27	28	30	23	18	30	50
8	TA (mg/L)	611	679	871	562	588	742	200	120
9	CHLORIDE (mg/L)	335	240	409	366	370	331	250	250
10	SULPHATE (mg/L)	48.5	44.2	48.8	48.7	49.3	8.16	200	500
11	NITRATE (mg/L)	41.7	31.9	34.0	20.9	52.6	13.4	-	45
12	FLUORIDE (mg/L)	2.7	2.4	2.4	1.8	2.4	2.8	1	1-1.5

Table 2: Average results of physico-chemical parameters.
**WHO-World Health Organization.*

3.1. pH

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. The entire water samples under study are alkaline in nature. The pH values of water samples varied between 7.69 to 8.13 and were found within the limits prescribed by BIS and WHO.

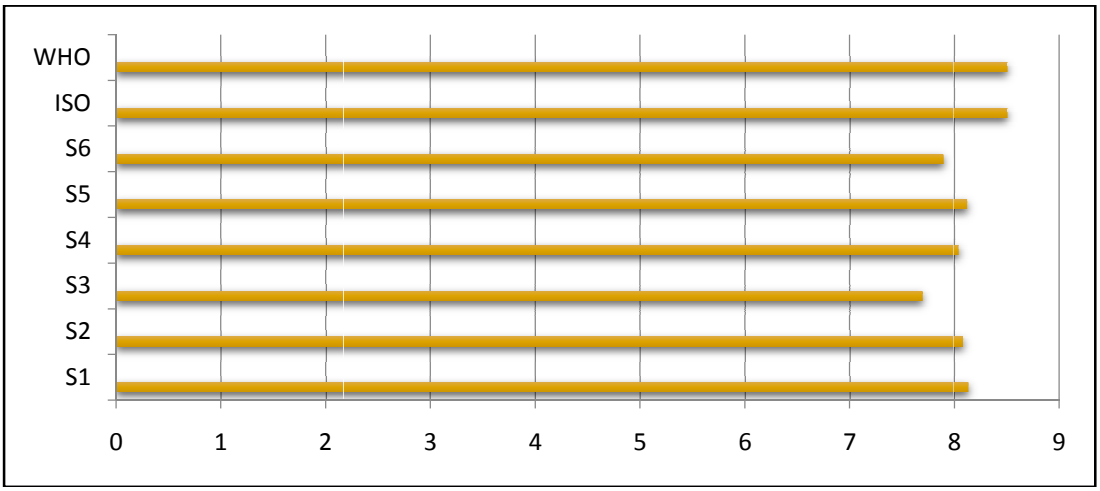

Figure 3: pH variations of the different samples compared with standards.

3.2. Electrical Conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts (Dahiya and Kaur 1999). EC values were in the range of 568 µS/cmto 1052 µS/cm. The entire studied sample showed higher amount of electrical conductivity than the permissible units, indicating the presence of high amount of dissolved inorganic substances in ionized form, due to industrial activities in this area.

3.3. Total Dissolved Solids (TDS)

A total dissolved solid indicates the salinity behavior of groundwater. TDS values were in the range of 432 mg/L to 721 mg/L. Water containing more than 500 mg/L of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/L is also allowed (Shrinivasan and Venkateswaralu, 2000). The entire sample except S6 showed higher TDS values than the prescribed limits given by BIS.

3.4. Turbidity

Suspension of particles in water interfering with passage of light is called turbidity. In most waters turbidity is due to colloidal and extremely fine dispersions. The turbidity values varied between 4.26 NTU to 9.28 NTU and found within the limits prescribed by BIS. Similar observations were reported by (Patil and Patil, 2011).

3.5. Total Hardness (TH)

Hardness is the capacity of water to neutralize soap and is defined as the sum of the Calcium and Magnesium concentration. Hardness increases the boiling point of water. (Trivedy and Goel, 1986). In the present study total hardness of water samples ranged between 213 mg/L to 298 mg/L. The maximum value of 298 mg/L of total hardness was recorded at site S3. The total hardness values of all the studied water samples were less than the prescribed limit of BIS. Most of the ground water samples of study area were found to be hard (100-300 mg/L) as suggested by (Sawyer and Mc Carty, 1967).

3.6. Calcium and Magnesium (Ca^{2+} and Mg^{2+})

Calcium and Magnesium are directly related to hardness. The calcium content of the sample ranged from 195 mg/L to 270 mg/L. The minimum value was found to be 195 mg/L in hand pump water at Borgaon Chikhana village and maximum concentration was found in open well sample taken from site S3. The amount of Calcium in the entire studied water samples were more than the prescribed limit of BIS and WHO. The Magnesium concentration in the water sample were ranged from 18 mg/L to 30 mg/L. Minimum concentration of Mg was recorded to be 18 mg/L in hand pump water sample (S-6). Maximum concentration was recorded in the open well sample taken near Mathani village (S4). The values of Magnesium in the entire water sample are below the permissible limit prescribed by BIS and WHO.

3.7. Total Alkalinity (TA)

Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide of Calcium, Sodium and Potassium. Total Alkalinity values of the studied water samples were recorded in the range of 562 mg/L to 871 mg/L. Total alkalinity values for the entire investigated groundwater samples were recorded to be higher than the values prescribed by BIS and WHO.

3.8. Chloride (Cl^-)

The Chloride concentration serves as an indicator of pollution by sewage. The high concentration of Chloride is considered to be an indication of pollution due to high organic waste of animal origin. (Rao et al, 2010). In the present analysis, Chloride concentration was found in the range of 240 mg/L to 409 mg/L. The concentration of Chloride in the entire studied water samples was found to be higher than the prescribed limit of BIS and WHO. Higher Chloride content in water samples may be due to contamination by sewage carrying Nag-Nullah in the study area.

3.9. Sulphate (SO_4^{2-})

Sulphate is the most common ion present in water as a result of leaching from gypsum and other common minerals. Discharge of industrial wastes and domestic sewage tends to increase its concentration. In the present study, Sulphate concentration varied between 8.16 mg/L to 49.3 mg/L and found within the prescribed limit.

3.10. Nitrate (NO_3^-)

Groundwater contains nitrate due to leaching of nitrate with the percolating water. Groundwater can also be contaminated by sewage and other wastes rich in nitrates. The concentration of nitrate in the study area varied in the range of13.4 mg/L to 52.6 mg/L. The nitrate concentration in all the samples except site S5 was below the prescribed limit of WHO.

High nitrate concentration in the water of study area may be due to percolation of Nitrate from fertilizers used in agricultural fields in the study area.

3.11. Fluoride (F^-)

Fluoride is an essential element for the normal growth of bones and teeth. According to World Health Organization, the amount of fluoride in water should be in the range of 1.0 mg/L to 1.5 mg/L. High concentration of fluoride in drinking water causes dental and skeletal fluorosis. The fluoride concentration in sample S6 which is a hand pump sample was observed maximum with 2.8 mg/L whereas minimum at site S1 which is a well sample with a value of 1.8 mg/L, when compared with other samples. In the present study, the concentration of fluoride in entire samples showed higher than the values prescribed by BIS and WHO and hence unfit for drinking.

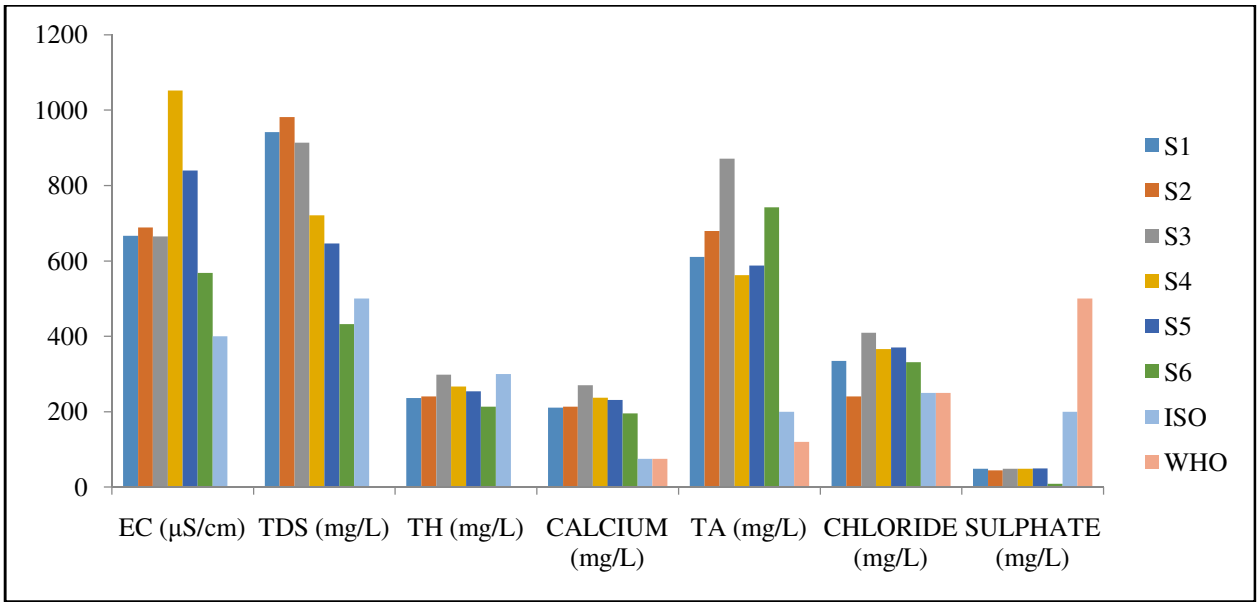

Figure 4: Variations of EC, TDS, TH, Ca, TA, Cl, and SO4 of different samples compared with standards.

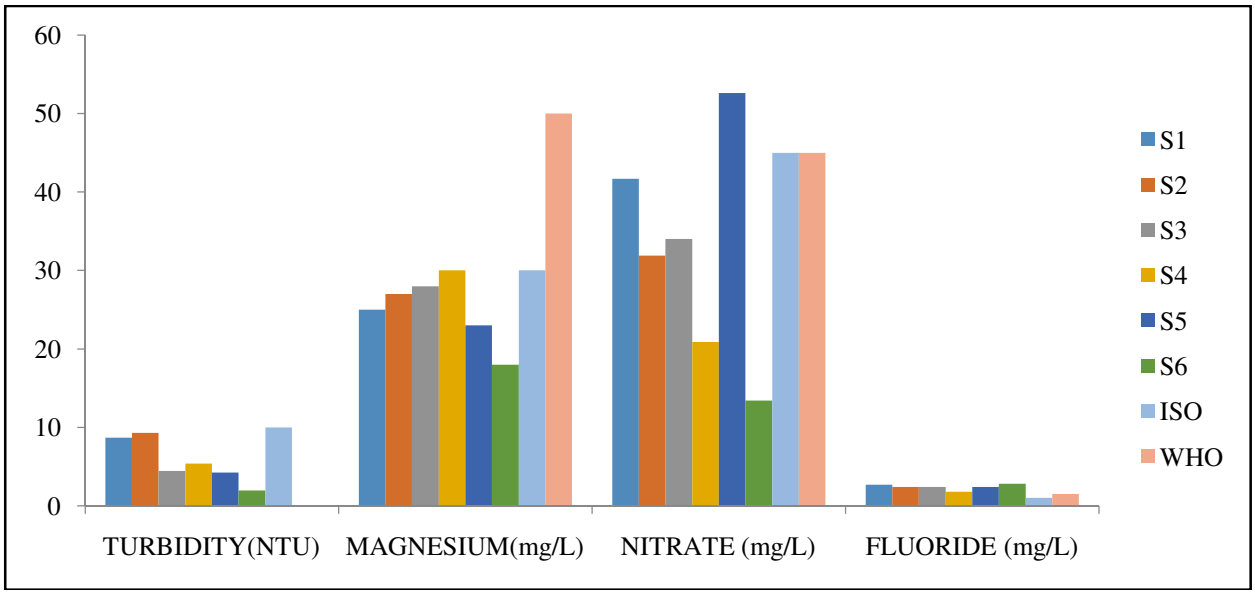

Figure 5: Variations of Turbidity, Mg, NO3 and Fluoride of different samples compared with standards.

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4. Summary and Conclusion

A total of six ground water samples were analyzed for twelve physico-chemical parameters. Deviations were observed by groundwater samples from water quality standards indicating groundwater pollution. Out of the twelve parameters studied, the amount of pH, Turbidity, Total Hardness, Magnesium and Sulphate in all the studied samples were found to be less than the values prescribed by BIS and WHO. The concentrations of other parameters like EC, TDS, Calcium, Total Alkalinity, Chloride, Nitrate and Fluoride in all the samples were observed higher than the standard values prescribed by BIS and WHO indicating the need of some treatment for minimization of the parameters. The higher concentration of some parameters may be due to leaching of chemicals and other pollutants from industrial activity, sewage run-off and agricultural activities in this particular area. It is concluded that the overall physico-chemical quality of water is not suitable for drinking purpose without proper treatment.

5. Acknowledgement

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