Assessment of Physico-Chemical Properties of Ground Water in Sankari Granite Mining Areas, Salem District, Tamil Nadu, India

C Sakthivel*, A Thirunavukkarasu

Department of Geology, Periyar University, Salem, Tamil Nadu, India

Research Article

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***For Correspondence:** C Sakthivel, Department of Geology, Periyar University, Salem, Tamil Nadu, India

E-mail: petrosakthi25@gmail.com

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ABSTRACT

A study was carried out in a granite mining area in the Sankari area to evaluate the current status of physicochemical contaminants and their sources in groundwater. The groundwater samples collected from mining and residential areas at ten (18) different locations were analysed. The physico-chemical parameters such as pH, DO, EC TDS, alkalinity, turbidity, calcium hardness, magnesium hardness, total hardness, nitrate, fluoride, iron, and chloride have been analysed. The results showed that among the mining and residential locations, many of the estimated physico-chemical parameters were similar. WHO and APHA standards. The basic physiochemical properties of the collected groundwater samples have been analysed. Comparative data analysis for the samples based on the analysed parameters has been made. The highest possibility of water quality issues that affect the day-to-day consumption of groundwater for the domestic needs of the people has been emphasized.

Keywords: Physicochemical contaminants; Groundwater; Mining and residential; WHO and APHA standards

INTRODUCTION

Water resources have played a critical and vital role throughout history in the growth and context of all societies and continue to be a factor important in the economic growth of all societies. In societies like ours with developing economies, the optimum development, efficient utilization, and effective management of their water resources should be the dominant strategy for economic growth, but in recent years, the unscientific management and use of these resources for various purposes almost invariably has created undesirable problems in their wake, including water logging and salinity in the case of agriculture use and environmental pollution of various limits as a result of mining, industries, and municipal use[1]. Water is one of the most indispensable resources and is the elixir of life. It constitutes about 70% of the body weight of almost all living organisms. Life is not possible on this planet without water. It exists in three states: Solid, liquid, and gas [2-5]. It acts as a medium for both chemical and biochemical reactions and also as an internal and external medium for several organisms. About 97.2% of the water on earth is salty, and only 2.8% is present as fresh water, of which about 20% is ground water. Groundwater is highly valued because it has certain properties not possessed by surface water [6-8].

Significance of study

The present work attempts to study the physicochemical properties of ground water in the Sankari area, which is situated 43 km from Salem city. The results of the study will help in gathering significant data pertaining to the quality status of groundwater in the Sankari area. The outcome of the study may help groundwater conservation managers, technocrats, and urban planners improve and restore groundwater.

Objective

To determine the physico-chemical characteristics of different groundwater samples in and around the granite mining area of Sankari.

MATERIALS AND METHODS

Study area

The present study area, Salem district, south India, has been chosen for conducting the study. The study area is located between latitudes 110 29’56.59" N to 110 30’15.92" N and longitudes 770 51’19.50" E to 770 51’40.49" E (Figure 1). The area of the selected study area is 65.25 km^2 . The limestone mines and the surrounding areas are well connected by roads. Physiographically, the area is characterised by a plain topography with a gentle slope, which consists of mainly limestone associated with gneiss and hard rock formations. The climate of the area belongs to a tropical wet and dry climate. The average annual rainfall of the study area is 950.5 mm. The southwest and northeast monsoons together account for approximately 85% of the rainfall. The Precambrian crystalline basement occurs at a depth of about 130 m below ground level [9-11].

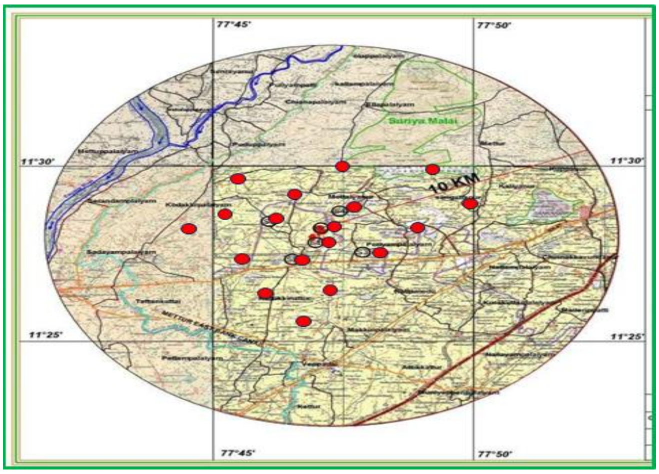
Water sampling

During the study, sampling was carried out at the different sites in the Sankari area (mining and residential). The sampling and analysis work for this study started in January 2022 and has been extended up to September 2022. Samples were collected in pre-cleaned 2 L polythene bottles with the necessary precautions.

Sample container: For sampling, plastic bottles were used. Before sampling, the bottle was soaked in HCL and rinsed with double-distilled water. The necks of the bottles were tightly sealed [12].

Sample collection: For sampling, the bottle has been rinsed 2 to 3 times for the sample to be examined, and after samples were collected from different sites of Sankari mining and residential areas, all samples are collected from hand pumps, open wells, and dug wells that are used for drinking water and are situated in different sites in the study area. Complete information was recorded about the source and the conditions under which the samples were collected [13-16].

Figure 1. Sample location map of the study area.



Water analysis: During the present study, groundwater samples were collected and analysed for various physiochemical parameters to ascertain the characteristics of the groundwater in the Sankari area [17-20]. All the samples were examined to determine pH, DO, EC TDS, alkalinity, turbidity, calcium hardness, magnesium hardness, total hardness, nitrate, fluoride, iron, and chloride using standard methods.

RESULTS AND DISCUSSION

pH

pH is the measure of acidity or alkalinity in water. The pH values of residential areas are within the permissible limits of WHO standards (7.0–8.5). The pH value is found between 7.05 and 7.71. This may be attributed to different types of buffers normally present in groundwater. The variations in pH are relatively small. However, the values reveal in the mining areas the slight alkaline nature of the ground water. The mild alkalinity indicates the presence of weak basic salts in the soil. The mild alkaline nature suggests that approximately 95% of the CO_2 in water is present as bicarbonate. pH is considered an important ecological factor and provides an important piece of information in many types of geochemical equilibrium or solubility calculations.

Alkalinity (Alk)

The ranges of alkalinity have been found to be between 164 and 396 mg/l in the mining and residential areas of Sankari. In the mining area, it has been found between the ranges of 221-242 mg/l, whereas in the residential area of Sankari, it has been found between 164 and 396 mg/l, which is also shown in Table 1.

Total Dissolved Solids (TDS)

The Total Dissolved Solids (TDS) values of the sampling area are more or less within the permissible limits of the WHO (500 ppm), except for one mining site, which has a very high concentration. The high TDS value may also be due to the presence of granitic materials in that area, which are resistant to dissolution. High levels of TDS may be aesthetically unsatisfactory for bathing and washing. Table 1 show that the residential area TDS values are between 226-475 mg/l, whereas the mining areas of Sankari are between 224-1790 mg/l. The sample (GW-10) of mining areas shows very high concentrations of TDS in every month of sampling, whereas the GW-11 and GW-12 are not detected in the month of May.

Electrical Conductivity (EC)

The importance of EC is its measure of salinity, which greatly affects the taste and thus has a significant impact on the user's acceptance of the water as potable. Electrical conductivity talks about the conducting capacity of water, which in turn is determined by the presence of dissolved ions and solids. The higher the ionizable solids, the greater the EC. The WHO permissible limit for EC in water is 600 μ mhos cm^1. When this exceeds 3000 μ mhos cm^1, the germination of almost all the crops will be affected, which may result in a much reduced yield. The electrical conductivity of water is a direct function of its total dissolved salts. The values of EC in residential areas are between 97 and 645 μ mhos cm^1, whereas the values of EC in mining areas are between 878 and 469 μ mhos cm^1.

Turbidity (NTU)

The ranges of turbidity have been found between 2.3 and 1.1 Nephelometric Turbidity Unit (NTU) in the mining and residential areas of Sankari. In residential areas, it has been found between the ranges of 2.0 and 1.1 NTU, whereas in mining areas like Sankari, it has been found between 2.3 and 1.5 NTU, which is also shown in Table 1.

Table 1. The mean values of the various physico-chemical parameters of groundwater samples.

	Mining sites	pH	Alk	TDS	EC	NTU	DO	Ca	Mg	T.H	NO^{3-}	F^-	Fe	Cl^-
SANKARI	GW-1	7.57	232	348	450	2	7.7	72	19	260	10	1	0.16	22
	GW-2	7.5	238	226	438	1.8	7.4	79	21	284	9	0.83	0.14	25
	GW-3	7.48	230	234	454	1.9	7	74	18	259	10	1.05	0..11	19
	GW-4	7.34	396	1248	1500	1.8	7.8	204	82	852	74	0.39	0.12	22
	GW-5	7.3	370	803	1474	1.9	7.5	186	88	826	72	0.28	0.14	0
	GW-6	7.4	388	812	1490	1.5	7.2	193	80	811	83	0.31	0.11	0
	GW-7	7.59	230	475	730	1.2	6.2	94	15	296	25	0.27	0.16	36
	GW-8	7.43	236	385	738	1.4	6.5	91	17	297	27	0.23	0.19	31
	GW-9	7.55	242	375	720	1.1	6.8	90	11	270	31	0.29	0.23	39
	GW-10	7.18	366	1790	2750	2	6	237	40	760	25	0.72	0.14	35
	GW-11	7.35	358	0	0	2.3	5.9	230	44	755	0	0.77	0.16	0
	GW-12	7.05	372	0	0	2	6.2	227	45	752	0	0.65	0.11	0
	GW-13	7.71	228	322	495	1.5	5.1	56	29	252	6.3	1.05	0.43	24
	GW-14	7.68	221	250	483	1.6	5.6	52	25	233	6.7	1.1	0.41	27
	GW-15	7.65	236	246	476	1.5	5	48	32	251	7	1.02	0.38	24
	GW-16	7.35	176	329	485	1.8	4.9	61	24	252	25	0.12	0.69	28
	GW-17	7.32	179	248	480	1.6	4.8	55	22	228	22	0.17	0.72	24
	GW-18	7.38	164	242	468	1.9	5	59	25	250	23	0.2	0.62	27

All the values are expressed in mg/l except pH and EC. EC–micromho cm^{-1}; Turbidity-NTU.

Dissolved Oxygen (DO)

The condition in the case of Dissolved Oxygen (DO) is slightly complicated since, in contrast to other pollutants, the quality of water is enhanced if it contains more oxygen. An ideal DO value of 5.0 mg/l is the standard for drinking water. In natural waters, DO values vary according to physicochemical and biological activities. The DO values of the mining area are more or less below the permissible limits of the WHO (6 ppm). The ranges of DO have been found to be between 7.8 and 4.8 mg/l in the mining and residential areas of Sankar. In residential areas, it has been found between the ranges of 7.7 and 5.0 mg/l, whereas in mining areas in Sankari, it has been found between 7.8 and 4.8 mg/l.

Calcium hardness (Ca)

Calcium comes from natural sources like granitic terrain, which contains a large concentration of this element. The result shows that calcium values for most samples in mining and residential areas lie within the WHO level (100 ppm), except in January and May in mining areas of Sankari. Calcium is an ion of total hardness, and hence they are interrelated. High values of calcium hardness in the study area may be due to the cationic exchange with sodium. However, low values do not mean that it is not influenced by the pollutants; it might be due to the reverse cationic exchange with sodium. (*i.e.,* sodium ions replace Ca ions, thereby reducing their concentration in groundwater after percolation. In the study, values of calcium hardness were within the permissible level of the WHO. The range of calcium hardness has been found to be between 237 and 48 mg/l in the mining and residential areas of Sankari. In residential areas, it has been found between the ranges of 94 and 48 mg/l, whereas in mining areas in Sankari, it has been found between 237 and 55 mg/l.

Magnesium hardness (Mg)

Magnesium comes from natural sources like granitic terrain, which contains large concentrations of these elements. The result shows that magnesium values for most samples in mining lie very well within the safe limits of the WHO (150 ppm). Magnesium is supposed to be non-toxic at the concentration generally found in natural water. The range of magnesium hardness has been found to be between 88 and 11 mg/l in the mining and residential areas of Sankari. In the mining area, it has been found between the ranges of 88 and 22 mg/l, whereas in the residential area of Sankari, it has been found between 32 and 11 mg/l.

Total Hardness (TH)

Hardness is the property of water that prevents lather formation with soap and increases the boiling point of water. The total hardness is an important parameter of water quality, whether it is to be used for domestic, industrial, or agricultural purposes. It is due to the presence of excess of Ca, Mg and Fe salts. The carbonate and bicarbonate concentrations are useful to determine the temporary hardness and alkalinity. The alkalinity is mainly due to bicarbonates. The maximum total hardness value was observed as 297 mg/l at residential area and minimum was 228 mg/l at mining area.

Nitrates (No^{3-})

The high nitrogen content is an indicator of organic pollution. It results from the addition of nitrogenous fertilizers, the decay of dead plants and animals, animal urine, etc. They are all oxidized to nitrate by natural processes, and hence nitrogen is present in the form of nitrate. The increase in one or all of the above factors is responsible for the increase in nitrate content. The groundwater contamination is due to the leaching of nitrate present on the surface with percolating water. The nitrate content of mining and residential areas is well within the permissible limit of WHO (50 ppm) except in the month of January in mining areas, whereas in the month of May, the samples GW-11 and GW-12 were not detected. The low nitrate content may be due to less usage of nitrogen fertilisers and less disposal of waste around study areas. The concentration varies from 83 ppm to 6.3 ppm. Nitrogen from untreated or partially treated wastewater discharges and manure may be either organic or ammonium form, while nitrogen from chemical fertilizers will typically be in ammonium or nitrate form [21]. Ammonia volatilization is a physicochemical process where ammonium–nitrogen is known to be in equilibrium between the gaseous and hydroxyl forms and it is pH (with an alkaline pH favouring the presence of aqueous forms of NH_3 in water, while at acidic or neutral pH, the ammonium–nitrogen is predominantly in ionic form) and temperature dependent (low temperature ammonium ion predominant, while high temperature ammonia ion present) [22-24].

Fluoride (F^-)

Fluoride occurs in nature as fluorspar (fluorite), rock phosphate, triphite, phosphorite crystals, etc. Among the factors that control the concentration of fluoride are the climate of the area and the presence of accessory minerals in the rock mineral assemblage through which the groundwater is circulating. In this study, the fluoride concentration of all the sampling areas lies within the range of the WHO permissible limit. The source of fluoride in these water samples may be the weathering of rocks, phosphatic fertilisers used for agriculture, or sewage sludge. The percolation of phosphatic fertilisers from the agricultural runoff from the nearby lands and the discharge of domestic waste or waste from the surrounding industries increase the fluoride values. This study shows all values are within the permissible level of WHO. The concentration found during the study period was between 1.10-0.12 ppm in residential areas; it varies between 1.10-0.23 ppm in mining areas; and its concentration varies between 0.77 and 0.12.

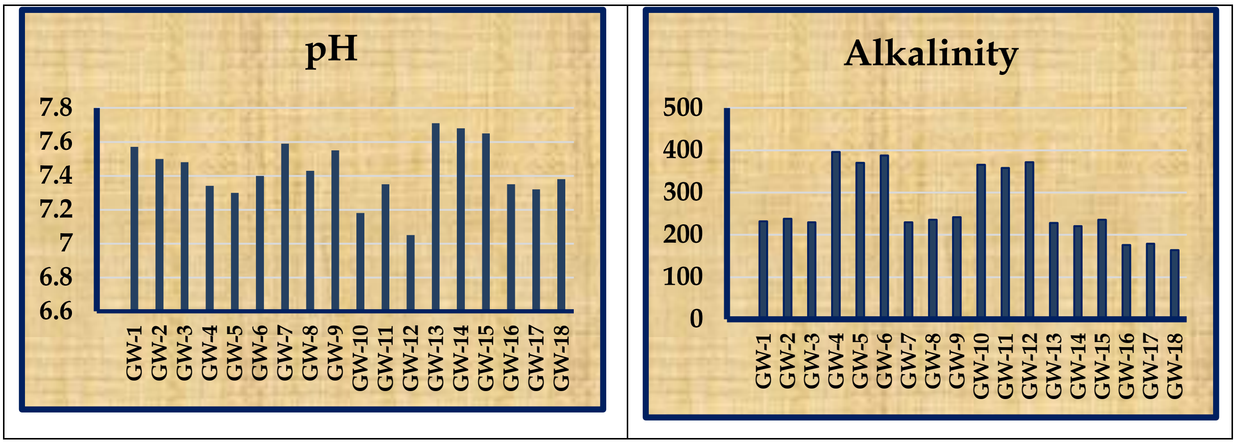
Iron (Fe)

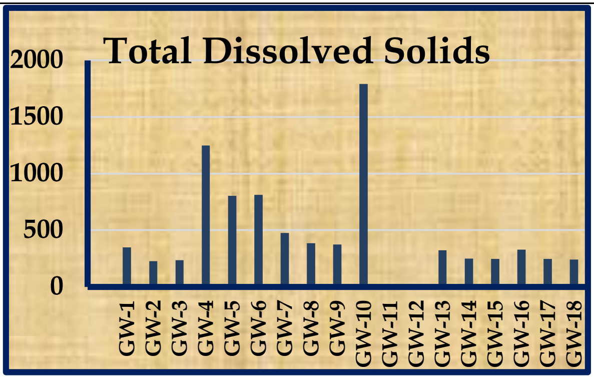
The main sources of iron in ground water are naturally occurring as a mineral from sediment and rocks or from mining, industrial waste, and corroding metals [25]. The ranges of iron have been found to be between 0.72-0.11 ppm in the mining and residential areas of Sankari, which are under WHO guidelines (1.0 ppm). From Table 1, it is also shown that all sites' concentrations are within the permissible limits of WHO. The high concentration of iron causes a bitter, astringent taste to water and a brownish colour to laundered clothing and plumbing fixtures.

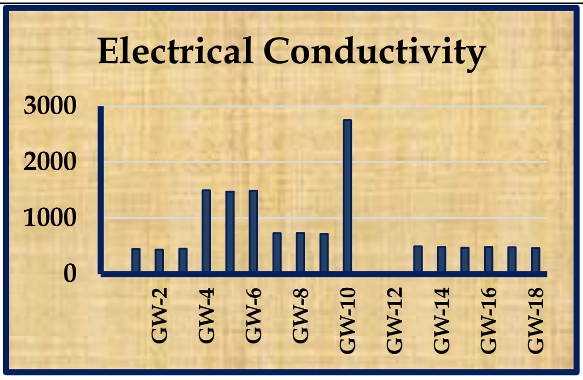
Chloride (Cl^-)

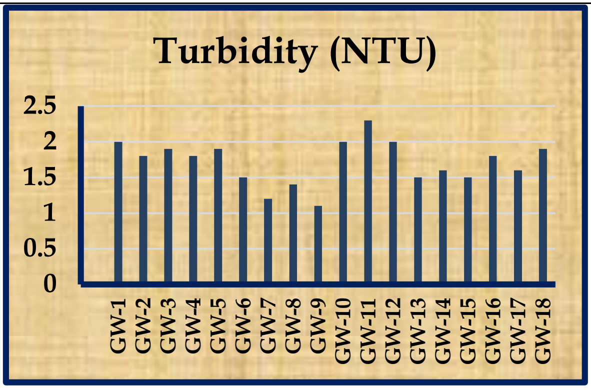
Chloride occurs naturally in all types of water [26-28]. Chloride in natural water results from agricultural activities, industries, and chloride-rich rocks. High concentrations of chloride are due to the invasion of domestic wastes and disposals by human activities. In the study areas, chloride levels are within the permissible limit of the WHO (250 ppm), which indicates less contamination of chloride. The ranges of chloride have been found to be between 39 and 19 mg/l in the mining and residential areas of Sankari. In residential areas, it has been found between the ranges of 39 and 19 mg/l, whereas in mining areas in Sankari, it has been found between 35 and 34 mg/l, whereas the two samples in the months of January and May were not detected (Figure 2).

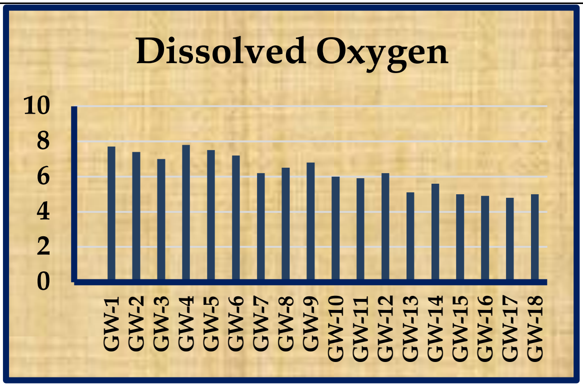
Figure 2. Groundwater analysis of physico-chemical parameters of granitic area.

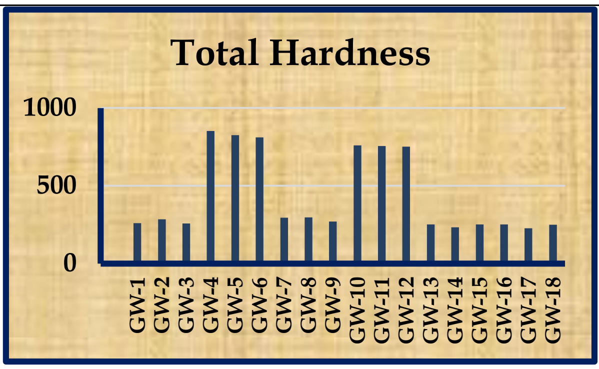


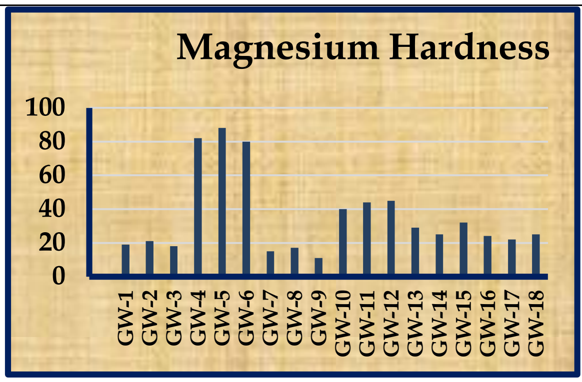

Total Dissolved Solids
2000
1500
1000
500
0
GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16 GW-17 GW-18

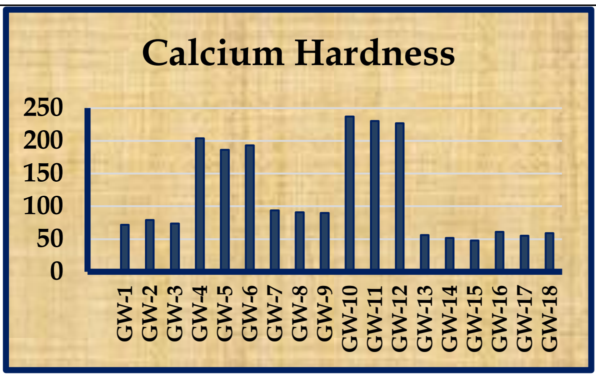

Electrical Conductivity
3000
2000
1000
0
GW-2 GW-4 GW-6 GW-8 GW-10 GW-12 GW-14 GW-16 GW-18

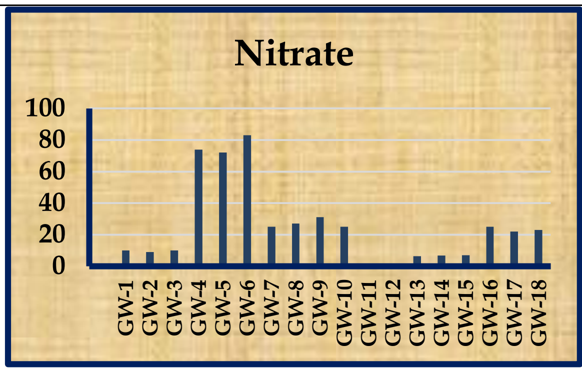

Turbidity (NTU)
2.5
2
1.5
1
0.5
0
GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16 GW-17 GW-18

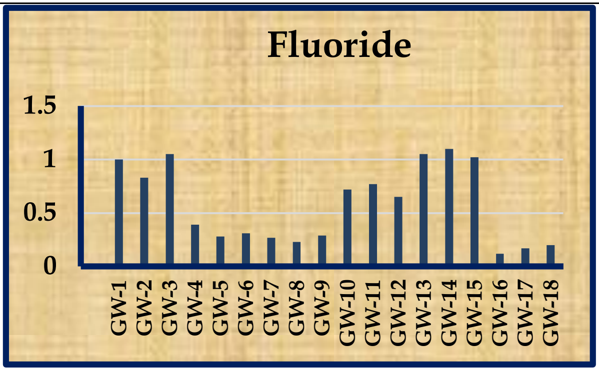

Dissolved Oxygen
10
8
6
4
2
0
GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16 GW-17 GW-18

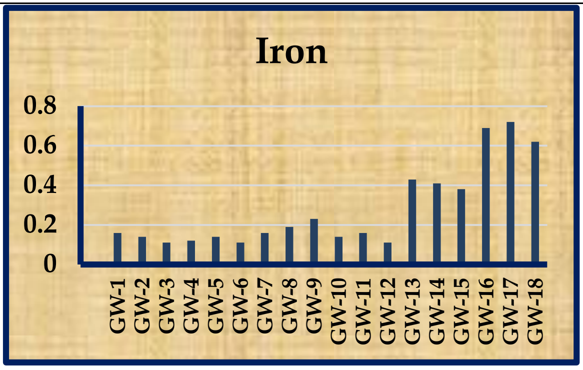

Total Hardness
1000
500
0
GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16 GW-17 GW-18

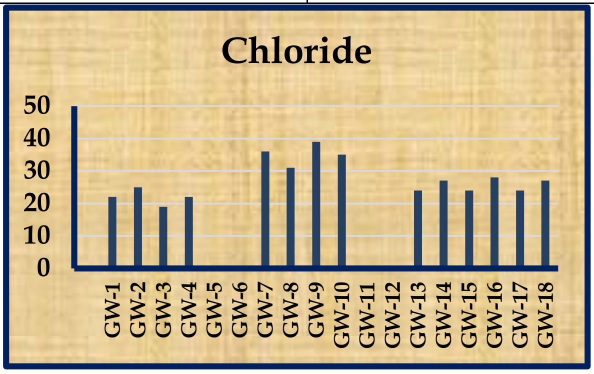

Magnesium Hardness
100
80
60
40
20
0
GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16 GW-17 GW-18


Calcium Hardness
250
200
150
100
50
0
GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16 GW-17 GW-18


Nitrate
100
80
60
40
20
0
GW-1 GW-2 GW-3 GW-4 GW-5 GW-6 GW-7 GW-8 GW-9 GW-10 GW-11 GW-12 GW-13 GW-14 GW-15 GW-16 GW-17 GW-18







CONCLUSION

The groundwater of the Sankari area was collected and analysed for various physico-chemical parameters. The results of the above work show that most of the physico-chemical parameters are well within the acceptable limit except for some samples of E.C., calcium, nitrate, and D.O. in mining areas in the month of January, which mostly exceeded the value of WHO. Dissolution of rock minerals in groundwater is a reason for pollution. The high level of contamination may be the outcome of high human, industrial, and agricultural activities in their locality. All the above results confirm that the groundwater quality is not up to par and is slowly degrading. Even though at present the condition is not very bad, if the same continues in the future, the groundwater source will be completely polluted and unfit for portability and other purposes. It is time to preserve and protect this valuable ground source. For these reasons, various measures have to be taken to control the contamination from different sources. These include proper management of mining waste, proper mining technique, and, above all, public awareness, which is a must for the conservation of these precious groundwater resources.

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