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GROUNDWATER QUALITY IN HANDIGUNDI STATE FOREST BLOCK OF RAMANAGARAM TALUK, KARNATAKA, INDIA

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ABSTRACT

The paper focused on the groundwater quality in Handigundi Quarry area of Karnataka, India. Quarrying causes grave disturbances in to the water regime of the region. Water quality undergoes great change, as the hydrogeochemical processes are very slow and the change may continue for decades leading to degradation of natural environment. The dust generated from the quarrying activities and the erosion of loose waste materials from excavated land and dumps of the mining and quarrying areas causes siltation and eutrophication of the water bodies. Groundwater samples from the study area showed low concentration of Nitrates and 60% of the samples showed highest turbidity and exceeded the permissible limits, 90% of the samples showed higher amount of dissolved solids near the crushing quarries. These groundwater samples showed higher levels of calcium and are not desirable for household uses because of the consumption of more soaps and cleaning agents and also not fit for industrial use because of their scale forming nature. However the water can be used for irrigation purposes, as the Ca is an essential element for the normal plant growth.

Keywords: Groundwater, Physicochemical Characteristics, Quarrying, Pre-monsoon, Post-monsoon

INTRODUCTION

Water is a precious natural resource available on the plant earth and it is an essential constituent of all animal and vegetable matter. Water is essential not only for the sustenance of human life and activities but also for the quality of life. It is the essence of life on earth and totally dominates the chemical composition of all organisms. Earth consists of 71% of water and 29% land. Of this 71% available water, only 3% of the total global content of approximately 1.4 billion cubic meter is fresh water and suitable for human use. Of this again 77.2% is permanently frozen, 22.4 % occurs as ground water and soil moisture. 0.35% is contained in lakes and wetlands and less than 0.01% in rivers and stream **[1]**. This small amount of fresh water since, a decade has been subjected to different levels of ecological stress by increasing pace, green revolution, population explosion, urbanization and industrialization, in the public or private sectors. Hence it is necessary to have an ecological balance.

Mining quality of water undergoes great change, as the hydrogeochemical processes are very slow and the change on ground water quality may continue for decades leading to degradation of natural environment **[2, 3]**. Quarrying causes grave disturbances in to the water regime of the region. The dust generated from the quarrying activities and the erosion of loose waste materials from excavated land and dumps of the mining and quarrying areas causes siltation and eutrophication of the water bodies. The objective of this paper is to study the physicochemical characteristics of groundwater in Handigundi State Forest of Karnataka.

MATERIALS AND METHODS

Study Area

Handigundi State Forest Block of Ramanagaram Taluk is located 45 km west of Bangalore covering an area of 677.03 sq km. The latitude of the area is 12º30¹ to 13º55¹ N and longitude 77º 15¹ to 77º 25¹. The topography is rugged rugged granitic and gneissic terrain with a maximum elevation of 960m and a minimum of 600m above the MSL, characterized by open undulating plain. Uplands are bare / covered with few shrubs, lowlands with a series of irrigation tanks. The rock type mainly granite and gneissic complex which are referred to as CLOSPET granite and PENINSULAR gneisses respectively. The rivers like Arkavathi, Vrishabhavathi and Suvarnamukhi are the chief water resources in the study area.

Besides there are large irrigation tanks like Nelligudda, Alahallikere, Tenginamaradadoddi kere etc and a few small other water bodies.

Sampling and Characterization of Groundwater Quality

Ground water samples were collected from 20 different sampling stations which are present in and around the quarries. Samples B1 to B10 were collected from crushing area and samples B11 to B20 from ornamental stone quarry areas.

To evaluate the groundwater quality status of the study area, 20 samples were drawn from bore wells during pre and post monsoon seasons from crushing area and ornamental stone quarry areas **(Table 1)**. The samples were analyzed for pH (pH meter), electrical conductivity (Conductivity meter), turbidity (Nephelometer), total hardness (EDTA Titrimetry), total dissolved solids, calcium and magnesium hardness (Titrimetry), Sulphates (Turbidimetry), Chlorides (Argentiometry), Fluorides (Fluoride meter), Sodium and Potassium (Flame photometer method), Iron, Nitrates and Phosphates (Spectrophotometry) following the standard methods **[4]**.

Table 1: Ground Water Sampling Stations

B1 – Bidadi	**B11 - Kailancha**
B2 - Hultur hosadoddi	**B12 - Nellamale**
B3 – Xanadu	**B13 – Ammanapura**
B4 – Kallugopanahalli	**B14 - K.G.Hosahalli**
B5 – Kenchenkuppe	**B15 - Chikkenahalli**
B6 – Dasapannadoddi	**B16 - Bethimgere**
B7 - Janatha Site Colony	**B17 – Mudavadi**
B8 – Billekempanahalli	**B18 - Lakkasandra**
B9 – Kempanahalli	**B19 -Urghahalli**
B10 – Tammanadoddi	**B.20 – Ramanagaram**

RESULTS AND DISCUSSION

Physicochemical characteristics of ground water samples were for pre monsoon **(Table 2)** and post monsoon **(Table 3) (Figure 1)** seasons over a period of three years and compared to BIS and ICMR drinking water standards **[5]**.

About 60% of the groundwater samples showed highest turbidity and exceeded the permissible limit of Beauro of Indian Standards (BIS) of 5 NTU. The maximum value observed is 55.87 NTU and minimum value is 0.9 NTU. The average value of pre monsoon varies between 2.17 and 19.60 NTU and between 2.73 to 55.87 NTU in post monsoon period. Higher values of turbidity were shown by the bore wells in the ornamental stone quarry areas that may be attributed to the lithology/mineralogy of the area. The sudden appearance of turbidity in the water samples is an indication of pollution of water particularly if the source is near the drain, cesspool, ditches or measured grounds **[6]**.

Total dissolved solids (TDS) values ranged between 390 to 1127 mg/L the average values range between 445 and 1081.33 mg/L in the pre monsoon and between 440.33 and 1000.33 mg/L the post monsoon samples. During the present investigation 90% of the samples showed higher amount of dissolved solids except the samples Kallugopanahalli and Dasappanadoddi and are very much close to the crushing quarries. The concentration of TDS in 90% of the samples is higher than the limits (500 mg/L). Pre monsoon samples shows greater values than the post monsoon samples which can be attributed to high evaporation rate in pre monsoon and dilution in the post monsoon period. In general conditions, higher concentration of TDS does not pose any particular health hazard except a change in taste **[5]** but to people who are sensitive, high amount of TDS can cause laxative and sometimes reverse effects particularly among those who travel frequently **[6]**, However higher concentration of dissolved solids may produce distress in cattle and live stock **[7]** and TDS and electrical conductivity are directly related. Higher the TDS, higher is the electrical conductivity (EC).

The total alkalinity (TA) ranges from 40 mg/L as $CaCO_3$ to 490 mg/L as $CaCO_3$. TA in the pre monsoon samples varies between 68.33 to 296.67 mg/L as $CaCO_3$ and the post monsoon samples varies between 68.33 to 286.67. Among the samples studied, 50% of the samples showed less than the hardness values. Hence, neutral salts of calcium or magnesium might be present that is not carbonates but may be sulphates and 60% of the samples exceed the permissible limits of 200 mg/L as $CaCO_3$ prescribed by BIS. Alkalinity itself is not harmful to human beings. The alkalinity of natural waters is normally due to the presence of bicarbonates, carbonates, hydroxides of calcium, magnesium, sodium and potassium. Borate, phosphates and silicates also contribute to alkalinity.

BIS has classified the degree of hardness in drinking water in terms of the equivalent $CaCO_3$ concentration as acceptable limit is 300 mg/L and emergency limit is 600 mg/L. The emergency limit is applied in cases of absence of alternate drinking water sources.

In the present study the total hardness (TH) ranges from 150 to 510 mg/L as $CaCO_3$ with an average values of 176.62 to 500mg/L in pre monsoon and 165 to 493.33 mg/L as $CaCO_3$ in the post monsoon period Nearly 40% of the samples exceeds the permissible limits of 300 mg/L. The rest are well with in the limits. The hardness values in samples, which exceed the limit, may be attributed to the geology of the area. Hardness below 300 mg/L as $CaCO_3$ is considered as potable but beyond this limit produces gastrointestinal irritation **[8]**. According to the degree of hardness, the water samples from the study area can be classified as hard and very hard water.Calcium concentration ranges from 90mg/L to 360 mg/L. The average value of Ca for pre monsoon varies between 118.33 and 358.33 mg/L as CaCO3 and for the post monsoon sample varies between 106.67 and 321.67 mg/L as CaCO3. All most all the sample i.e. 100% of the samples exceeds the permissible limit of 75 mg/L prescribed by BIS. The high concentration of calcium may be attributed to the lithology of the area, which comprises of amphibolities (comprising equal proportions of plagioclase and hornblende) and the area, which is basically a peninsular gneiss and granitic terrain. The range of calcium content in ground water is largely dependent on the solubility of calcium carbonate, sulphates and very rarely chlorides **[1]**. **[9]** has opined that the difference in relative mobility of Ca, Mg, Na and K is more pronounced in the ground waters from granite terrain and the higher concentration of calcium and magnesium. Chlorides and bicarbonates in several cases are probably due to their low rate of removal of soil. As such higher concentration of calcium does not cause any physiological effects on humans. In fact, it is an essential element, required around 0.7 to 2.0 g of calcium per day as a food element. The water samples in study area, due to higher levels of calcium concentration are not desirable for household uses because of the consumption of more soaps and cleaning agents. They are not fit for industrial use because of their scale forming nature. But they can be used for irrigation purposes, as the Ca is an essential element for the normal plant growth.

Magnesium is an important component of basic igneous rocks such as dunites, pyroxenites and amphiboles, volcanic rocks such as basalt, metamorphic rocks such as slate and tremolite-schists, and of sedimentary rocks such as dolomite usually limestone also contain some magnesium carbonate. Olivine, augite, biotite, hornblende, serpentine and talc are some of the major magnesium bearing minerals. Although in the igneous and metamorphic rocks, magnesium occurs in the form of insoluble silicates, weathering breaks them down into more soluble carbonates, clay minerals and silica. In the presence of carbonic acid in water magnesium carbonate is converted into more soluble bicarbonate.

In groundwater, calcium content generally exceeds the magnesium content in accordance with their relative abundance in rocks but contrary to the relative solubilities of their salts. In the present study, magnesium ranges between 15 mg/L as $CaCO_3$ to 20 mg/L. The average concentration of magnesium varies between 38.33 and 176.67 mg/L as $CaCO_3$ in the pre monsoon and the post monsoon samples varies between 35.00 and 191.67 mg/L as $CaCO_3$. About 95% of the samples in all the seasons exceed the permissible limits, of 30 mg/L as $CaCO_3$. The minimum concentration observed is in Ammanapura village. And maximum concentration was observed in Lakkasandra. Magnesium as such does not cause any health hazard but it is of concern since it contributes to hardness in water **[6]**. Magnesium salt acts as cathartics and diuretics among animals as well as human beings. Since, the present samples contain higher concentration of magnesium, they can be used as irrigation water sources as Mg is essential to normal plant growth.

Higher concentration of chloride may be due to the contamination by seawater, brines sewage or industrial effluents such as those from paper works galvanizing plants water softening plants and petroleum refineries. The chloride content normally increases proportionately with the mineral content **[6]**. Human excreta particularly urine contains chloride the amount equal to the chlorides consumed with food and water being around 6 g/person/day. This increases the amount of chlorides in municipal wastewater by 15 mg/L above that of the carriage water. Thus wastewater effluents add considerable amount of chlorides to receiving streams and ground water through percolatives. In addition leachate from land fills septic tanks, latrines pit **[10]**, also contribute a significant amount of chlorides into ground water. In the present study, the chloride value, ranged between 22.83 mg/L to 196.82 mg/L. Average concentration of Chlorides in the samples studied varied between 40.48 and 455.29 mg/L in pre monsoon and the post monsoon samples ranged between 39.29 and 175.86 mg/L. In general 100 % of the samples are well within the permissible limits of 250 mg/L set by BIS 1991. The pre monsoon chloride values are slightly higher than the post monsoon samples. Since the chlorides are present in lower concentration, all the samples can be used for irrigation purposes and also for drinking.

The concentration of fluoride in groundwater is limited due to low solubility of most of the fluorides. The solubility of fluorides in pure water, at 25 ^{0} c is only to the extent of 8.7 PPM of fluoride **[11]**. Magnesium fluoride is more soluble than calcium fluoride. Groundwater with total dissolved solids less than 1000 PPM contain fluoride less than 1 PPM. But in some areas the concentration reaches above 5 PPM **[12]**. Fluoride ions in excess concentration in drinking water are known to damage teeth, skeleton and other organs. Fluoride content below 1.5 mg/L causes dental fluorosis and at a concentration greater than 4 mg/L causes skeletal fluorosis **[6]**. The BIS has prescribed a permissible limit of 1 mg/L and an emergency limit of 1.5 mg/L for fluorides in drinking water in absence of an alternative source.

The concentration of sodium in groundwater samples ranges between 15.52 mg/L to 95.29 mg/L. The average values of sodium ion ranged between 18.41 and 89.97 mg/L in pre monsoon samples and between 20.59 and 84.65 mg/L in post monsoon samples. Among the samples studied 98% of the samples exceeded the permissible limit of 20 PPM for drinking water prescribed by BIS. Minimum value is recorded in the sample collected in the residential colony of Dasappanadoddi village. The maximum concentration of sodium was observed in the village Nellamale in ornamental stone quarry area. Sodium has important consideration with regard to irrigation waters only. Regarding drinking and industrial purposes it is of minor importance only. However, excessive amounts of sodium in drinking water are harmful to persons suffering from cardiac, renal and circulatory diseases. When the sodium concentration exceeds 500 mg/L makes the water unpalatable and causes appetite disturbances.

The concentration of potassium ranges from 1 PPM or less to about 10-15 PPM in potable waters and from 100 PPM to over several thousand PPM in some brines and hot springs. Potassium salts being more soluble than sodium salt they are the lasts to crystallize during evaporation. In the present study, 100 % of the samples are well within the permissible limits of 10 mg/L prescribed by BIS standards. The potassium concentration ranged between 0.3 mg/L to 8.2 mg/L .The average concentration of potassium in pre monsoon samples ranges between 0.90 to7.37 mg/L and post monsoon samples varied between 0.72 and 6.10 mg/L Potassium does not pose any health hazard at lower and moderate concentration. It is an essential nutritional element, but in excessive amounts it acts as a cathartic.

In the present study, 100% of the water samples studied showed very low concentration of nitrates which ranged from 0.10 to 5.63 mg/L with an average concentration of 0.08 to 4.83 mg/L in pre monsoon samples and 0.13 to 4.65 mg/L in post monsoon samples which are very much within the prescribed limits of 45 mg/L of BIS.

Phosphates occur in natural waters and waste waters in the form of various phosphates, which are commonly classified as orthophosphates, condensed phosphates and organically bounded phosphates. They may occur in soluble form or in particulate form. In the present study the phosphate concentration ranged between 0.21 to 8.30 mg/L. The pre monsoon samples showed a range of 0.40 to 7.28 mg/L and post monsoon samples varied between 0.42 to 6.54 mg/L. 70% of the samples studied are within the permissible limits of 1.5 mg/L prescribed by WHO. The remaining 30% of samples show higher concentration of phosphate that may be attributed to lithology of the area. Phosphates as such do not pose any health hazard. In fact, it is an essential nutrient for plant growth. Hence the samples under investigation are suitable for irrigation purpose.

Silica is a common constituent of natural water and treated waters. The concentrates of silicates in the analyzed samples ranges from 0.7 mg/L to 4.7 mg/L. The average concentration of silicates in pre monsoon varied between 0.70 and 4.23 mg/L and the post monsoon samples varied between 0.76 and 3.50 mg/L .No permissible limit is prescribed by the BIS for silicates in drinking water, hence it is not used as a criterion for classifying drinking water. Higher values were obtained in the villages of the ornamental stone quarries. This may be attributed to the local geology of the area.

Iron may occur in solution by ground water coming in contact with iron objects such as well casing, delivery pipes etc. Most tube wells yield iron rich water in pumping after prolonged periods **[1]**. In the present study, the concentration of iron varied between 0.38 to 1.63 mg/L. The average concentration of iron varied between 0.49 to 1.44 mg/L in the pre monsoon samples and 0.42 to 1.34 mg/L in post monsoon samples. 98% of the samples studied showed values higher than the permissible limits of 0.3 mg/L, however nearly 78% of the samples were within the BIS, a permissible limit in case of absence of any other alternative drinking water source. The high concentration of iron in groundwater limit of 1 mg/L prescribed by samples may be due to rusting of casing pipes, geology of the area and human interference.

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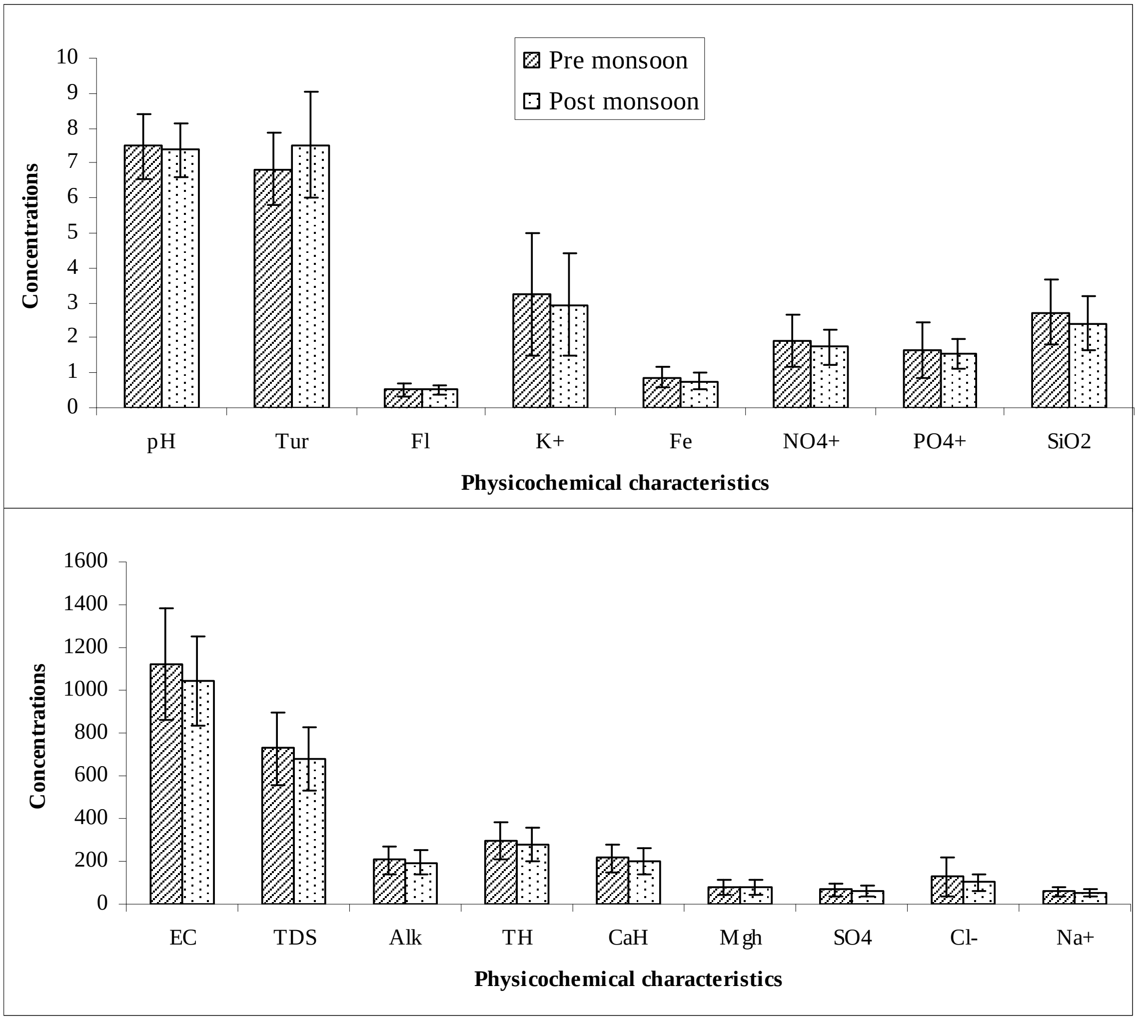

Figure 1: Physicochemical Characteristics of Groundwater Samples for Pre and Post Monsoon Seasons.

Table 2: Physicochemical Characteristics of Groundwater Samples for Pre monsoon Season

Samples	pH	EC	TDS	Tur	Alk	TH	CaH	MgH	SO_4	Cl^-	Fl	Na^+	K^+	Fe	NO_4^+	PO_4^+	SiO_2
	8.7	902	588	3.6	257	238	159	79	30	55	0.65	50	6.8	0.56	0.08	1.23	1.09
B1	±0.2	±28	±16	±1.8	±32	±58	±50	±32	±3	±4	±0.03	±1	±0.4	±0.04	±0.05	±0.08	±0.07
	6.7	965	627	3.9	157	237	176	61	36	154	0.40	79	2.8	0.78	1.53	0.80	2.13
B2	±0.3	±59	±38	±0.3	±30	±24	±7	±17	±3	±12	±0.08	±2	±0.7	±0.05	±0.20	±0.06	±0.55
	6.6	1182	725	6.3	145	388	261	131	55	188	0.23	46	3.8	0.79	2.45	0.70	2.80
B3	±0.5	±65	±42	±0.9	±13	±90	±44	±52	±8	±3	±0.08	±3	±0.3	±0.12	±0.58	±0.06	±0.26
	7.3	733	477	2.2	157	182	120	62	67	111	0.41	83	2.7	0.75	0.48	0.73	1.13
B4	±0.4	±116	±75	±0.3	±40	±13	±13	±8	±2	±7	±0.02	±5	±0.5	±0.06	±0.05	±0.03	±0.21
	6.0	902	586	3.6	87	340	245	95	45	155	0.38	31	2.6	0.85	0.33	0.57	2.03
B5	±0.3	±55	±36	±0.6	±25	±40	±13	±28	±4	±8	±0.13	±5	±0.4	±0.02	±0.08	±0.06	±0.82
	5.2	685	445	7.2	68	198	140	58	27	93	0.39	18	7.4	0.55	0.33	1.42	0.70
B6	±0.5	±94	±61	±1.0	±26	±16	±17	±19	±3	±8	±0.12	±1	±0.8	±0.11	±0.22	±0.15	±0.53
	7.8	985	637	11.2	183	202	145	57	37	59	0.27	74	2.8	0.57	0.43	0.95	2.13
B7	±0.3	±121	±83	±3.3	±12	±20	±18	±8	±5	±27	±0.14	±4	±1.7	±0.08	±0.09	±0.32	±0.25
	7.1	940	613	5.9	217	247	152	95	52	93	0.79	61	4.4	1.43	0.42	2.04	2.43
B8	±0.3	±125	±85	±1.5	±32	±12	±8	±18	±2	±13	±0.15	±5	±0.7	±0.18	±0.21	±0.08	±0.21
	7.1	1347	875	5.4	270	322	277	45	81	135	0.76	75	3.1	0.92	0.74	2.56	3.23
B9	±0.2	±135	±88	±1.6	±20	±25	±12	±13	±4	±7	±0.02	±3	±1.5	±0.08	±0.13	±0.25	±0.21
	7.7	1501	975	19.6	247	333	225	108	68	455	0.49	79	1.5	0.89	0.18	0.71	3.70
B10	±0.9	±159	±104	±26.3	±15	±40	±48	±10	±4	±560	±0.09	±6	±0.6	±0.28	±0.15	±0.07	±0.36
	8.4	1113	724	3.9	185	299	223	76	50	165	0.72	81	3.4	1.44	0.75	0.62	2.97
B11	±0.4	±138	±90	±0.3	±5	±11	±25	±36	±2	±8	±0.07	±3	±0.5	±0.13	±0.55	±0.07	±0.06
	8.2	1447	940	12.4	237	473	358	108	30	198	0.63	90	4.1	0.71	0.26	0.79	3.37
B12	±0.3	±106	±69	±4.9	±16	±21	±18	±20	±7	±7	±0.10	±5	±0.3	±0.08	±0.15	±0.28	±0.23
	8.8	1230	800	7.3	297	258	220	38	68	44	0.41	73	2.2	1.29	3.73	0.40	3.30
B13	±0.4	±86	±56	±0.9	±40	±38	±26	±16	±4	±22	±0.11	±2	±0.6	±0.25	±0.42	±0.08	±0.20
	8.3	898	583	3.8	228	177	118	58	80	40	0.68	34	1.5	0.73	2.53	3.09	2.80
B14	±0.2	±108	±70	±1.3	±46	±15	±13	±3	±5	±12	±0.10	±1	±0.6	±0.09	±0.21	±0.45	±0.17

Table 2, continued…

Samples	pH	EC	TDS	Tur	Alk	TH	CaH	MgH	SO4	Cl^-	Fl	Na^+	K^+	Fe	NO_4^+	PO_4^+	SiO_2
	7.5	1171	761	8.1	253	265	183	83	100	85	0.39	37	2.7	0.87	4.13	7.28	3.33
B15	±0.4	±135	±87	±6.0	±28	±18	±20	±6	±3	±6	±0.15	±4	±0.5	±0.06	±0.44	±1.00	±0.31
	8.0	1035	673	8.5	197	257	197	60	62	72	0.45	46	1.0	0.70	3.58	1.07	3.23
B16	±0.5	±52	±34	±2.4	±13	±32	±40	±10	±3	±6	±0.09	±4	±0.6	±0.06	±0.94	±0.32	±0.35
	6.9	1386	901	8.9	152	317	262	55	140	108	0.68	53	1.8	0.77	4.83	2.83	3.57
B17	±0.5	±46	±31	±8.1	±28	±6	±8	±13	±6	±16	±0.08	±17	±0.2	±0.05	±0.71	±0.04	±0.23
	8.5	1241	823	5.6	267	363	285	78	107	97	0.84	46	0.9	0.82	2.88	3.47	3.07
B18	±0.4	±44	±57	±0.8	±12	±13	±5	±18	±5	±6	±0.09	±3	±0.5	±0.06	±0.44	±0.49	±0.31
	7.7	1664	1081	3.1	277	500	323	177	101	129	0.28	62	5.2	1.37	4.83	0.53	4.23
B19	±0.3	±83	±54	±0.7	±33	±17	±3	±14	±19	±14	±0.13	±2	±0.3	±0.16	±0.62	±0.33	±0.42
	7.2	1132	736	5.9	247	278	195	83	69	86	0.71	53	4.4	0.49	3.78	0.79	3.27
B20	±0.3	±118	±77	±2.5	±6	±16	±22	±20	±6	±12	±0.04	±3	±0.4	±0.07	±0.07	±0.20	±0.40

Table 3: Physicochemical characteristics of groundwater samples for post monsoon season

Samples	pH	EC	TDS	Tur	Alk	TH	CaH	Mgh	SO4	Cl^-	Fl	Na^+	K^+	Fe	$NO4^+$	$PO4^+$	SiO2
	8.1	837	544	2.8	232	247	171	76	26	50	0.55	47	6.1	0.53	0.13	1.28	1.08
B1	±0.2	±37	±24	±1.3	±20	±47	±8	±39	±2	±3	±0.03	±2	±0.3	±0.09	±0.12	±0.61	±0.10
	6.8	933	615	3.3	151	232	165	66	33	137	0.39	71	3.4	0.67	1.38	0.83	1.94
B2	±0.5	±64	±48	±0.3	±18	±28	±5	±24	±3	±1	±0.06	±5	±1.3	±0.10	±0.26	±0.15	±0.05
	6.6	1035	680	5.1	142	372	256	116	52	173	0.26	43	3.3	0.72	2.27	0.62	2.57
B3	±0.4	±37	±36	±0.6	±25	±66	±51	±24	±13	±11	±0.02	±3	±0.5	±0.07	±0.55	±0.10	±0.35
	7.3	732	474	4.4	152	165	107	58	63	105	0.43	77	2.3	0.73	0.40	0.59	1.40
B4	±0.1	±58	±34	±3.2	±14	±13	±15	±20	±5	±9	±0.08	±9	±0.5	±0.05	±0.08	±0.09	±0.70
	6.2	869	566	3.6	95	300	223	77	43	140	0.37	30	2.2	0.73	0.33	0.56	1.39
B5	±0.4	±45	±29	±0.4	±20	±44	±42	±6	±1	±17	±0.11	±4	±0.1	±0.05	±0.04	±0.10	±0.70
	5.5	704	440	7.7	68	204	132	64	29	103	0.34	21	5.4	0.60	0.30	1.51	0.76
B6	±0.6	±66	±35	±0.8	±13	±28	±11	±25	±6	±12	±0.08	±5	±2.8	±0.10	±0.08	±0.10	±0.10

Table 3, continued…

Samples	pH	EC	TDS	Tur	Alk	TH	CaH	Mgh	SO_4	Cl^-	Fl	Na^+	K^+	Fe	$NO4^+$	PO_4^+	SiO_2
B7	**7.8**	**956**	**501**	**55.8**	**180**	**197**	**112**	**81**	**43**	**80**	**0.47**	**68**	**3.9**	**0.81**	**0.46**	**1.27**	**2.13**
	±0.6	**±409**	**±452**	**±81.6**	**±5**	**±56**	**±64**	**±31**	**±4**	**±26**	**±0.23**	**±15**	**±0.6**	**±0.33**	**±0.03**	**±0.50**	**±0.25**
B8	**6.9**	**922**	**619**	**5.9**	**199**	**247**	**133**	**113**	**49**	**95**	**0.77**	**58**	**3.6**	**0.95**	**0.43**	**1.74**	**2.03**
	±0.5	**±166**	**±90**	**±2.7**	**±24**	**±29**	**±12**	**±41**	**±1**	**±2**	**±0.06**	**±6**	**±1.1**	**±0.33**	**±0.15**	**±0.10**	**±0.31**
B9	**7.0**	**1184**	**780**	**4.9**	**243**	**308**	**248**	**58**	**68**	**120**	**0.66**	**68**	**2.7**	**0.84**	**0.68**	**2.35**	**2.63**
	±0.2	**±155**	**±84**	**±1.6**	**±31**	**±55**	**±34**	**±33**	**±4**	**±9**	**±0.03**	**±1**	**±1.3**	**±0.08**	**±0.15**	**±0.25**	**±0.46**
B10	**7.6**	**1377**	**898**	**4.2**	**225**	**313**	**224**	**89**	**63**	**116**	**0.46**	**71**	**1.5**	**0.42**	**0.18**	**0.64**	**3.23**
	±0.2	**±91**	**±57**	**±0.6**	**±26**	**±41**	**±40**	**±1**	**±7**	**±21**	**±0.04**	**±1**	**±0.6**	**±0.25**	**±0.09**	**±0.09**	**±0.25**
B11	**8.1**	**1028**	**665**	**3.7**	**170**	**268**	**220**	**48**	**43**	**146**	**0.63**	**75**	**2.6**	**1.29**	**0.89**	**0.52**	**2.77**
	±0.4	**±65**	**±57**	**±1.0**	**±38**	**±28**	**±20**	**±30**	**±3**	**±10**	**±0.06**	**±4**	**±0.1**	**±0.09**	**±0.44**	**±0.01**	**±0.12**
B12	**8.2**	**1251**	**846**	**8.1**	**213**	**410**	**322**	**88**	**29**	**176**	**0.60**	**85**	**3.6**	**0.64**	**0.24**	**0.72**	**3.03**
	±0.1	**±201**	**±95**	**±1.7**	**±16**	**±57**	**±40**	**±23**	**±3**	**±30**	**±0.17**	**±4**	**±0.4**	**±0.08**	**±0.06**	**±0.30**	**±0.06**
B13	**8.4**	**1131**	**771**	**7.2**	**287**	**250**	**215**	**35**	**64**	**39**	**0.33**	**67**	**2.1**	**1.34**	**3.19**	**0.42**	**3.03**
	±0.2	**±153**	**±66**	**±1.5**	**±15**	**±35**	**±22**	**±17**	**±5**	**±21**	**±0.10**	**±6**	**±0.6**	**±0.10**	**±0.12**	**±0.08**	**±0.15**
B14	**8.0**	**870**	**573**	**3.1**	**197**	**187**	**130**	**63**	**77**	**43**	**0.67**	**32**	**1.5**	**0.60**	**2.23**	**2.83**	**2.47**
	±0.3	**±56**	**±47**	**±0.7**	**±43**	**±32**	**±30**	**±28**	**±5**	**±2**	**±0.08**	**±2**	**±0.6**	**±0.06**	**±0.08**	**±0.32**	**±0.21**
B15	**7.3**	**1096**	**709**	**3.4**	**225**	**246**	**165**	**81**	**92**	**82**	**0.44**	**35**	**2.7**	**0.82**	**3.58**	**6.54**	**3.13**
	±0.3	**±95**	**±66**	**±4.3**	**±10**	**±21**	**±26**	**±6**	**±3**	**±3**	**±0.12**	**±2**	**±0.4**	**±0.04**	**±0.39**	**±0.57**	**±0.25**
B16	**8.0**	**1001**	**564**	**6.7**	**183**	**248**	**183**	**65**	**58**	**68**	**0.44**	**45**	**0.7**	**0.67**	**2.86**	**1.12**	**2.60**
	±0.1	**±28**	**±177**	**±1.3**	**±14**	**±16**	**±38**	**±22**	**±5**	**±4**	**±0.06**	**±2**	**±0.2**	**±0.03**	**±0.26**	**±0.34**	**±0.53**
B17	**6.6**	**1296**	**867**	**9.0**	**177**	**315**	**257**	**58**	**121**	**103**	**0.56**	**58**	**1.6**	**0.65**	**4.09**	**2.27**	**2.77**
	±0.8	**±75**	**±32**	**±3.6**	**±28**	**±15**	**±21**	**±28**	**±5**	**±13**	**±0.02**	**±2**	**±0.3**	**±0.04**	**±0.88**	**±0.26**	**±0.40**
B18	**8.4**	**1102**	**752**	**5.2**	**263**	**338**	**265**	**73**	**72**	**92**	**0.75**	**44**	**0.7**	**0.74**	**3.04**	**3.31**	**2.67**
	±0.2	**±89**	**±32**	**±1.9**	**±22**	**±18**	**±18**	**±3**	**±55**	**±5**	**±0.12**	**±3**	**±0.5**	**±0.10**	**±0.23**	**±0.77**	**±0.35**
B19	**7.5**	**1510**	**1000**	**2.7**	**263**	**493**	**302**	**192**	**104**	**132**	**0.52**	**58**	**4.9**	**1.16**	**4.65**	**0.61**	**3.50**
	±0.5	**±107**	**±51**	**±0.2**	**±11**	**±25**	**±3**	**±28**	**±17**	**±9**	**±0.32**	**±5**	**±0.3**	**±0.18**	**±0.36**	**±0.14**	**±0.40**
B20	**7.1**	**1044**	**695**	**3.7**	**228**	**268**	**192**	**77**	**65**	**82**	**0.64**	**49**	**4.0**	**0.45**	**3.39**	**0.99**	**3.07**
	±0.3	**±109**	**±65**	**±0.8**	**±14**	**±37**	**±18**	**±51**	**±5**	**±6**	**±0.02**	**±2**	**±0.2**	**±0.15**	**±0.39**	**±0.72**	**±0.35**

Table 4: Correlation of Physicochemical Characteristics of Groundwater Samples for Pre monsoon Season

	pH	EC	TDS	Turb	Alk	TH	CaH	MgH	SO_4	Cl^-	Fl	Na^+	K^+	Fe	NO_4^+	PO_4^+	SiO_2
pH	1.00																
EC	0.33	1.00															
TDS	0.35	1.00	1.00														
Tur	0.08	0.43	0.42	1.00													
Alk	0.78	0.58	0.59	0.13	1.00												
TH	0.09	0.81	0.80	0.17	0.26	1.00											
CaH	0.14	0.82	0.82	0.20	0.28	0.95	1.00										
Mgh	-0.04	0.50	0.48	0.05	0.12	0.75	0.51	1.00									
SO4	0.14	0.51	0.52	-0.02	0.34	0.23	0.29	0.05	1.00								
Cl-	-0.13	0.45	0.44	0.64	-0.03	0.42	0.35	0.41	-0.07	1.00							
Fl	0.33	0.07	0.11	-0.08	0.36	-0.03	0.09	-0.27	0.23	-0.09	1.00						
Na+	0.42	0.37	0.37	0.25	0.35	0.19	0.24	0.00	-0.14	0.36	0.08	1.00					
K+	-0.30	-0.21	-0.22	-0.25	-0.17	0.04	-0.08	0.29	-0.48	-0.15	-0.09	-0.17	1.00				
Fe	0.24	0.35	0.35	-0.16	0.30	0.30	0.25	0.30	0.19	0.11	0.10	0.31	-0.06	1.00			
NO4+	0.16	0.43	0.43	-0.13	0.32	0.23	0.25	0.13	0.75	-0.32	-0.08	-0.26	-0.29	0.13	1.00		
PO4+	0.04	0.03	0.05	0.00	0.23	-0.14	-0.10	-0.17	0.53	-0.25	0.23	-0.40	-0.23	-0.06	0.34	1.00	
SiO2	0.38	0.88	0.88	0.35	0.59	0.63	0.65	0.36	0.61	0.28	0.14	0.24	-0.46	0.40	0.62	0.17	1.00

Table 5: Correlation of Physicochemical Characteristics of Groundwater Samples for Post monsoon Season

	pH	EC	TDS	Turb	Alk	TH	CaH	MgH	SO_4	Cl^-	Fl	Na^+	K^+	Fe	NO_4^+	PO_4^+	SiO_2
pH	**1.00**																
EC	**0.29**	**1.00**															
TDS	**0.25**	**0.97**	**1.00**														
Tur	**0.11**	**-0.08**	**-0.26**	**1.00**													
Alk	**0.72**	**0.61**	**0.63**	**-0.08**	**1.00**												
TH	**0.08**	**0.79**	**0.81**	**-0.23**	**0.34**	**1.00**											
CaH	**0.17**	**0.77**	**0.82**	**-0.30**	**0.37**	**0.92**	**1.00**										
Mgh	**-0.10**	**0.45**	**0.43**	**-0.03**	**0.16**	**0.68**	**0.34**	**1.00**									
SO4	**0.04**	**0.57**	**0.57**	**-0.15**	**0.40**	**0.28**	**0.26**	**0.22**	**1.00**								
Cl-	**-0.35**	**0.27**	**0.29**	**-0.14**	**-0.36**	**0.58**	**0.54**	**0.35**	**-0.19**	**1.00**							
Fl	**0.36**	**0.17**	**0.22**	**-0.09**	**0.45**	**0.10**	**0.11**	**0.05**	**0.18**	**-0.14**	**1.00**						
Na+	**0.41**	**0.38**	**0.36**	**0.19**	**0.34**	**0.16**	**0.23**	**-0.04**	**-0.08**	**0.30**	**0.17**	**1.00**					
K+	**-0.28**	**-0.18**	**-0.17**	**0.12**	**-0.13**	**0.08**	**-0.12**	**0.39**	**-0.40**	**0.10**	**-0.11**	**-0.05**	**1.00**				
Fe	**0.26**	**0.21**	**0.21**	**0.04**	**0.28**	**0.17**	**0.17**	**0.09**	**0.15**	**0.03**	**0.00**	**0.28**	**-0.02**	**1.00**			
NO4+	**0.15**	**0.49**	**0.49**	**-0.19**	**0.43**	**0.35**	**0.33**	**0.25**	**0.79**	**-0.23**	**0.02**	**-0.22**	**-0.25**	**0.23**	**1.00**		
PO4+	**0.02**	**0.02**	**0.03**	**-0.06**	**0.21**	**-0.16**	**-0.15**	**-0.09**	**0.43**	**-0.32**	**0.26**	**-0.41**	**-0.20**	**-0.10**	**0.33**	**1.00**	
SiO2	**0.46**	**0.85**	**0.82**	**-0.08**	**0.67**	**0.56**	**0.59**	**0.28**	**0.58**	**0.10**	**0.23**	**0.33**	**-0.38**	**0.28**	**0.61**	**0.16**	**1.00**

CONCLUSION

Groundwater samples from the study area showed low concentration of nitrates and 60% of the samples showed highest turbidity and exceeded the permissible limits, 90% of the samples showed higher amount of dissolved solids near the crushing quarries. These groundwater samples showed higher levels of calcium and are not desirable for household uses because of the consumption of more soaps and cleaning agents and also not fit for industrial use because of their scale forming nature. However the water can be used for irrigation purposes, as the Ca is an essential element for the normal plant growth. Quarrying in the unsaturated zone is likely to result in relatively local impacts such as increased runoff, reduced water quality, rerouting of recharge water through the aquifer, and localized reduction in ground-water storage.

REFERENCES

[1] Karanth KR, Hydrogeology, Tata Mc.Graw- Hill Publishing Company Limited, New Delhi, 1989.

[2] Hobbs SL, Gunn J, The hydrogeological effect of quarrying karstified limestone: options for prediction and mitigation, Quarterly Journal of Engineering Geology and Hydrogeology, 31, 1998, 147-157.

[3] Yang T, Zhu W, Yu Q, Liu H, The role of pore pressure during hydraulic fracturing and implications for groundwater outbursts in mining and tunneling, Hydrogeology Journal, 19, 2011, 995–1008.

[4] APHA, AWWA, WPCF, Standard Method for the Examination of water and waste water. 19th ed., American Public Health Association, Washington, D.C., 1995.

[5] Manivasakam N, Physico-chemical Examination of Water, Sewage and Industrial Effluents, 3rd Edn., Pragati Prakashan, Coimbatore, 1996.

[6] Sawyer CN, McCarty PL, Parkin GF, Chemistry for Environmental Engineering, 4th edn., McGraw-Hill, New York, 1994, 658.

[7] Chatterjee C, Raziuddin M, Determination of water quality index (WQI) of a degraded river in Asansol industrial area (W.B). Ecology of polluted water. Vol. II Edn, Arvind Kumar A.P H Publishing Corporation, New Delhi, 2002.

[8] ICMR, Manual of Standards of Quality for drinking water supplies, ICMR, New Delhi, 1975.

[9] Somashekar RK, Rameshaiah V, Chethana Suvarna A, Groundwater chemistry of Channapatna Taluk (Bangalore rural district) – Regression and cluster analysis, Journal of Environmental Pollution, 7(2), 2000, 101-109.

[10] Sharma BK, Kaur H, Environmental Chemistry, 2nd Edn, Goel Publishing House, 1995, 405.

[11] Aumeras M, Studies of ionic equilibria, 11. Equilibrium of calcium fluoride in dilute hydrochloric, J. Chem. Phys., 24, 1927, 548-571.

[12] Hem JD, Study and Interpretation of the chemical characteristics of Natural water, U-S Geol, Sur. water supply paper, 1985, 264.