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APPRAISAL OF GROUND WATER CHARACTERISTICS AND WATER QUALITY INDEX OF RICH IRON MINERAL CITY, KARNATAKA STATE, INDIA

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Abstract* - Bellary is a rich iron ore city in Karnataka; it is experienced degradation due to rapid urbanization and mining activity. The hydro-chemical investigation in the present study is restricted to the major ions concentrations, distributions, their relative abundance, and the pattern of the variability in groundwater chemistry. The present work is aimed at assessing the water quality index (WQI) for the groundwater of rich iron mineral city. For calculating the WQI, the following 16 parameters have been considered: turbidity, pH, EC, TDS, Total hardness, calcium, magnesium, total alkalinity, Bicarbonate, carbonate, chloride, Fluoride, Nitrate, Sulphate, sodium and potassium. The WQI for these samples ranges from 79.1 to 180.2 the maximum value of 180.2 is observed in the sample 3 (ATP Road) of rich iron mineral city, while the minimum is recorded in 9 (Bislahalli). The high value of WQI has been found to be mainly from the higher values of nitrate, total dissolved solids, hardness, fluorides, bicarbonate and chlorides in the groundwater. The results of analyses have been used to suggest models for predicting water quality. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination. Water Quality Index, has been calculated for the Rich iron mineral city and was studied for the suitability of water for drinking purposes and the results showed that 28% of the ground water quality was poor quality category and localities are scoring a water quality index greater than 100. The continuous monitoring of groundwater is required in the rich iron mineral city to protect water in future from any possible contamination due to growing industrialization and agricultural practices.

Key words:* rich iron mineral, WQI, ground water, permissible limit.

I. INTRODUCTION

Water is the most important a biotic component on the biosphere. It is addressed as a basic need for all the life and also considered as resource and life preservative. Water is used for most human activities like drinking, cooking bathing, washing, agriculture, industry, recreation, navigation and fisheries etc. About 75% of the world's surface area is covered with hydrosphere. Out of which 97% of the earth's water is in the marine, not fit for human consumption due to its high salt content. Remaining 1.8% is locked in polar ice caps and only 1.2% is available as fresh water in rivers, lakes, streams reservoirs and ground water, suitable for human consumption.

Due to disturbance of unscientific human activity, the water is still a distance dream for many people. Hence, present need to create awareness among the community of our country about the importance of water for present and future. Groundwater is the second purest water on the earth, which is used for domestic and industrial water supply and irrigation all over the world. In the last few decades, there has been a tremendous increase in the demand for fresh water due to rapid growth of population and the accelerated pace of industrialization. Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of inorganic fertilizers. The concept of Water Quality Index (WQI) to represent gradation in water quality was first proposed by Horten, 1965. Most effective tool to identify the water quality of aqua resources is Water Quality Index (WQI) [Sinha, et al., 1994 and Rajankar, et al., 2010].

WQI a well-known method as well as one of the most effective tools to express water quality (Suresh, *et al.,* 2008) that offers a simple, stable, reproducible unit of measure and communicate information of water quality to the policy makers and concerned citizens. It thus, becomes an important parameter for the assessment and management of ground water (Rajankar, *et al.,* 2013). To determine WQI, a total of twelve physicochemical parameters were considered in the present study. The objectives behind the study were to develop an overall picture of the groundwater quality using WQI, assessment of seasonal variation in the groundwater quality, suitability of groundwater for different purposes, and contamination causes in rich iron mineral city.

II. MATERIALS AND METHODS

STUDY AREA

Bellary city is situated in the eastern side of Karnataka state in India. It has a geographical area of 81.95 sq. kms, it is bounded by north latitudes 14°59' to 15°26' N and 76°10' to 77°38' E longitude. The taluk has a population of about 6,25,494. The average annual rainfall of the study area is 495 mm. The average annual maximum temperature is 40°C and minimum 26°C.

SAMPLING

The sampling locations consist of rich iron mineral city is Bellary in this region. Forty groundwater samples were collected from hand pump and bore well. Ground water samples were collected in 2 liter capacity plastic container. Collected samples were transported to the laboratory and subjected to 12 physicochemical parameters as per the standard procedure (APHA, 1998).

METHODS

Total thirty (30) underground water samples from different bore wells and pumps were collected in polyethylene bottles during 2009. Grab sampling has been adopted to collect groundwater samples. The samples were transported in a cool box to be stored under suitable temperature until analysis. The necessary precautions were adopted during sampling (Brown et al., 1974).

WATER QUALITY INDEX (WQI)

Water quality index were calculated using twelve indicator parameters of water quality and the National Sanitation Foundation (NSF) WQI calculator (NSF). WQI is one of the most effective ways to communicate information on the quality of water to the concerned citizen and the policy makers (Ravi Kant Dubey, et al., 2014). It, thus become an important parameters for the assessment and management of groundwater. WQI may be defined as a rating reflecting the composite influence of a number of water quality parameters on the overall quality of water. The main objective of the WQI is to turn complex water quality data into information that understandable and usable by the public. WQI is the based on some important parameters viz., pH, temperature, turbidity, nitrate, phosphate, total solids, dissolved oxygen, biochemical oxygen demand, and coliforms, which can provide simple indicator of water quality. It gives a general idea of the possible problems with water in particular region [NSF). NSF has given the classification of water quality on the basis of WQI rating is given in table 1 (Rajankar, et al., 2009).

TABLE 1. WATER QUALITY STANDARDS BASED ON WATER QUALITY INDEX RATING

WATER QUALITY RATING	WATER QUALITY
0 to 25	Poor
25 to 50	Bad
30 to 70	Medium
70 to 90	Good
90 to 100	Excellent

III. RESULT AND DISCUSSION

The physicochemical results have been subjected to statistical analysis and given in the Table 2. The observed averages values of water quality parameters, BIS standards and their weight ages are given in Table 3.

The qi and Wi values indicate the variation in groundwater quality (Table 4 and Table 5), which might happen due to different anthropogenic activities carried out near the sources. A number of indices have been developed to summarize the facts of ground water quality in an easily expressible and easily understood format. A water quality index is a means to summarize large amounts of water quality data into simple terms (e.g., good) for reporting to management and the community in a consistent manner. Thirty samples were collected from rich iron mineral city and the physicochemical parameters of these samples including turbidity, pH, EC, TDS, Total hardness, calcium, magnesium, total alkalinity, Bicarbonate, carbonate, chloride, Fluoride, Nitrate, Sulphate, sodium and potassium were cumulated into a single parameter known as Water Quality index(W.Q.I).

The pH values ranged between 7.0 - 8.2 indicating samples was neutral to slightly alkaline. The TDS varied from 360-3180 mg/l. Very high TDS compared to standard limit of 600 mg/l may be due to high concentrations of chloride and nitrates. Fluoride concentration ranged from 0.23 to 2.47 mg/l and the maximum concentration is very high as compared to standard limit 1.5 mg/l. Chloride concentration ranged from 20.0 – 840.0 mg/l and the maximum concentration is very high as compared to standard limit 250 mg/l. Sulphate concentration ranged between 4.0 -500.0 mg/l which were above the permissible limit of 150 mg/l. Nitrate concentration in groundwater samples ranged between 5.0 – 69.0 mg/l. High concentration of nitrate may be due to leaching from nitrogenous fertilizers, manures and may also be due to other anthropogenic origin. Total hardness ranged from 120.0 to 2420.0 mg/l and some samples have crossed the standard limit of 300 mg/l.

The Ground Water Quality index for drinking purposes is calculated using the steps: Weight is assigned to the parameters under consideration (wi). These weights indicate the relative harmfulness when present in water. The maximum weight assigned is 5 and minimum is 1.The relative weights (Wi) are calculated as per the formula Application of Water Quality Index (WQI) in this study has been found useful in assessing the overall quality of water and to get rid of judgment on quality of the water. This method appears to be more systematic and gives comparative evaluation of the water quality of sampling stations. It is also helpful for public to understand the quality of water as well as being a useful tool in many ways in the field of water quality management. Sawyer classified the water on the basis of hardness as shown in Table 4. According to this classification no source is soft and moderately hard. Bislahalli, Harishchandranagar and Railway Colony are showing poor condition, ten localities like Bapujinagar, Beechinagar, Gandhinagar, Devinagar, Ganeshnagar, Hussainnagar, Netajinagar, Parvathinagar. S.N.Pet were under very poor category remaining seventeen (17) sources are very hard hence not suitable for domestic purpose (Figure 1). From the water quality index parameter it has been observed that 93.33% of samples tested have been found poor water quality (Table 4), While only two samples (6.67)% samples have been found to have good water quality and no one ground water samples belongs to the very poor and unsuitable category of water quality.

Overall WQI (OWQI) has been developed for surface water by Singh, et al. (2015) which can also be used for groundwater also (Stigter, et al., 2006). From the comparative analysis of WQI values for all sampling localities, it was observed that WQI values varies from 79.1 to 180.2 the maximum value of 180.2 is observed in the sample 3 (ATP Road) of rich iron mineral city, while the minimum is recorded in 9 (Bislahalli) of rich iron mineral city and second lowest in 14 (Gonahal School) is given in Table 6. It may also be reflected that parameters particularly chloride, sulphate, nitrate and hardness are found to be higher compared to the permissible level resulting TDS value at higher order owing to anthropogenic contribution viz. Agricultural and industrial activities in the Rich iron mineral city. The water quality index of major villages in rich iron mineral city was found to be poor quality of water. The water quality index in villages like Bislahalli and Gonahal School was found to be good. The most villages had poor water quality index. The water present in the villages in the selected localities in rich iron mineral city was found to be unfit for drinking. The main reasons for this as we have observed are mining activity, open dumping of solid wastes, presence of, misused ponds, use of fertilizers, etc., Based on the status of water quality data, the index value ranges from 0 to 100 and is classified into five categories: heavily polluted (0-24), poor (25-49), fair (50-74), good (75-94) and excellent (95- 100). The status of water corresponding to different WQI values is presented in Table 4.

IV. CONCLUSIONS

It is necessary that the drinking water should be pure. However the absolute pure water is not found in nature. Even the rain water which absolutely pure at the instant it is formed becomes impure because as it passes through atmosphere it dissolves. certain gases, traces of minerals, dust, bacteria, and various other substances, It is therefore essential to ascertain the quality of water available from the various sources to whether the water is potable or not. So to know the portability conditions various parameters like turbidity, pH, EC, TDS, Total hardness, calcium, magnesium, total alkalinity, Bicarbonate, carbonate, chloride, Fluoride, Nitrate, Sulphate, sodium and potassium analyzed for the study area and tabulated. Water quality index was calculated and spatial distribution of WQI was developed. The final output has given in the pictorial representation of ground water quality suitable or unsuitable for drinking purposes in the area under study.

Out of 30 villages only two villages contain ground water in 'good' category and other twenty eight villages in 'poor' category as per WQI. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption. The continuous monitoring of groundwater is required in the rich iron mineral city to protect water in future from any possible contamination due to growing industrialization and agricultural practices.

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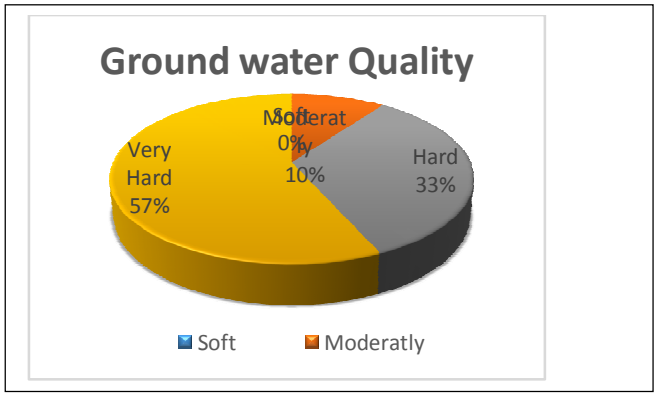

Figure 1 Ground water Quality as per Sawyer Classification of ground water for domestic purpose

TABLE 2 PHYSICO-CHEMICAL QUALITY OF GROUND WATER IN AND AROUND THE RICH IRON MINERAL CITY OF KARNATAKA STATE

Bore well No.	Turbidity (NTU)	pH	EC (μ mhos/cm)	TH (mg/l)	Ca (mg/l)	Mg (mg/l)	Na(mg/l)	K (mg/l)	Cl (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	F (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	TA (mg/l)	TDS (mg/l)
Allipur	1.0	7.1	1500.0	650.0	51.0	56.0	92.0	6.3	337.0	14.0	348.5	0.9	80.0	51.0	262.0	1320.0
Andrahal Poultry Farm	1.6	8.2	3410.0	1264.0	66.0	38.0	81.0	2.2	840.0	32.0	522.0	0.8	330.0	59.8	279.0	1650.0
ATP Road	2.1	7.7	4500.0	2420.0	24.0	16.0	106.0	1.2	114.0	0.0	296.0	1.1	500.0	24.9	348.0	3180.0
Bandhihatti	1.2	7.1	1900.0	440.0	58.2	36.0	108.0	4.3	295.5	0.0	94.0	1.2	164.0	26.0	241.0	1160.0
Bapujinagar	0.6	7.6	550.0	215.0	23.6	8.0	64.0	1.6	20.0	0.0	230.0	1.9	120.0	63.0	326.0	360.0
Basaveswaranagar	1.0	7.4	1300.0	460.0	65.1	48.0	62.0	2.2	130.5	12.0	142.0	1.7	125.0	63.0	312.0	1080.0
Beechinagar	1.0	7.6	730.0	250.0	72.0	30.0	82.0	1.6	21.0	11.0	186.0	1.1	82.0	55.0	318.0	500.0
Belagal Road	1.0	8.0	4120.0	1290.0	164.3	24.0	67.0	1.8	135.0	0.0	590.0	0.2	42.0	68.0	324.0	2980.0
Bislahalli	0.2	7.1	310.0	160.0	72.0	22.0	61.0	2.0	24.5	0.0	84.0	0.6	73.0	27.0	395.0	520.0
Cowl Bazar	1.8	7.8	2100.0	645.0	64.1	32.0	74.0	2.3	152.0	0.0	168.0	1.2	190.0	67.0	361.0	1340.0
Gandhinagar	1.0	8.0	1000.0	294.0	60.5	38.0	73.0	1.8	103.5	10.0	96.0	2.1	86.0	48.0	381.0	540.0
Devinagar	1.0	7.3	860.0	225.0	62.5	22.0	60.0	21.0	58.5	0.0	124.0	2.5	50.0	16.0	402.0	530.0
Ganeshnagar	1.0	7.5	1100.0	266.0	83.8	28.0	48.0	2.4	71.0	0.0	168.0	2.1	90.0	19.0	372.0	620.0
Gonahal School	1.0	7.9	1100.0	398.0	107.4	21.0	58.0	2.0	132.0	0.0	232.0	0.8	4.0	28.0	398.0	440.0
Guggarahatti	2.0	8.1	2600.0	658.0	84.2	32.0	168.0	1.6	455.5	0.0	436.0	1.2	300.0	27.0	301.0	1780.0
Harishchandranagar	1.0	7.4	650.0	120.0	64.2	24.0	56.0	3.8	37.5	14.0	82.5	1.2	10.0	64.0	376.0	360.0
Hussainnagar	1.0	7.6	800.0	286.0	85.8	44.0	118.0	3.2	129.5	10.0	110.0	1.1	40.0	15.0	318.0	620.0
Ishwarayya Colony	1.4	7.6	2000.0	565.0	120.0	26.0	48.0	2.0	165.0	9.0	212.0	0.8	115.0	50.0	329.0	1340.0
Jagratinagar	1.2	7.9	1800.0	765.0	68.1	36.0	58.0	1.8	176.5	5.0	148.0	1.3	210.0	5.0	379.0	1120.0
Jayanagar Park	1.8	7.8	3000.0	1412.0	82.2	23.0	74.0	0.9	129.0	0.0	190.0	1.5	160.0	69.0	368.0	2040.0
Industrial Area	1.6	7.5	3500.0	326.0	436.9	11.0	52.0	1.7	126.0	0.0	130.0	0.4	135.0	54.3	260.0	1200.0
Nallacharuvu	1.7	7.8	2300.0	770.0	132.3	22.0	75.0	0.8	102.0	0.0	210.5	0.6	142.5	22.8	349.0	1465.0
Nehru colony	2.0	7.7	1600.0	803.0	44.0	21.0	64.0	1.8	81.0	19.0	206.0	1.2	280.0	23.0	336.0	1320.0
Netajinagar	1.0	7.6	500.0	265.0	94.2	44.0	118.0	3.2	39.0	10.0	103.0	0.3	10.0	61.0	326.0	440.0
Parvathinagar	1.0	8.1	795.0	235.0	18.2	20.0	58.0	2.2	59.0	0.0	180.0	1.0	35.0	63.0	395.0	565.0
Polytechnic Hostel	2.0	8.0	2700.0	810.0	117.0	23.0	61.0	2.0	108.5	0.0	232.0	1.3	145.0	40.8	383.0	1900.0
R.K.Colony	1.3	8.1	1100.0	450.0	128.3	64.0	83.0	4.3	91.5	7.0	312.0	0.7	24.0	66.0	314.0	740.0
S.N.Pet	1.1	7.0	1050.0	255.0	46.1	22.0	46.0	4.0	64.5	14.0	124.0	1.2	140.0	65.0	376.0	440.0
Railway Colony	1.0	7.8	860.0	190.0	74.1	14.8	52.0	3.2	30.0	12.0	104.0	1.5	36.0	66.0	368.0	630.0
Vinayaknagar	1.2	7.9	860.0	250.0	29.3	20.0	54.0	1.3	31.5	8.0	206.0	1.9	84.0	18.0	391.0	500.0

TABLE 3 AVERAGE VALUES OF WATER QUALITY PARAMETER, BIS STANDARDS AND THEIR WEIGHTAGES

Bore well No.	Turbidity (NTU)	pH	EC (µ mhos/cm)	TH (mg/l)	Ca (mg/l)	Mg (mg/l)	Na(mg/l)	K (mg/l)	Cl (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	F (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	TA (mg/l)	TDS (mg/l)
Max	2.05	8.20	4500.00	2420.00	436.90	64.00	590.00	32.00	840.00	2.47	69.00	500.00	402.00	3180.00	168.00	21.00
Min	0.20	7.00	310.00	120.00	18.20	8.00	82.50	0.00	20.00	0.23	5.00	4.00	241.00	360.00	46.00	0.80
Sd	0.44	0.33	1124.97	491.03	74.42	12.86	125.60	7.74	163.53	0.55	20.64	109.96	44.40	735.78	26.87	3.60
Avg	1.3	7.7	1686.5	571.2	86.6	28.9	208.9	6.2	142.0	1.2	44.2	126.8	342.9	1089.3	74.0	3.0
BIS	5	7	2000	300	75	30	244	250	250	1	45	150	200	500	20	10
Wi	0.011364	0.129032	0.008577	0.064516	0.064516	0.064516	0.096774	0.096774	0.01	0.129032	0.16129	0.129032	0.02144166	0.005146	0.032258	0.032258

TABLE 4 DETAILS OF SAMPLES AND THEIR QUALITY BASED ON HARDNESS AND WQI

WATER QUALITY INDEX VALUE	WATER QUALITY	HARDNESS DETAILS OF SAMPLES	WQI DETAILS OF SAMPLES
<50	Excellent	0	0
50 – 100	Good Water	0	(02) Bislahalli and Gonahal School
100 – 200	Poor Water	(03), Bislahalli Harishchandranagar Railway Colony	(28) Allipur, Andrahal Poultry Farm, ATP Road, Bandhihatti, Bapujinagar, Basaveswaranagar, Beechinagar, Belagal Road, Cowl Bazar, Gandhinagar, Devinagar, Ganeshnagar, Guggarahatti, Harishchandranagar, Hussainnagar, Ishwarayya Colony, Jagratinagar, Jayanagar Park, Industrial Area, Nallacharuvu, Nehru colony, Netajinagar, Parvathinagar, Polytechnic Hostel, R.K.Colony, S.N.Pet, Railway Colony, Vinayaknagar
200 – 300	Very poor water	(10), Bapujinagar, Beechinagar, Gandhinagar, Devinagar, Ganeshnagar, Hussainnagar, Netajinagar, Parvathinagar. S.N.Pet	-
>300	Water unsuitable for drinking	(17) Allipur, Andrahal Poultry Farm, ATP Road, Bandhihatti, Basaveswaranagar, Beechinagar, Belagal Road, Cowl Bazar, Gandhinagar, Devinagar, Ganeshnagar, Guggarahatti, Ishwarayya Colony, Jagratinagar, Jayanagar Park, Industrial Area, Nallacharuvu, Nehru colony, Polytechnic Hostel, .K.Colony, Vinayaknagar	-

TABLE 5 CALCULATED QI VALUES FOR GROUND WATER IN AND AROUND THE RICH IRON MINERAL CITY OF KARNATAKA STATE

Bore well No.	Turbidity (NTU)	pH	EC (μ mhos/cm)	TH (mg/l)	Ca (mg/l)	Mg (mg/l)	Na(mg/l)	K (mg/l)	Cl (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	F (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	TA (mg/l)	TDS (mg/l)
Allipur	20.0	101.4	75.0	216.7	68.0	186.7	142.8	5.6	134.8	91.0	113.3	53.3	131.0	264.0	460.0	63.0
Andrahal Poultry Farm	32.0	117.1	170.5	421.3	88.0	126.7	213.9	12.8	336.0	78.0	132.9	220.0	139.5	330.0	405.0	22.0
ATP Road	41.0	110.0	225.0	806.7	32.0	53.3	121.3	0.0	45.6	112.0	55.3	333.3	174.0	636.0	530.0	12.0
Bandhihatti	23.6	101.4	95.0	146.7	77.6	120.0	38.5	0.0	118.2	120.0	57.8	109.3	120.5	232.0	540.0	43.0
Bapujinagar	12.0	108.6	27.5	71.7	31.5	26.7	94.3	0.0	8.0	186.0	140.0	80.0	163.0	72.0	320.0	16.0
Basaveswaranagar	20.0	105.7	65.0	153.3	86.8	160.0	58.2	4.8	52.2	171.0	140.0	83.3	156.0	216.0	310.0	22.0
Beechinagar	20.0	108.6	36.5	83.3	96.0	100.0	76.2	4.4	8.4	111.0	122.2	54.7	159.0	100.0	410.0	16.0
Belagal Road	20.0	114.3	206.0	430.0	219.1	80.0	241.8	0.0	54.0	23.0	151.1	28.0	162.0	596.0	335.0	18.0
Bislahalli	4.0	101.4	15.5	53.3	96.0	73.3	34.4	0.0	9.8	61.0	60.0	48.7	197.5	104.0	305.0	20.0
Cowl Bazar	36.0	111.4	105.0	215.0	85.5	106.7	68.9	0.0	60.8	120.0	148.9	126.7	180.5	268.0	370.0	23.0
Gandhinagar	20.4	114.3	50.0	98.0	80.7	126.7	39.3	4.0	41.4	207.0	106.7	57.3	190.5	108.0	365.0	18.0
Devinagar	20.0	104.3	43.0	75.0	83.3	73.3	50.8	0.0	23.4	247.0	35.6	33.3	201.0	106.0	300.0	210.0
Ganeshnagar	20.0	107.1	55.0	88.7	111.7	93.3	68.9	0.0	28.4	210.0	42.2	60.0	186.0	124.0	240.0	24.0
Gonahal School	20.0	112.9	55.0	132.7	143.2	70.0	95.1	0.0	52.8	84.0	62.2	2.7	199.0	88.0	290.0	20.0
Guggarahatti	39.2	115.7	130.0	219.3	112.3	106.7	178.7	0.0	182.2	119.0	60.0	200.0	150.5	356.0	840.0	16.0
Harishchandranagar	20.0	105.7	32.5	40.0	85.6	80.0	33.8	5.6	15.0	121.0	142.2	6.7	188.0	72.0	280.0	38.0
Hussainnagar	20.0	108.6	40.0	95.3	114.4	146.7	45.1	4.0	51.8	110.0	33.3	26.7	159.0	124.0	590.0	32.0
Ishwarayya Colony	27.2	108.6	100.0	188.3	160.0	86.7	86.9	3.6	66.0	82.0	111.1	76.7	164.5	268.0	240.0	20.0
Jagratinagar	24.0	112.9	90.0	255.0	90.8	120.0	60.7	2.0	70.6	131.0	11.1	140.0	189.5	224.0	290.0	18.0
Jayanagar Park	36.0	111.4	150.0	470.7	109.6	76.7	77.9	0.0	51.6	150.0	153.3	106.7	184.0	408.0	370.0	9.0
Industrial Area	32.0	107.1	175.0	108.7	582.5	36.7	53.3	0.0	50.4	35.0	120.7	90.0	130.0	240.0	260.0	17.0
Nallacharuvu	33.0	111.4	115.0	256.7	176.4	73.3	86.3	0.0	40.8	62.0	50.7	95.0	174.5	293.0	375.0	8.0
Nehru colony	40.0	110.0	80.0	267.7	58.7	70.0	84.4	7.6	32.4	116.0	51.1	186.7	168.0	264.0	320.0	18.0
Netajinagar	20.0	108.6	25.0	88.3	125.6	146.7	42.2	4.0	15.6	32.0	135.6	6.7	163.0	88.0	590.0	32.0
Parvathinagar	20.0	115.7	39.8	78.3	24.3	66.7	73.8	0.0	23.6	101.0	140.0	23.3	197.5	113.0	290.0	22.0
Polytechnic Hostel	39.6	114.3	135.0	270.0	156.0	76.7	95.1	0.0	43.4	126.0	90.7	96.7	191.5	380.0	305.0	20.0
R.K.Colony	26.0	115.7	55.0	150.0	171.1	213.3	127.9	2.8	36.6	66.0	146.7	16.0	157.0	148.0	415.0	43.0
S.N.Pet	21.4	100.0	52.5	85.0	61.5	73.3	50.8	5.6	25.8	119.0	144.4	93.3	188.0	88.0	230.0	40.0
Railway Colony	20.0	101.4	75.0	216.7	68.0	186.7	142.8	5.6	134.8	91.0	113.3	53.3	131.0	264.0	460.0	63.0
Vinayaknagar	32.0	117.1	170.5	421.3	88.0	126.7	213.9	12.8	336.0	78.0	132.9	220.0	139.5	330.0	405.0	22.0

TABLE 6 CALCULATED WI VALUES FOR GROUND WATER IN AND AROUND THE RICH IRON MINERAL CITY OF KARNATAKA STATE

Bore well No.	Turbidity (NTU)	pH	EC (μ mhos/cm)	TH (mg/l)	Ca (mg/l)	Mg (mg/l)	Na(mg/l)	K (mg/l)	Cl (mg/l)	CO_3 (mg/l)	HCO_3 (mg/l)	F (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	TA (mg/l)	TDS (mg/l)	**WQI**
Allipur	0.2	13.1	0.6	14.0	4.4	12.0	13.8	0.5	1.3	11.7	18.3	6.9	2.8	1.4	14.8	2.0	**119.0**
Andrahal Poultry Farm	0.4	15.1	1.5	27.2	5.7	8.2	20.7	1.2	3.4	10.1	21.4	28.4	3.0	1.7	13.1	0.7	**163.6**
ATP Road	0.5	14.2	1.9	52.0	2.1	3.4	11.7	0.0	0.5	14.5	8.9	43.0	3.7	3.3	17.1	0.4	**180.2**
Bandhihatti	0.3	13.1	0.8	9.5	5.0	7.7	3.7	0.0	1.2	15.5	9.3	14.1	2.6	1.2	17.4	1.4	**106.8**
Bapujinagar	0.1	14.0	0.2	4.6	2.0	1.7	9.1	0.0	0.1	24.0	22.6	10.3	3.5	0.4	10.3	0.5	**108.6**
Basaveswaranagar	0.2	13.6	0.6	9.9	5.6	10.3	5.6	0.5	0.5	22.1	22.6	10.8	3.3	1.1	10.0	0.7	**123.4**
Beechinagar	0.2	14.0	0.3	5.4	6.2	6.5	7.4	0.4	0.1	14.3	19.7	7.1	3.4	0.5	13.2	0.5	**106.2**
Belagal Road	0.2	14.7	1.8	27.7	14.1	5.2	23.4	0.0	0.5	3.0	24.4	3.6	3.5	3.1	10.8	0.6	**144.6**
Bislahalli	0.0	13.1	0.1	3.4	6.2	4.7	3.3	0.0	0.1	7.9	9.7	6.3	4.2	0.5	9.8	0.6	**79.1**
Cowl Bazar	0.4	14.4	0.9	13.9	5.5	6.9	6.7	0.0	0.6	15.5	24.0	16.3	3.9	1.4	11.9	0.7	**133.0**
Gandhinagar	0.2	14.7	0.4	6.3	5.2	8.2	3.8	0.4	0.4	26.7	17.2	7.4	4.1	0.6	11.8	0.6	**119.0**
Devinagar	0.2	13.5	0.4	4.8	5.4	4.7	4.9	0.0	0.2	31.9	5.7	4.3	4.3	0.5	9.7	6.8	**109.4**
Ganeshnagar	0.2	13.8	0.5	5.7	7.2	6.0	6.7	0.0	0.3	27.1	6.8	7.7	4.0	0.6	7.7	0.8	**108.2**
Gonahal School	0.2	14.6	0.5	8.6	9.2	4.5	9.2	0.0	0.5	10.8	10.0	0.3	4.3	0.5	9.4	0.6	**97.2**
Guggarahatti	0.4	14.9	1.1	14.2	7.2	6.9	17.3	0.0	1.8	15.4	9.7	25.8	3.2	1.8	27.1	0.5	**162.4**
Harishchandranagar	0.2	13.6	0.3	2.6	5.5	5.2	3.3	0.5	0.2	15.6	22.9	0.9	4.0	0.4	9.0	1.2	**101.4**
Hussainnagar	0.2	14.0	0.3	6.2	7.4	9.5	4.4	0.4	0.5	14.2	5.4	3.4	3.4	0.6	19.0	1.0	**107.0**
Ishwarayya Colony	0.3	14.0	0.9	12.2	10.3	5.6	8.4	0.3	0.7	10.6	17.9	9.9	3.5	1.4	7.7	0.6	**122.3**
Jagratinagar	0.3	14.6	0.8	16.5	5.9	7.7	5.9	0.2	0.7	16.9	1.8	18.1	4.1	1.2	9.4	0.6	**123.3**
Jayanagar Park	0.4	14.4	1.3	30.4	7.1	4.9	7.5	0.0	0.5	19.4	24.7	13.8	3.9	2.1	11.9	0.3	**162.6**
Industrial Area	0.4	13.8	1.5	7.0	37.6	2.4	5.2	0.0	0.5	4.5	19.5	11.6	2.8	1.2	8.4	0.5	**137.9**
Nallacharuvu	0.4	14.4	1.0	16.6	11.4	4.7	8.3	0.0	0.4	8.0	8.2	12.3	3.7	1.5	12.1	0.3	**125.2**
Nehru colony	0.5	14.2	0.7	17.3	3.8	4.5	8.2	0.7	0.3	15.0	8.2	24.1	3.6	1.4	10.3	0.6	**136.3**
Netajinagar	0.2	14.0	0.2	5.7	8.1	9.5	4.1	0.4	0.2	4.1	21.9	0.9	3.5	0.5	19.0	1.0	**117.2**
Parvathinagar	0.2	14.9	0.3	5.1	1.6	4.3	7.1	0.0	0.2	13.0	22.6	3.0	4.2	0.6	9.4	0.7	**112.3**
Polytechnic Hostel	0.5	14.7	1.2	17.4	10.1	4.9	9.2	0.0	0.4	16.3	14.6	12.5	4.1	2.0	9.8	0.6	**144.3**
R.K.Colony	0.3	14.9	0.5	9.7	11.0	13.8	12.4	0.3	0.4	8.5	23.7	2.1	3.4	0.8	13.4	1.4	**143.3**
S.N.Pet	0.2	12.9	0.5	5.5	4.0	4.7	4.9	0.5	0.3	15.4	23.3	12.0	4.0	0.5	7.4	1.3	**125.4**
Railway Colony	0.2	14.4	0.4	4.1	6.4	3.2	4.1	0.5	0.1	19.4	23.7	3.1	3.9	0.6	8.4	1.0	**122.4**
Vinayaknagar	0.3	14.6	0.4	5.4	2.5	4.3	8.2	0.3	0.1	25.0	6.5	7.2	4.2	0.5	8.7	0.4	**118.6**

