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HYDROGEOCHEMICAL ANALYSIS OF GROUND WATER PARAMETERS IN COIMBATORE DISTRICT, TAMILNADU, INDIA

P. SANTHOSH* and D. REVATHI

Department of Chemical Engineering, Kongu Engineering College, Perundurai, ERODE – 638052 (T.N.) INDIA

ABSTRACT

This study deals with the hydrogeochemical analysis of ground water parameters in the Noyyal river basin along the Coimbatore district. By this process the quality of ground water for drinking and irrigation purpose are estimated. The secondary data were collected from Public Work Department (PWD) and these data were analysed and compared with BIS standards and WHO standards. Their physio-chemical characteristics and calculate parameters viz., pH, total dissolved solids (TDS), potassium (K), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), chlorides (Cl^{-}), sulphates (SO_4^{2-}), concentration of sodium (Na^{+}), carbonates (CO_3^{2-}), bicarbonates (HCO_3^{-}) and fluoride (F^{-}). These parameters are useful in predicting the ground water quality and its characteristics. In this study, it is found that the water is not suitable for drinking purpose and less suitable for irrigation.

Key words: Physio-chemical characteristics, Permissible limit, Water quality parameters.

INTRODUCTION

Ninety nine percent of all fresh water on earth is ground water. Ground water is found in natural rock formations. These formations called aquifers are a vital natural resource with many uses. Nationally 53% of the population relies on groundwater as a source of drinking water.

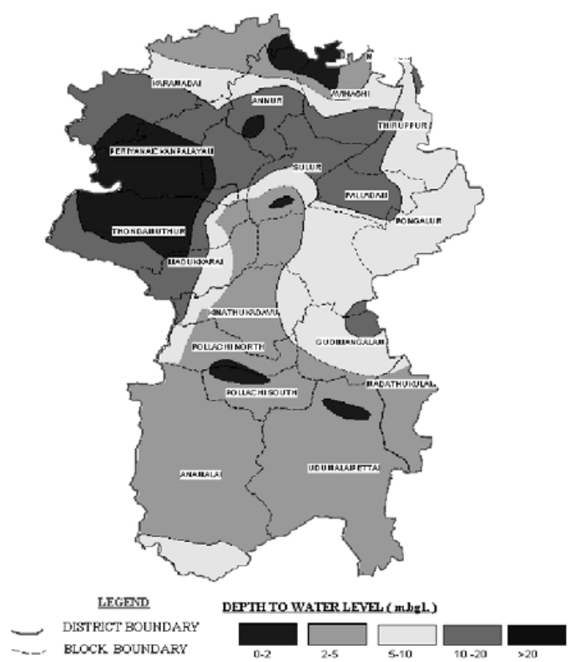
Ground water is considered to be very clean and safe in past days but in recent decades rapid industrialization causes severe environmental problems in most of the countries, due to the discharge of effluents into ground water by industries like textile, dyeing, leather, tannery, pulp and paper processing industries etc., The effluent discharged by these industries leads to serious pollution, which altered the geochemical parameters of surface water and ground water. Generally, the above industrial units are functioning mainly

*Author for correspondence; E-mail: psantoshsciencetechnology@gmail.com

in small/medium scale with high employment generation and foreign exchange potential. As most of these industries require high water demand in nature, they are concentrated along the river courses. This gives them good access of water and enables the use of the river for untreated effluent discharge. So the continuous discharge of effluent leads to the accumulation of pollutants in river basin. This paper investigates on the results of physio-chemical analysis of ground water samples obtained from Noyyal river basin. The river is small in size as compared to other Indian rivers, but it has all the ingredients of a riveting contest between use and abuse between desperate and sustainable development.

Study area

Noyyal river originates from the Velliangiri hills of the Western Ghats in Coimbatore and flows through Coimbatore, Erode and Karur districts of Tamil Nadu and it ends in river Cauvery at Kodumudi. The river has a length of 180 Km and it has average width of 25 m. The boundary of the river basin is between North latitude 10°54' 00" to 11°19' 03" and East longitude 76°39' 30" to 77°05' 25". Annual rainfall is highly varied in the basin. The upper receives high rainfall of more than 3000 mm annually, while the lower region of the basin receives only 600 mm. Noyyal river has been associated with water quality problems and practice of discharging untreated industrial wastewater into the river course has been alarming. The quality of ground water in Coimbatore district has been deteriorating rapidly during the last decade.



EXPERIMENTAL

Methodology

The basis methodology used to determine water quality index (WQI), which was developed by Environmental Protection Agency (EPA). The secondary data are collected from the public work department (PWD) for Coimbatore districts. These data are analysed and compared with WHO standards and BIS standards. Five basic steps are involved in this process (1) secondary data collection, (2) analysis and comparison, (3) correlation and interpolation, (4) water quality index interpretation, (5) results and recommendations.

Water Quality Index (WQI)

Water quality Index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water. It reduces the large amount of water quality data to a single numerical value. It is calculated from the point of view of human consumption. Water quality and its suitability for drinking purpose have been considered for calculation of WQI. In this method the weight age for various water quality parameters is assigned to be inversely proportional to the recommended standards for the corresponding parameters as shown in Table 1. Water Quality Index is computed by the following formula

$$WQI = \text{Antilog}\ [SW^{n}_{n=1} \log_{10} q_n]$$

Where, W_n, Weightage = K/S_n and K, constant = $1/(S^{n}_{n=1}\ 1/S_i)$, S_n and S_i correspond to the WHO/ICMR standard value of the parameters. Quality rating (q) is calculated as $Q_{ni} = [(V_{actual} - V_{ideal})/(V_{standard} - V_{ideal})] \times 100$, where q_{ni} = quality rating of i^{th} parameter for a total of n water samples, V_{actual} = value of the water quality parameter obtained from the laboratory analysis, $V_{standard}$ = value of the water quality parameter obtained from the standard tables. V_{ideal} for pH = 7 and for the other parameters it is equivalent to zero.

Table 1: Water quality scale with reference to WQI

WQI	Quality of water
0-24	Excellent
25-49	Good
50-74	Poor
75-100	Very poor
>100	Unfit for drinking

RESULTS AND DISCUSSION

pH

The water quality indices were calculated to determine the suitability of water for drinking purpose from the analyzed result. The pH was alkaline in nature and it varies between 7.81 to 8.11. As per BIS standards the nature pH may ranges from 4.4 to 8.8. The presence of chlorine in natural water are mainly due to dissolution of salt deposits.

Chloride ion

The chloride ion is formed when the element chlorine, a halogen, gains an electron to form an anion (negatively charge ion) Cl^-. The salts of HCl contain chloride ions and can also be called chlorides. The chloride ions, and its salts such as sodium, chloride, are very soluble in water. It is an essential electrolyte located in all body fluids responsible for maintain acid/base balance, transmitting nerve impulses and regulating fluid in and out of cells. The chloride content was high in all the area except Anakati, Andipalayam, Ambarapalayam, Metupalayam, Badrakaliammankovil, Bogampatti, Pichanur, Thenkarai, Natchipalayam, Vadavalli, and Valparai. The water qualities of the above area are compared better than other stations. The high amount of chloride has deleterious effect on metallic pipes and structures as well as on plants.

Total dissolved solids

The total dissolved solids content of ground water water is two to three times higher than the surface water due to longer residential time. It's the main factor, which determines the use of groundwater for any purposes. Salts of calcium, magnesium, sodium and potassium present in irrigation water may prove detrimental to crops. If total dissolved solids are above 1000 mg/L, it is considered as unsuitable for irrigation. A total dissolved solid varies from 290 mg/L in Andipalayam to 1050 mg/L in Ponnayur showing higher variation above the permissible limit. The high amount of TDS in the soil causes negative impact on irrigation.

Total hardness

It is the sum of calcium and magnesium concentration the permissible limit is 600 mg/L, in most of the place it ranges from 430 mg/L to 1650 mg/L, which is within the permissible limit. But areas such as Sirumugai, Pongalur, Possaripalayam, Gopalapuram, Kattpatti, Karinur and Chokkanur are having higher values than permissible limit.

Calcium

Calcium is not naturally found in its elemental state. Calcium occurs most commonly in sedimentary rocks in the minerals like calcite, dolomite and gypsum. It also occurs in igneous and metamorphic rocks chiefly in the silicate minerals: plagioclases, amphiboles, pyroxenes and garnets. High calcium intakes or high calcium absorption were previously thought to contribute to the development of kidney stones. For calcium permissible limit is 75 mg/L to 200 mg/L, most of samples come under this limit, except Ondipudur and Ponnur, which exceeds the permissible limit.

Magnesium

It is an alkaline earth metal and the eight most abundant elements in the earth crust. Magnesium supplementation lowers high blood pressure in does dependent manner. Low serum magnesium level is associated with metabolic syndrome, diabetes mellitus and hypertension. For magnesium the permissible limit lies between 30 mg/L to 100 mg/L, most of the samples taken from various stations are coming under this limit, except Sirumugai, Pongalur, Ponnayurand Chokkanur has higher values than the permissible limit. A higher value causes encrustation in water supply and adverse effect on domestic use.

Sodium

The compounds that are the most important include table salt (NaCl), it is also one of the abundant elements in natural water due to vast use in agricultural. The sample from our river range from 50 mg/L to 72.33 mg/L, which is above permissible limit, but the areas like Valparai, Vellamadai and Panimadai arewithin the permissible limit. Excess sodium in the soil limits the uptake of water due to decreased water potential, which may result in wilting, similar concentrations in the cytoplasm can lead to enzyme inhibition, which in turn causes and chlorosis. Excess sodium may also be stored in old plant tissue, limiting the damage to new growth.

SAR (Sodium adsorption ratio)

It is a measure of the suitability of water for use in agricultural irrigation, as determined by the concentrations of solids dissolved in the water. It is also a measure of the sodicity of soil, as determined from analysis of water extracted from the soil. The formula for calculating SAR is –

$$SAR = Na^{+} / \{([Ca^{2+}] + [Mg^{2+}])/2\}^{0.5}$$

where sodium, calcium and magnesium are in milliequivalents/liter.

Table 2: Summary statistics of the physio-chemical parameters (EC expressed in μS/cm; All other parameters are expressed in mg/L)

S. No.	Parameters	Pre-monsoon				Post-monsoon				IS 10500 Limits		IS 2296 Limits
		Minimum	Maximum	Mean	S.D	Minimum	Maximum	Mean	S.D	Desirable	Permissible	Desirable
1.	pH	7.81	8.11	7.99	0.13	7.27	7.78	7.47	0.23	6.5-8.5	6.5-9.2	-
2.	TDS	290	1050	635.8	267.4	250	1070	683.3	295.6	500	1500	<1500
3.	EC	0.96	5.68	3.15	1.47	1.14	5.81	3.4	1.6	-	-	<0.25
4.	TH	430	1650	954.6	415.6	660	1720	1138.7	379.8	300	600	-
5.	Ca^{2+}	90	590	256.7	144.1	195	590	374.2	127.2	75	200	-
6.	Mg^{2+}	335	1220	697.9	284.8	370	1385	764.6	298.7	30	100	-
7.	Na^{+}	50.67	72.33	58.66	10.29	114	150.33	124	19.93	-	-	-
8.	SO_4^{2-}	72	372	119.9	78.10	45	220	115.1	45.8	150	400	<1000
9.	Cl^{-}	69.2	83.23	76.5	6.09	83.23	122.67	100.57	17.44	250	1000	<600
10.	K^{+}	6.33	13.67	9	3.51	12.67	42.67	23	14.75	-	-	-
11.	Alkalinity	335	805	585.3	131.7	585	1110	845.8	130.4	200	600	-

It is a relationship between SAR values of irrigation water and sodium absorbed by soil. The calculation of SAR value for the given water provides a useful index of sodium hazard of that water to soil and crops. The SAR value in our study area is above permissible limit, which would lead to sodium hazard. But the areas like Valparai, Vellamadai and Panimadai are within the permissible limit.

Kelly's ratio

Sodium against Ca^{2+} and Mg^{2+} is used to calculate Kelly's ratio. The formula used in the estimation of Kelly's ratio is expressed as –

$$\text{Kelley's Ratio (KR)} = Na^{+}/\ Ca^{2+} + Mg^{2+}$$

A Kelley's Ratio (KR) of more than one indicates an excess level of sodium in waters. Hence, waters with a Kelley's Ratio less than one are suitable for irrigation, while those with a ratio more than one are unsuitable for irrigation. Based on Kelley's Ratio (KR) values, all values less than 1 and are suitable for irrigation in our study area it varies from 0.15 to 4.8 (from Table 2). So the areas having above 1 is considered for unfit for irrigation.

Magnesium Adsorption Ratio (MAR)

Magnesium content of water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation, Generally, calcium and magnesium maintain a state of equilibrium in water. More magnesium in water will adversely affect crop yields as the soil become more saline. The formula for calculating magnesium adsorption ratio is –

$$\text{MAR} = \frac{Mg^{2+}\ \text{x}\ 100}{Ca^{2+} + Mg^{2+}}$$

Excess of magnesium affects the quality of soil, which causes poor yield of crops. The Magnesium ratio in our study area varies from 3.2 to 79.8 epm. Except few locations, other locations are found above permissible limit.

Correlation coefficient analysis

Sources of measured parameters in ground water were examined through the analysis of linear correlation. The correlation metric for all samples are shown in Table 3. We considered the correlation as good if $r > 0.6$ and marginal of $0.47 < r < 0.6$. Since the total hardness and total alkalinity ($r = 0.50$) has good correlation as well as pH with sodium and potassium (r = 0.052, 0.33 respectively), it clearly indicates the level of bicarbonate and carbonate of sodium and potassium were found excess in the ground water. Hence, it makes ground water more alkaline. Calcium has good correlation with chloride and sulphate (r = 0.12 and 0.0030, respectively) indicating that it is in the form of $CaCl_2$ and $CaSO_4$ so as to produces permanent hardness. Also, sulphate shows marginal correlation with magnesium (r = 0.013) and good correlation with sodium (r = 0.0029) and potassium (r = 0.0017). It means that nitrate exist in the non-acidic salt form. Similarly, the conductivity has good correlation with calcium (r = 0.0280), sodium (r = 0.0276), chloride (r = 0.0120) and sulphate (r = 0.0029).

Table 3: Correlation matrix

	K^+	TDS	pH	TH	Ca^{2+}	Mg^{2+}	Cl^-	F^-	SO_4^{2-}	Na^+
K^+	1.0000									
TDS	0.0175	1.0000								
pH	0.3357	0.5000	1.0000							
TH	0.0177	0.0265	0.5080	1.0000						
Ca^{2+}	0.0189	0.0282	0.5410	0.0230	1.0000					
Mg^{2+}	0.0130	0.0213	0.4095	0.1280	0.0230	1.0000				
Cl^-	0.0072	0.1119	0.2289	0.0310	0.1280	0.0131	1.0000			
F^-	0.0175	0.0287	0.5509	0.0030	0.0310	0.0031	0.0131	1.0000		
SO_4^{2-}	0.0017	0.0028	0.0549	0.0029	0.0030	0.0013	0.0013	0.0031	1.0000	
Na^+	0.0166	0.0273	0.05242	0.0276	0.0295	0.0223	0.0124	0.03	0.0029	1.0000

CONCLUSION

The observation, we collected and estimated in this present study indicates the higher value of most of the parameters of the sample. Since due to this higher value of TDS obtained at different stations along the Noyyal river basin makes the ground water unsuitable for drinking and irrigation purpose. When WQI is greater than 100, it implies that the pollutants are above the standard limits. Similarly $0 < WQI > 100$ those areas are unfit for drinking purpose. The four stations like Valparai, Vellamadai, Panimadaiand Karamadai has WQI less than 50, which comes under excellent water quality. So the ground water present in these areas are suitable for drinking and domestic purpose. Finally this research suggest that the ground water having higher parameters values along the study area can be used domestically only after proper treatment methods.

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