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An Environmental Quality Assessment on Groundwater Geochemistry in Western Part of Perambalur District, Tamilnadu, India

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ABSTRACT

A study with the objective of identifying the hydro-geochemical processes and their relation with existing quality of groundwater was carried out in an intensively partially hilly region of the district of Tamilnadu, India. The study area is one of the backward city in our state. The study approach includes conventional graphical plots and multivariate analysis of the hydrochemical data to define the geochemical evaluation of aquifer system based on the ionic constituents, water types, and factors controlling groundwater quality. Groundwater quality maps are effective for identifying locations that involve the threat of contamination. The study area situated in central part of Tamilnadu, India. Study area lies between 11°06'11" N to 11°80'05"N in latitude and in longitude from 78°39'28" E to 79°39'19" E. The groundwater samples were collected from different location of our study area and the locations having a coordinates point. It's obtained by using handheld global positioning system (GPS) receiver. The analysed geochemical data were to be discussed in the various methodologies like USSL, Piper. The above analytical methods to give the solution to our ground water quality.

1. Introduction

Groundwater is an essential source of drinking water in rural India. Contamination of groundwater (resulting from human activities or from inherent aquifer material composition) reduces the supply of safe drinking water posing a threat to public health and a challenge to water managers and strategists. Groundwater quality maps are effective for identifying locations that involve the threat of contamination. Part of the study area poor quality of ground water present. The character of groundwater in dissimilar aquifers over space and time proved to be an imperative technique in solving dissimilar geochemical problems [1].

Because increased industrialization, urbanization and agricultural activities during the last few decades have deteriorated the surface water and groundwater quality of Tamilnadu, the southernmost state of India. Understanding the special distribution of pH, Electrical Conductivity (EC), Total suspended solids (TDS), sodium percentage (Na%), chloride and total iron content will help to identify the quality of ground water. Groundwater contamination can often have serious ill effects on human health. Groundwater with low pH values can cause gastrointestinal disorders, such as hyper acidity, ulcers, stomach pain and burning sensation. pH values below 6.5 cause corrosion of metal pipes, resulting in their lease of toxic metals such as Zn, Pb, Cd, Cu etc. [2] Electrical conductivity (EC) of groundwater is considered as an important parameter for irrigation and industrial purposes. Total dissolved solids help to identify the portability of groundwater. Total iron content may not have direct effects on human health but is of importance due to aesthetic reasons. The excess presence of iron in groundwater causes stains to cloths and fixtures and has a bad taste and odour. These problems arise when iron concentration approaches more than 0.3 mg/L in groundwater. High concentration of fluoride in drinking water is also linked with cancer.

Perambalur District have the very famous temple of Lord Shiva and Krishna temple, engineering colleges, medical colleges, etc. The population of Perambalur District is around six lakhs and area 1,756 sq.km. The main water source for the town is Cauvery River flowing in the region and the composite district has a canal system covering just 47 km. At present there is some industry in and around the study area, yet household waste and garbage are directly discharged into the area. Keeping this in focus, the quality aspects of groundwater in Perambalur area were analysed for general water quality. Thus in this paper an attempt has been made to assess the physical and chemical properties of groundwater in and around Perambalur town.

2. Experimental Methods

2.1 Study Area

Our research focused on quantitative assessment of pollution within a shallow groundwater resource. The area involved in the study is small residential areas located in Padalur block, Perambalur district of Tamilnadu state, India. Fig. 1 shows the study area of the Perambalur district. The study area map indicates, the area is lies between 78°39'28" E to 79°39'19" E in longitude and between 11°06'11" N to 11°80'05" N in latitude.

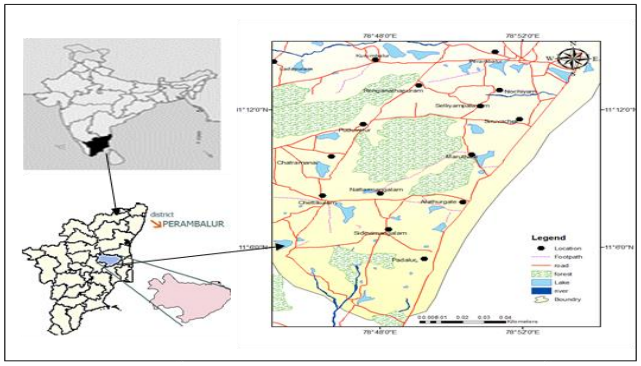

Fig. 1 Map of the study area

2.2 Drainage

After a reconnaissance survey, the watershed was delineated on the basis of drainage line, land slope, and outlet point. Cauvery is the major river flowing in the region and the composite district has a canal system covering just 47 km stretch and ayacut of 11,610 ha. This is the major

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source of water drainage in the study area. In all, the watershed has one unlined main drain and three sub-drains. Fig. 2 shows the drainage of the study area. Based on drainage channels and land topography, we found that the area could be subdivided into two or three sub watersheds.

2.3 Methodology

The water samples were collected during Pre-monsoon to broadly cover the Water quality variation. A total of 15 water samples were collected from bore wells in the pre-monsoon season (December 2014). Water samples were collected in one litre clean polyethylene bottle to broadly cover Quality variation along with lithology. EC and pH were determined in the field using electrode. Then it was sealed and brought to laboratory for analysis and stored properly (4 °C) before analysis. The cations and anions were analysed standard titration method and using instrumentation like Ca, Mg, CO_3, Cl for titration Na, K,SO_4, PO_4 and H_4SiO_4 [3] for Instrumentation like UV spectrophotometer and Flame photometer. Analysed data are given in Table 1.

The methodology adopted for this study follows the approach of [4], as depicted in Fig. 3. For generating thematic maps, we used the National Remote Sensing Agency IRS 1D LISS III digital image (Path-107, Row-56) from November 2001. We also used the Survey of India Topographic Sheet (No: 58 I/16 scale 1:50,000) and existing groundwater quality data for deriving our final results.

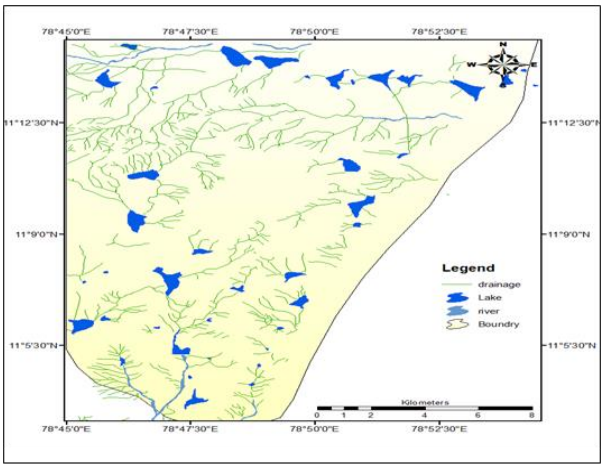

Fig. 2 Drainage map of the study area

Table 1 Physico chemical parameters of groundwater samples of Perambalur district (All values are in mg/L except EC (µs/cm) & pH)

Location name	pH	EC	TDS	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	PO_4^{3-}	NO_3^-	H_2SiO_4	Ca^{2+}	Mg^{2+}	Na^+	K^+
Ladapuram	6.49	1840	1310	0	415	478.57	1.0	0.035	0.011	10	52	48.0	130	1
Kurumbalur	6.29	2200	1560	0	342	584.92	2.6	0.035	0.011	10	56	57.6	69	1
Perambalur	6.64	2030	1440	24	293	443.12	1.6	0.045	0.07	15	56	16.8	127	1
Nochiyam	6.62	1342	950	0	305	319.05	1.8	0.067	0.35	14	76	21.6	73	0
Selliyampalayam	6.12	1312	929	0	281	301.2	1.0	0.042	0.034	18	96	38.4	86	2
Siruvachur	6.54	2090	1480	24	305	496.3	1.8	0.049	0.043	12	64	96.0	52	1
Marudhati	6.62	1436	1020	0	232	354.5	1.4	0.051	0.056	16	106	31.2	64	2
Alathur gate	6.65	1208	857	0	268	265.87	1.2	0.073	0.042	18	48	26.4	57	0
Padalur	6.29	1283	912	0	207	265.87	1.6	0.039	0.019	12	120	36.0	38	1
Sidevimangalam	6.69	1203	855	0	207	265.87	1.8	0.061	0.025	18	60	28.8	112	0
Chettikulam	6.19	1745	1240	0	293	389.95	2.0	0.056	0.068	18	44	16.8	61	2
Nattarmangalam	6.64	1611	1140	0	207	443.12	1.2	0.037	0.38	12	60	96.0	76	0
Chathramanai	6.33	1724	1220	0	207	354.5	1.6	0.063	0.073	16	84	52.8	37	2
Pudhu velur	6.72	1077	763	0	305	301.2	2.2	0.64	0.052	16	76	40.8	72	0
Renganathapuram	6.51	1864	1320	0	281	602.6	1.8	0.038	0.047	16	100	36.0	49	1
Maximum	6.72	2200	1560	24	415	602.6	2.6	0.64	0.38	18	120	96.0	130	2
Minimum	6.12	1077	763	0	207	265.87	1.0	0.035	0.011	10	44	16.8	37	0
Average	6.49	1597	1133	3.2	276	391.10	1.6	0.088	0.085	15	73.2	42.9	74	0.9

3. Results and Discussion

Water in the study area is generally had not more alkaline in nature, with pH ranging from 6.12 – 6.72 and average 6.49. In pre-monsoon season it is relatively suitable for drinking purpose. Electrical conductivity (EC) shows variation with values of 1077-2200 µs/cm, average 1598 µs/cm for the pre-monsoon.

Table 2 Comparison of chemical composition of water with WHO (2006) and ISI (1995), BIS (IS:10500) in mg/L (Except EC and pH), EC in µs/cm.

Parameters	Ground Water	WHO (2006)	ISI (1995)	BIS (IS:10500)
pH	6.12-6.72	6.5-8.5	6.5-8.5	6.5-8.5
EC	1077-2200	-	-	-
TDS	763-1560	1000	1500	2000
CO_3^{2-}	0-24	0	-	-
HCO_3^-	207.4-414.8	0	-	-
Cl^-	265.87-602.6	250	1000	1000
SO_4^{2-}	1-2.6	400	400	400
PO_4^{3-}	0.035-0.64	0	-	-
NO_3^-	0.011-0.38	50	45	100
H_2SiO_4	10.0-18.0	0	-	-
Ca^{2+}	44-120	100-300	200	200
Mg^{2+}	16.8-98	0	100	-
Na^+	37-130	200	-	-
K^+	0-2.0	0	-	-

The range of chemical parameters of all groundwater samples is in the following order, Cl > EC > TDS > HCO_3 > Ca > Na > Mg > pH > CO_3> SO_4> K> PO_4>NO_3. The ground water in the study area is generally odorless and colorless in most of the places. The analytical data were compared to standard organization of WHO, ISI and BIS (Table 2) [5-8].

3.1 Hydrochemical Facies

Major cations and anions such as Ca^{2+}, Mg^{2+}, Na^+, K^+, CO_3^{2-}, HCO_3^-, SO_4^{2-}, and Cl^- in mg/L were plotted in piper diagram to evaluate the hydrochemistry of groundwater of Perambalur region and it is adjoining area with the help of WATCLAST [8] computer programme-software and AQUA analytical software (Fig. 3). The piper diagram is using and discussed the geochemical facies of ground water [9]. It consists of two lower triangular fields and a central diamond shaped field. All the three fields have incorporation of major ions only. The triangular fields are plotted separately with EPM values of cations (Ca^{2+},Mg^{2+}) alkali earth, (Na^+, K^+) alkali, (HCO_3^-) weak acid and (SO_4^{2-} and Cl^-) strong acid. Water facies can be identified by projection of plots in the central diamond shaped field. The plot shows that groundwater samples fall in the field of Na^+-K^+-Cl^--SO_4^{2-} and Na^+- K^+- HCO_3^--CO_3^{2-} type water. The groundwater samples also fall in the transition zone between mixed Na-K-Cl-SO_4 facies and $CaCl_2$ type. This indicates that an increase in Ca and Cl in the system has eventually helped in the migration of these samples towards the sea water composition.

3.2 Sodium Percentage (Na%)

Sodium is an important ion used for the classification of irrigation water due to its reaction with soil, reduces its permeability. Percentage of Na is widely used for assessing the suitability of water for irrigation purposes. The Na% is computed with respect to relative proportion of cations present in water as,

$$Na\% = Na^+ + K^+/Ca^{2+}+Mg^{2+}+Na^++K^+ \times 100\%$$

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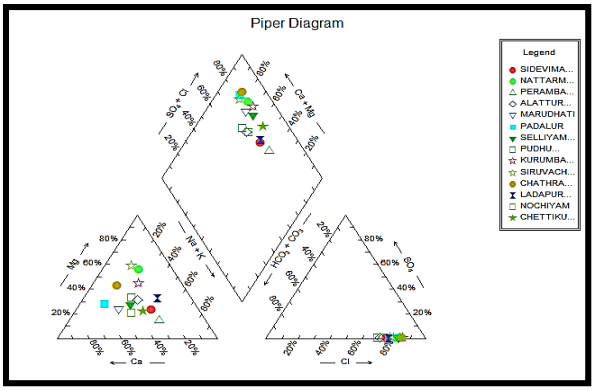

Fig. 3 Piper Diagram for ground water in North West region of Perambalur.

3.3 Sodium Adsorption Ratio (SAR)

Total salt concentration and probable sodium hazard of the irrigation water are the two major constituents for determining SAR. Salinity hazard is based on EC measurements. If water used for irrigation is high in Na^+ and low in Ca^{2+} the ion exchange complex may become saturated with Na^+ which destroys the soil structure, due to the dispersion of clay particles and reduces the plant growth. The SAR value is used to find the salinity of water. Excess salinity reduces the osmotic activity of plants.

The SAR is computed, using the following formula,

$$SAR\% = Na^+ / \sqrt{(Ca^{2+}+Mg^{2+})/2}$$

3.4 USSL Diagram

The plotting of SAR values in USSL diagram indicates that all the samples have low SAR value. Out of 15 samples, 4 sample lies in C3-S1 field, 8 samples in C3-S2 field, two samples in C3-S3 field and one sample lies in C3-S4 field (Fig. 4). The C3-S1 field in USSL diagram is considered as good water category for irrigation use [10].

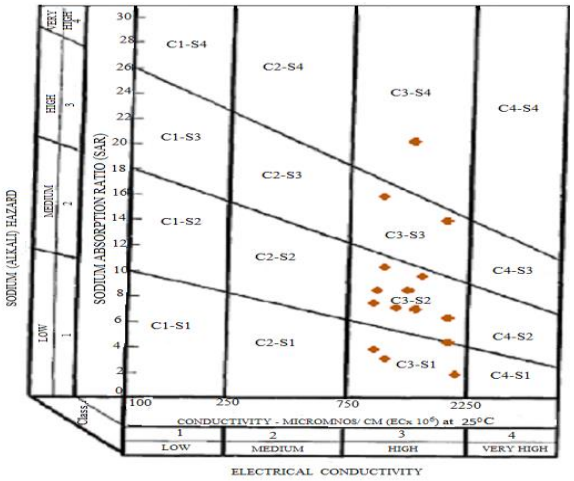

Fig. 4 USSL diagram for ground water samples

This implies that no alkali hazard is anticipated to the crops. Eight location (53%) samples occurred within C3–S2 category. This category is suitable for irrigational purposes. If the SAR value is greater than 6 to 9, the irrigation water will cause permeability problems on shrinking and swelling types of clayey soils [10].

4. Conclusion

We performed chemical analysis on groundwater samples taken from various locations within the Perambalur catchment. We noted that major water quality parameters (such as turbidity, pH, salinity, and dissolved oxygen) and measures of agriculture-derived ion (such as potassium, phosphorus, and nitrogen) reflected higher pollutant concentrations during the pre-monsoon season, which highlights the effect of precipitation on groundwater quality.

Hydrochemical analysis data revealed that the region has high concentrations of potassium and calcium. From our hydrochemical analysis results, it can also be inferred that excess concentrations of chloride and TDS, as well as the presence of water hardness, make the groundwater at some locations undesirable for drinking. As indicated on our spatially integrated drinking water quality map, the groundwater found in almost 80 percent of the Perambalur basin is desirable for drinking purposes. The irrigation water quality map shows that groundwater in over 60 percent of the area is doubt full for irrigation purposes, with salinity (as measured by electrical conductivity) of more than permissible limits of 1400 µs/cm. If they are to be used for agricultural purposes, these zones require special care and utilization of an alternative "salt tolerance" cropping pattern. However, this study has made clear that GIS-based methodology can be used successfully for groundwater quality mapping even in small catchments.

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