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Research Paper

A Drinking and Irrigational use Assessment of Groundwater in Part of Thirumanimuthar Sub Basin (Cauvery), Tamil Nadu, India.

Geology

KEYWORDS : Groundwater, Hydrogeochemistry, Pre monsoon, Part of Thirumanimuthar, Sub basin, Tamil Nadu

N. VIJAYAKUMAR

Associate Professor,Department of Geology, Government Arts College (Autonomous), Salem – 636 007.

ABSTRACT

The objective of this paper is to document and evaluate the groundwater quality of part of Thirumanimuthar sub basin (Cauvery) during May 2013. The analysis was conducted for the upper part of the watershed. During pre-monsoon season of 2013, thirty two representative groundwater samples were collected from dug and bore wells. These samples were analyzed to monitor the water chemistry of various ions, comprising Ca, Mg, Na, K, CO_3, HCO_3, SO_4 and Cl. The hydro geochemical values were compared with WHO 2004 standards. The other geochemical parameters like TDS, EC, SAR, Kelley's ratio SSP and Mg hazards were also determined. The above given parameters were calculated and used to find out the suitability of groundwater for drinking and Agricultural purposes. The USSL and Piper Trilinear Diagram interpretation were made to know the irrigational quality and facies of groundwater. It reveals that, the subsurface water is medium to high salinity in nature and falls in the Ca-Mg-CO_3 type.

INTRODUCTION

Groundwater plays an important role in human development and is an important natural resource. Development provides opportunities for pollution of ground water .The groundwater quality study involves a description of occurrence of various constituents in water and relation of these constituents to water use. The quality assessment of groundwater of Part of Thirumanimuthar Sub Basin aims to ascertain its suitability for drinking and irrigational purposes by cations, anions and other hydrologic parameters

Description of the Study Area

The Salem district is underlain by Archean crystalline metamorphic complex. The geology of the district is very complicated owing to recurring tectonic and magmatic activities in the Pre-Cambrian period. The minerals like magnestie, bauxite, iron-ore, limestone and chromite are the major contribution made to the state by the district. Charnockite, Gneiss and Dolerite are the major rock types of the study area. The Thirumanimuthar is one of the tributaries of river Cauvery. In this study area (Fig.1), Thirumanimuthar river flows from Northeastern direction to Southwestern direction.

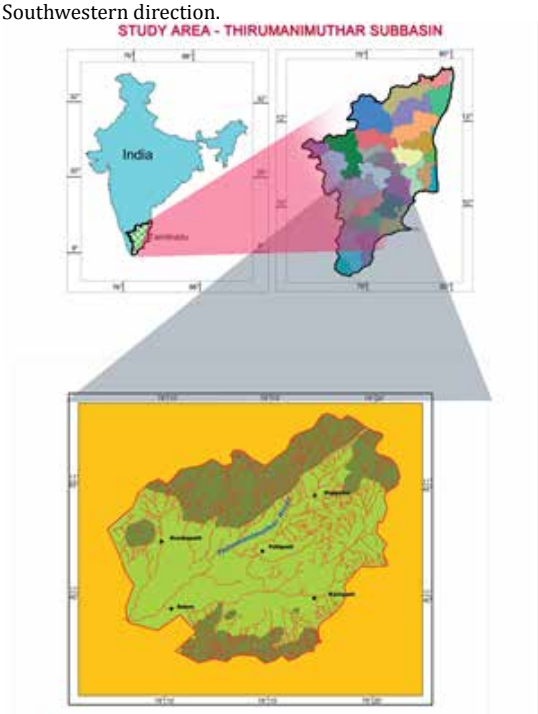

Figure.1 Location Map showing study area

Method of Analysis

In order to assess the groundwater chemistry, groundwater samples were collected during the month of May 2013. A total of thirty two representative water samples were collected from dug and bore wells respectively. The ground water samples were collected in well cleaned 1000 ml polythene bottles. The bottles were rinsed before sampling, tightly sealed after collection and were labeled in the field. The samples were analyzed for physico-chemical parameters (pH, EC), major cations (Ca, Mg, Na, K) and major anions (CO_3, HCO_3, SO_4, Cl) as per standard procedures and the results are given in the table(Table.1).The present study the specifications as proposed by Kelley's et. al., (1940), U.S.Salinity Laboratory Staff (1954), Wilcox (1948) and Paliwal (1972) have been used to assess the suitability of water for irrigational purposes. These specifications are mostly based on the chemical characters of natural water and their effect on plant growth. The calculated values of these specifications are given in the Table 2. The major cations and anions are plotted on the Piper Trilinear diagram and projected on to a common diamond – shaped field (Fig 3). It is used to study its chemical behavior and also determine its suitability for agricultural and domestic purposes.

Table 1 - Cations and Anions Concentration for Pre monsoon 2013 in ppm

S. No	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl
1	100	80	69	6	525	0	20	195
2	20	7	750	1803	1977	1266	20	177
3	140	105	90	33	964	24	20	124
4	56	143	101	21	793	0	30	177
5	44	107	205	6	732	24	10	248
6	72	119	76	4	561	0	20	248
7	76	95	225	20	720	0	40	319
8	52	117	101	12	622	0	29	213
9	100	73	85	6	622	0	20	142
10	100	78	159	23	683	0	20	230
11	44	45	53	4	342	0	10	106
12	36	26	25	35	183	0	30	71
13	44	105	274	9	635	0	10	426

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S. No	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	Cl
14	66	88	191	4	598	0	10	312
15	128	126	416	598	891	0	20	1259
16	180	73	499	18	940	0	20	780
17	88	61	191	4	879	0	20	89
18	80	71	225	4	769	0	10	248
19	172	158	320	4	1050	0	10	638
20	124	36	175	4	586	0	10	227
21	80	52	191	4	598	0	30	213
22	120	74	62	4	549	0	20	177
23	68	134	191	43	830	0	39	301
24	84	52	94	5	531	0	20	124
25	112	61	101	4	427	0	10	284
26	128	71	198	4	513	0	40	408
27	84	49	55	8	366	0	30	142
28	64	81	113	4	830	0	10	124
29	84	46	248	4	805	0	10	177
30	112	49	55	4	366	0	20	213
31	124	62	78	4	671	0	20	106
32	48	80	85	12	500	0	20	177

RESULTS AND DISCUSSION

Hydrogeochemistry

The average chemical composition of water of part of Thirumanimuthar sub basin is presented in Table 1. The analytical result shows that ground water is alkaline in nature as the pH range is 7.5 to 12. Specific conductance or EC which is the measurement of ionic strength of water varies between 500 to 8000 µS/cm. These considerably high values of EC in groundwater are possibly due thick clay beds which do not permit flushing and dilution through recharge (ShadabKhurshidet. al., 2002). Bicarbonate is the most dominant anion followed by chloride, carbonate and then sulphate. The analytical results indicate that the chloride concentration varied from 71 to 1259 mg/L, being minimum at Pallapatty and maximum at Uthamasolapuram. Generally the cation associated with the chloride which produces harmful effect. Chloride discharge relationships can help in identification of sources. Chloride ions are the major contribution to the salinity of water. WHO (2004) has suggested 200mg/L of chloride as desirable limit and 600 mg/L as maximum permissible limit in drinking water (Table2).

Table 2: Range of Chemical Constituents of Part of ThirumanimutharSubBasin and Comparison with WHO (2004) Drinking Water Standard

Constituents	Min	Max	Average	WHO (2004)	
				Highest Desirable Limit	Maximum Permissible Limit
pH	7.5	12	8	7 - 8.5	6.5 - 9.2
EC µS/cm	500	8000	2013	1000	2000
Ca mg/l	20	180	89	75	200
Mg mg/l	7	158	79	50	150
Na mg/l	25	750	178	_	200
K mg/l	4	1803	85	_	12
HCO_3mg/l	183	1977	689	_	240
CO_3mg/l	0	1266	41	_	_
SO_4 mg/l	10	40	20	200	400
Cl mg/l	71	1259	271	200	600

Calcium and Magnesium are the dominant cations in the study area. Concentration of Ca and Mg ranges between 20 to 180 mg/L and 7 to 158 mg/L respectively. Potassium is the least dominant cation and its concentration ranges between 4 to 1803 mg/L. Though low concentration of potassium in irrigation water is essential for plant nutrition, it must be maintained in proper balance with other mineral nutrients for good plant development.

Irrigational quality of water

Groundwater quality reflects inputs from the atmosphere, soil and water rock reactions as well as pollutant sources such as mining, land clearance,agriculture, acid precipitation, and domestic and industrial wastes (Appelo and Postma, 1993; Zhang et al.,2011).Suitability of water for various uses depends on type and concentration of dissolved minerals and groundwater has more mineral composition than surface water (Mirribasi et al., 2008).To understand the suitability of water for irrigational purpose, certain ratios are of fundamental importance and are described below:

Kelley et al., (1940) have suggested that the sodium problem in irrigational water could very conveniently be worked out on the basis of the values of Kelley's ratio. The Kelley's ratio has been calculated for all the water samples and presented in Table.3. It varies from 0.2 to 1.4 (except in one sample 20.4). The formula used in the estimation of this ratio is expressed as:

Kelley's Ratio $= \frac{Na}{Ca + Mg}$

Table 3: Irrigational Specifications Values of Groundwater of the Study Area

S. No	Location	RSC	SAR	Mg Hazards	Kelley's Ratio	SSP
1	Kombaipatty		1.3	56.9	0.3	21.36
2	Vinayagampatty		36.6	37.5	20.4	98.01
3	Vinayagampatty 2	1.0	1.4	55.1	0.3	23.3
4	Kondappanaikanpatty		1.6	80.8	0.3	25.24
5	Kannakurichi	1.8	3.8	80.0	0.8	45.14
6	Iyyanthirumaligai		1.3	73.1	0.2	20.24
7	Narasothipatty	0.2	4.1	67.2	0.8	47.03
8	Vellakalpatty		1.8	78.7	0.4	27.81
9	Karrupur		1.6	54.5	0.3	25.93
10	Reddiapatty		2.8	56.1	0.6	39.68
11	Suramangalam		1.4	62.7	0.4	28.92
12	Pallapatty		0.8	53.8	0.3	33.9
13	Annadhanapatty		8.5	79.6	1.1	52.9
14	Seelanaikanpatty		3.6	68.6	0.8	44.44
15	Uthamasolpuram		6.2	61.9	1.1	66.53
16	Jarikondalampatty	0.4	7.9	40.0	1.4	59.63

S. No	Location	RSC	SAR	Mg Hazards	Kelley's Ratio	SSP
17	Adimalaipudur	5.0	3.8	53.2	0.9	47.19
18	Achankuttapatty		4.5	59.2	1.0	50.25
19	Kuppanur		3.7	60.2	0.6	39.33
20	Parrutikaddu	0.4	3.6	32.6	0.8	45.56
21	Sukkampatty	1.5	4.2	51.8	1.0	50.3
22	Valasaiyur		1.1	50.4	0.2	18.79
23	Kullampatty		3.1	76.4	0.6	39.5
24	Aripudur	0.2	2.0	50.6	0.5	33.18
25	Jalakandapuram	1.9	2.1	47.2	0.4	29.8
26	Kottathupatty		3.4	47.5	0.7	41.63
27	Annupur		1.2	48.8	0.3	24.07
28	S.Nattarmangalam	3.7	2.2	67.7	0.5	33.56
29	Kararumpuram	5.2	5.4	47.5	1.4	57.67
30	Karipatty	1.4	1.1	41.7	0.3	20.66
31	AVS		1.4	45.1	0.3	23.65
32	G.A.C Hasthampatti		3.9	73.3	0.4	30.77

Eaton (1950) has pointed out that water having carbonate and bicarbonate ions in excess of Ca and Mg will lead to much greater alkali formation which is indicated by SAR and thereby decreasing the soil permeability. The indirect effect of CO_3 and HCO_3 on water quality is expressed in terms of Residual Sodium Carbonate (RSC). In the water sample of the study area, the value of RSC varies from 0.2 to 5.2 which is expressed by the following equation:

RSC= (HCO_3 + CO_3) (Ca + Mg)

The relativity of sodium ion in the exchange reaction with soil is expressed in terms of a ratio known as Sodium Adsorption Ratio (SAR). The SAR value of the water sample of the study area varies from 0.8 to 36.6, which is expressed by the following equation:

$$\textbf{SAR} = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$$

Wilcox (1955) has recommended another classification for rating irrigation water on the basis of Soluble Sodium Percentage. The values of SSP has been determined for all the water samples and presented in the Table 3. The ratio of the SSP values is 18.79 to 66.53. (Except in one sample 98.01).The value of SSP computed by using the following expression.

$$\textbf{SSP} = \frac{(Na+K)X100}{Ca+Mg+Na+K}$$

Paliwal (*1972*) has used the ratio as an index of magnesium hazards for irrigation water. The table 3 revels that the magnesium ratio for water samples of the study area varies from 32.6 to 80.8.

$$\textbf{Mg hazards} = \frac{Mg\,X100}{Ca+Mg+Na+K}$$

In order to study the suitability of groundwater for irrigational uses, the values of EC and SAR are compared and plotted on U. S. Salinity Laboratory diagram (Fig.2) which gives direct indication of the salinity and alkali hazards. It is evident form the figure that the water quality belongs to C_3S_1 classes which fall in the zone of good water quality in most of the area, while few samples fall within C_2S_1, C_3S_2, C_4S_1, C_4S_2 and C_4S_3 classes of poor water quality for irrigational use.

Table 4: Frequency Distribution of SSP, RSC, Mg Hazards and Kelley's Ratio

S. No	Water Quality Parameters	Rang	Water Classes	Number of Samples
1.	U.S.Soil Salinity Diagram	C2-S1	Good	1
		C3-S1	Good	20
		C4-S1	Good	1
		C3-S2	Moderate	3
		C4-S2	Moderate	3
		C4-S3	Bad	2
2.	RSC	<1.25	Safe	4
		1.25-2.5	Marginal	5
		>2.5	Unsuitable	3
3.	Mg Hazards	<50%	Suitable	9
		50-65	Marginal	13
		>65%	Unsuitable	10
4.	Kelley's Ratio	<1	Suitable	25
		1 to 2	Marginal	6
		>2	Unsuitable	1
5.	SSP	<20	Excellent	1
		20-40	Good	18
		40-60	Permissible	11
		60-80	Doubtful	1
		>80	Unsuitable	1

CONCLUSIONS

The water chemistry in part of Thirumanimuthar sub basin during may 2013 reveals that the water is suitable for drinking and irrigational uses**.** With reference to the WHO (2004) standard, the water is good for drinking purpose except in some places .

The salinity and sodium hazards have been evaluated by using the Kelley's ratio. The ratio is less than unity in 25 water samples, it indicates their suitable nature for irrigational uses. As per the Eaton's interpretation, 4 water samples have RSC values less than 1.25 and 5 samples have RSC values in between 1.25 to 2.5 which clearly indicates their marginal and suitable nature respectively for irrigational purposes. In the area of present investigation, 9 water samples have less than 50% magnesium hazards indicating their suitable nature for irrigational purposes.

With reference to the irrigation quality, the water is good for irrigation. The U. S. Salinity Laboratory diagram indicates that the water belong to C_3S_1 class. Piper trilinear diagram was used to find out the hydrochemical type of groundwater in the study area which shows most of the samples are $CaMgCO_3$ type.

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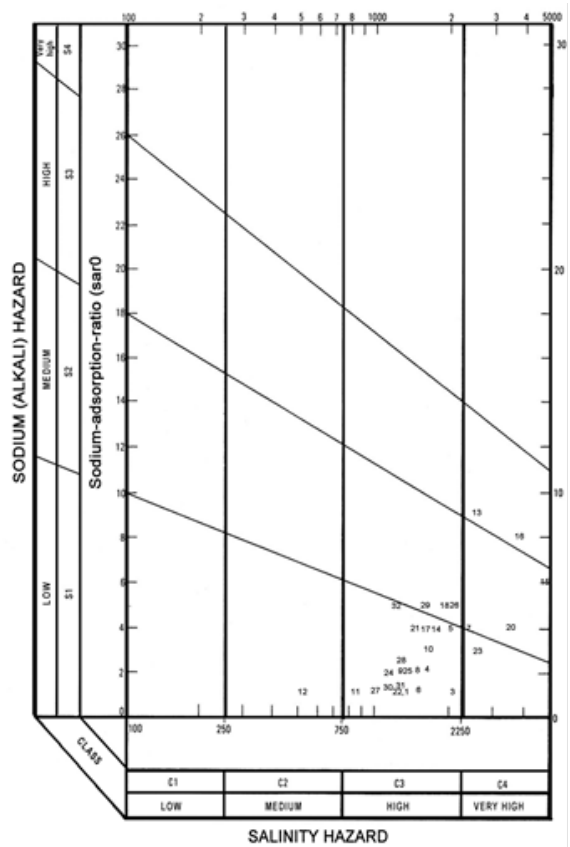

Fig. 2: Classification of Irrigation Waters(USSL DIAGRAM)

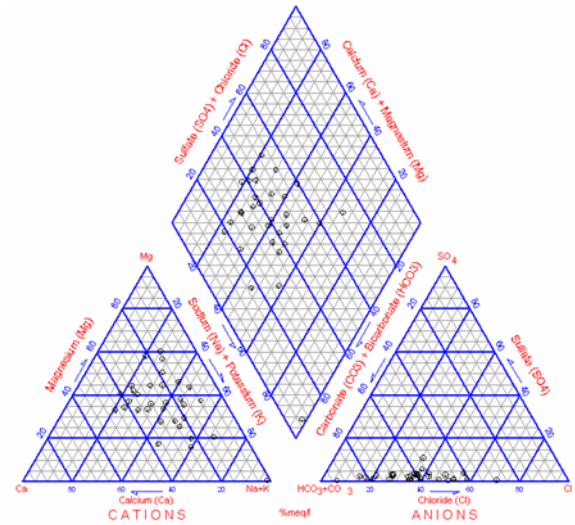

Fig 3. Piper Trilinear Diagram

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