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Physicochemical analysis of Borewell and River water samples of Tamiraparani river in Tirunelveli Region, Tamilnadu, India

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Abstract: The Middle Tamiraparani River Basin forms an important groundwater province in South India constituted by Archean and Tertiary formations dominated by igneous rocks overlain by alluvium. The present frequent failure of monsoon and over exploitation is threatening the aquifer in this region, also extensive agricultural and industrial activities and urbanization in this region has resulted in the increase in demand and contamination of the aquifer. To identify the sources and quality of groundwater, water samples from 17 bore wells and four river water samples were analysed for physcio-chemical parameters. The cation concentration of the 12% of the samples have the concentration Ca>Na>Mg>K, while the remaining 88% belong are Na>Ca>Mg>K; whereas anion chemistry shows that the samples have the concentration $Cl>SO_4>NO_3$ and $SO_4>Cl>NO_3$. This study reveals that the groundwater in many places of the study area is contaminated by higher concentrations of TDS, Ca, Cl, Mg, and K. Most of the physcio-chemical parameters of Tirunelveli town, Tachanallur and Udayarpatti ground water samples exceed the desirable standard drinking water limit. The percentage of sodium and other ions indicates that most of ground water samples are suitable for irrigation and domestic purposes. The pollution treat to ground water are associated with sewage, agriculture return flow and anthropogenic activities, so proper treatment is required before utilizing it.

Introduction

Water is a precious natural resource and at the same time complex to manage. Ground water plays a key role in meeting the water needs of various user-sectors in India. The quality of ground water in some parts of the country, particularly shallow ground water region, is changing as a result of human intervention. Changes in groundwater quality are due to rock–water interaction and oxidation–reduction reactions during the percolation of water through the aquifers. Water-born pathogens, toxic and nontoxic pollutants addition are the major water quality degradation parameters which are transported from recharge area to discharge area through aquifers by groundwater flow. Undesirable and soluble constituents in the water cannot be controlled after entering the ground[1 & 2]. The leaching of surficial salts, ion-exchange processes, and residential time of groundwater in the aquifer causes the hydrogeochemical variations in the groundwater[3]. Hydrogeochemical study is a useful tool to identify these processed, that are responsible for groundwater chemistry. The hydrogeological environmental plays vital role in human health and development.

The study area in and around Tirunelveli and Palyamkottai is situated in southern side of Tamil Nadu, India is underlain by Charnockites, peninsular gneisses and pink granites traversed by quartz veins and pegmatites. The river Tamiraparani flow through the city and ground water plays as the major source of drinking, domestic and industrial purpose in the urban and rural area of this region. Besides, it is also an

important source of water for the agricultural sector. Under these circumstances a comprehensive hydrogeochemical study is necessary to identify the chemical processes that affect the groundwater quality of this area. Hence, hydrogeochemical investigations were carried out in and around Tirunelveli and Palyamkottai region to evaluate the chemistry of groundwater, hydrogeochemical facies and assess the quality of groundwater. The study area covers an area of 108.65Km^2 and experiences a tropical monsoon climate with monsoons derived from both the south-west (June to September) and north-east (January). The average temperature ranges from 37ºC and 20ºC respectively. Average annual rainfall is 672mm, deriving from both monsoons[4].

Experimental

Totally seventeen groundwater samples and four Tamiraparani river water samples representative were collected in the areas of Tirunelveli and its surrounding villages during 2014. The locations of the water sample sites were listed in Table 1 and shown in Fig.1.

Table 1 showing the groundwater and river water sample locations

Sl.No	Sample ID	Location of Samples	Source
1	S1	South Street, Tirunelveli	Bore Well
2	S2	L-129, Perumalpuram	Bore Well
3	S3	Sivankovil Street, Palayamkottai	Bore Well
4	S4	Near Police Station, Santhi nagar	Bore Well
5	S5	Kamaraj Nagar, Sindhupundurai	Bore Well
6	S6	Near Govt. Engg. College, Rettiyarpatti	Bore Well
7	S7	21-A Post Office Street, Thachanallur	Bore Well
8	S8	5-Thenral Nagar, Udaiyarpatti	Bore Well
9	S9	RMKV Campus, Vannarpettai	Bore Well
10	S10	7-Thiruvalluvar Street, Kokarakulam	Bore Well
11	S11	10/9 Makilchi Nagar, Viramanikapuram	Bore Well
12	S12	2 nd Street, Near STC College	Bore Well
13	S13	53-A ,3rd Street, Melapalayam	Bore Well
14	S14	Kovil Street, Karunkulam	Bore Well
15	S15	16/10 Ragumath Nagar, Munnirpallam	Bore Well
16	S16	10 Noble Street, Tharuvai	Bore Well
17	S17	5 NGO Colony	Bore Well
18	S18	Thirupudaimaruthur	River Water
19	S19	Cheranmadevi	River Water
20	S20	Sevalaperi	River Water
21	S21	Tamiraparani river	River Water

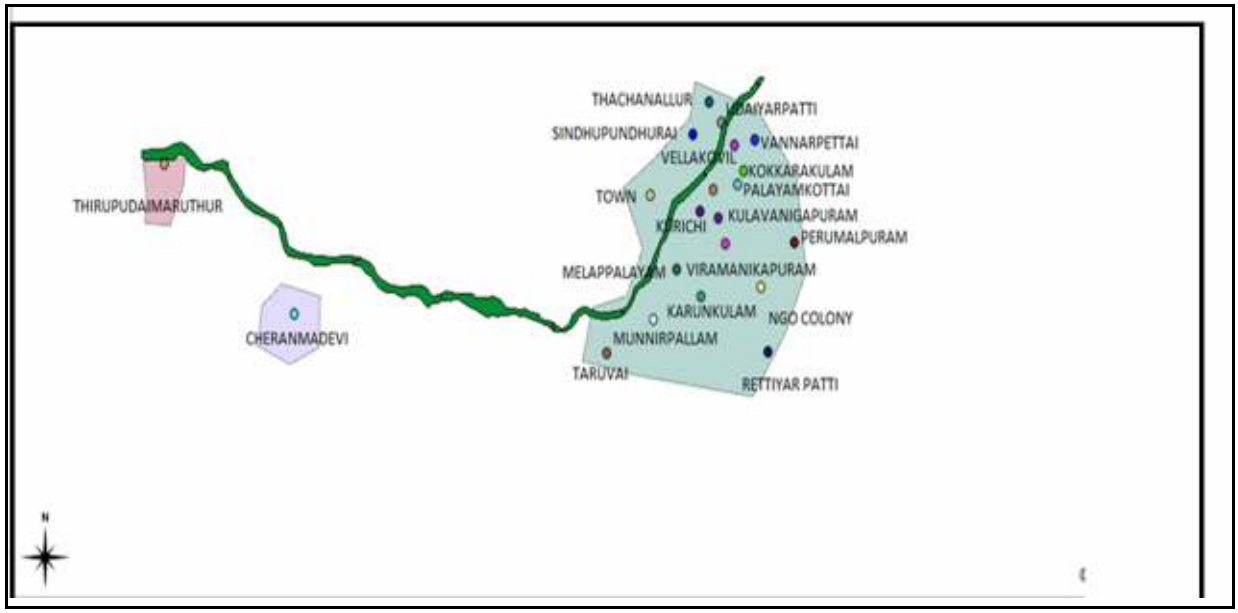

Fig.1 showing the water sample location

Samples were collected in pre cleaned polyethylene bottle. Samples were analysed for the major ion chemistry, employing the standard methods (APHA, 1992). Hydrogen ion concentration (pH) and specific electrical conductivity (SEC) were measured, using pH and SEC meters. Turbidity was measured with Nephelometer. Total dissolved solids were estimated by evaporation method. Total alkalinity was estimated by titration with HCl. Total Hardness (TH) as $CaCO_3$, and Calcium (Ca^{2+}) were estimated by titration method using standard EDTA. Magnesium (Mg^{2+}) was calculated from TH and Ca^{2+}. Sodium (Na^{+}) and potassium (K^{+}) were measured by a flame photometer. Chloride (Cl^{-}) was estimated by standard $AgNO_3$ titration. Sulphate (SO_4^{2-}), nitrate (Na^{2-}), nitrate(NO_3^{-}), and phosphate (PO_4^{3-}) were analysed using Perkin Elmer UV-. Fluoride was determined using Atomic Absorption Spectrophotometer.

Result and Discussion

Physical Parameters

The physico-chemical parameters for the studied samples were in table 2 and table 3.

Table 2 showing the Physico-chemical parameters for the collected ground water and river water samples.

Sl.No	Sample ID	Appear -Ance	Odour	Turb -Idity	Ec	Tds	Ph	P Alk	T Alk	Th
1	S1	C&C	NONE	0	1040	697	7.42	T	328	204
2	S2	C&C	NONE	1	1050	703	7.7	T	300	176
3	S3	C&C	NONE	0	2010	1347	7.72	T	364	700
4	S4	C&C	NONE	2	597	412	7.68	T	168	168
5	S5	C&C	NONE	0	2377	1616	7.3	T	480	800
6	S6	C&C	NONE	0	939	629	7.76	T	320	208
7	S7	C&C	NONE	1	2482	1688	7.72	T	632	510
8	S8	C&C	NONE	0	647	447	7.85	T	160	248
9	S9	C&C	NONE	1	1563	1047	7.49	T	392	344
10	S10	C&C	NONE	0	1226	821	7.82	T	360	320
11	S11	C&C	NONE	0	1402	939	7.6	T	376	368
12	S12	C&C	NONE	0	1583	1061	7.6	T	464	356
13	S13	C&C	NONE	0	496	332	7.4	T	128	136

14	S14	C&C	NONE	0	1812	1234	8	T	496	424
15	S15	C&C	NONE	0	2824	1892	6.84	T	392	860
16	S16	C&C	NONE	0	3409	2284	7.89	T	64	1240
17	S17	C&C	NONE	0	1271	852	7.55	T	200	296
18	S18	C&C	NONE	2	56	38	6.93	T	7	12
19	S19	C&C	NONE	3	96	65	7.01	T	20	22
20	S20	C&C	NONE	2	170	115	7.17	T	54	48
21	S21	C&C	NONE	3	115	78	7.12	T	36	39

C &C – clean and colourless, T- trace

Table 3 showing the Chemical parameters for the collected ground water and river water samples

Sl.No	Sample ID	Ca	Mg	Na	K	Fe	Mn	NH_3	NO_2	NO_3	CL	F	SO_4	PO_4
1	S1	67	91	132	9	T	T	T	3.57	10	84	0.4	16	T
2	S2	51	12	132	9	0.06	T	T	0.1	10	106	T	34	T
3	S3	160	72	144	12	T	T	T	0.06	8	355	T	56	T
4	S4	38	17	65	8	0.24	T	0.64	0.05	2	84	T	5	T
5	S5	168	91	184	20	T	T	T	0.07	13	435	0.1	100	T
6	S6	62	12	124	9	T	T	0.32	0.06	1	100	0.1	14	T
7	S7	104	60	276	30	0.06	T	1.28	0	13	430	0.1	53	T
8	S8	58	25	12	22	T	T	0.16	0.07	7	96	T	35	T
9	S9	74	38	160	23	T	T	T	0.1	5	116	0.6	86	T
10	S10	60	29	132	17	T	T	T	0.01	10	136	1	76	T
11	S11	96	31	144	18	T	T	T	0.01	5	156	T	38	T
12	S12	77	39	152	22	T	T	T	0.02	5	136	0.6	61	T
13	S13	34	12	46	9	T	T	0.32	0.08	2	52	0.1	19	T
14	S14	83	52	168	32	T	T	0.16	0.02	8	206	0.1	54	T
15	S15	232	67	270	23	T	T	11.2	3.57	13	520	T	306	T
16	S16	352	86	192	24	T	T	T	0.02	13	420	0.1	1000	T
17	S17	74	27	132	17	T	T	0.48	0.01	10	260	0.1	33	T
18	S18	2	1	6	2	0.12	T	0.08	T	2	13	T	2	T
19	S19	4	3	9	2	0.24	T	0.16	T	2	13	T	5	T
20	S20	8	6	16	2	0.12	T	0.48	T	1	20	0.1	4	T
21	S21	11	3	6	1	0.24	T	0.8	T	1	12	T	5	T

The appearance indicates that the ground water samples and river water samples were clean and clear (Table 2). Also there was no odour in ground water samples and as well as in the river water samples. The Turbidity values for the ground water samples range from 0 to 2 NTU with an average value of 1 NTU and for the river water samples range from 2 to 3 NTU with an average value of 2 NTU (Table 2). This indicates the presence of suspended solids in the river water, which may be from anthropogenic activities. The pH of the ground water varied from 6.84 to 8 (Table 2, Fig 2) with an average value of 7.49. While the pH for the river samples ranges from 6.93 to 7.17. Only few samples have pH value less than 7 whereas, all other samples have values more than 7, indicating alkaline nature of the ground water samples. Total hardness for the ground water samples ranging from 136 to 1240 mg/l with an average concentration of 510 mg/l (Table 2, Fig 2) and for the river water samples ranging from 12 to 48 mg/l, with an average value of 39 mg/l respectively. The EC (Table 2) values for the ground water samples range from 496 to 3,409 mS/cm with an average value of 1583 mS/cm and for the river samples, it ranges from 56 to 170 mS/cm, with an average value of 115 mS/cm. The TDS (Table 2, Fig.3) values for the ground water samples range from 447 to 2,284 mg/l with an average value of 1,047 mg/l and river sample ranges from 38 to 115 mg/l with an average of 78 mg/l respectively. The large variation in TDS in the ground water samples is mainly attributed to anthropogenic activities and to geochemical processes prevailing in this region.

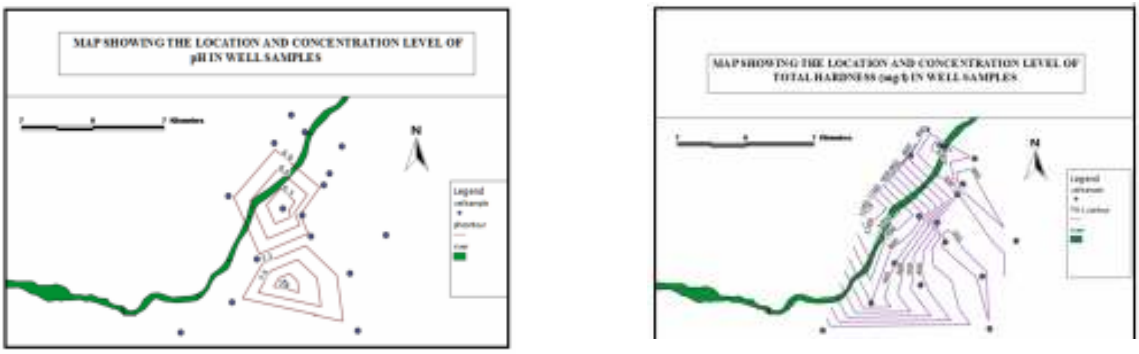

Fig 2. Shows the distribution of pH and Total Hardness in ground water samples

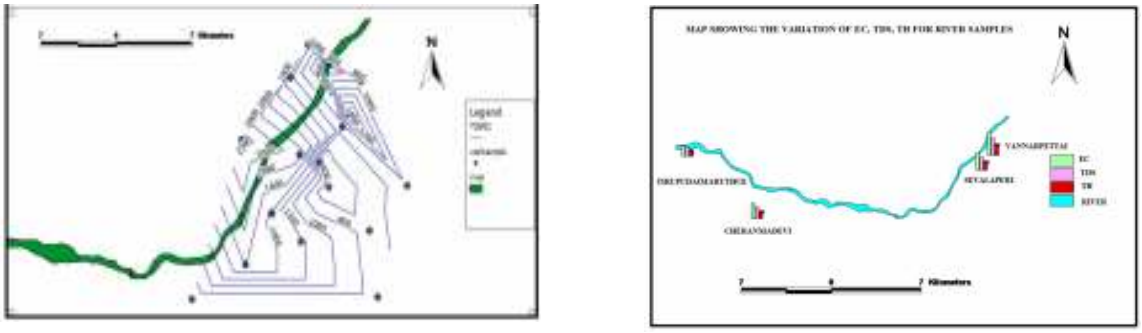

Fig 3. Shows the distribution of TDS in ground water and EC, TDS and TH of River water samples

Chemical Parameters

The cation and anion concentration of ground water and river samples were given in the Table 2. Cation concentration indicates that 12% of the samples have the concentration Ca≥Na>Mg>K, while the remaining 88% belong are Na>Ca>Mg>K; whereas anion chemistry shows that the samples have the concentration $Cl>SO_4>NO_3$ and $SO_4>Cl>NO_3$ (Fig. 4& 5).

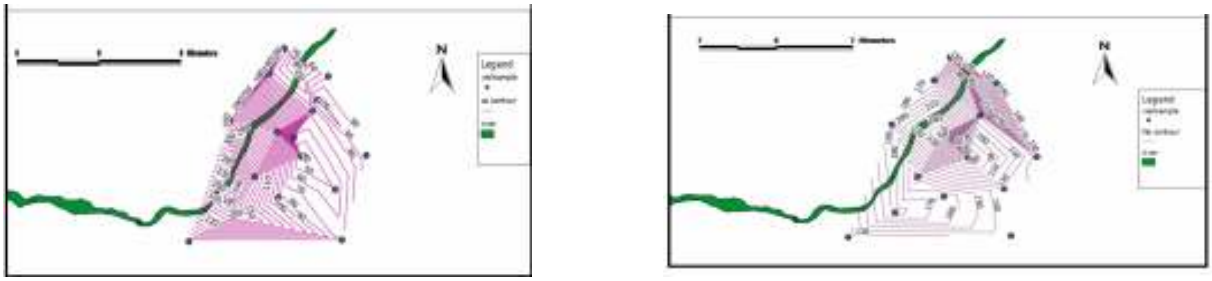

Fig 4 Shows the distribution of Calcium and Sodium (mg/l) for the ground water samples

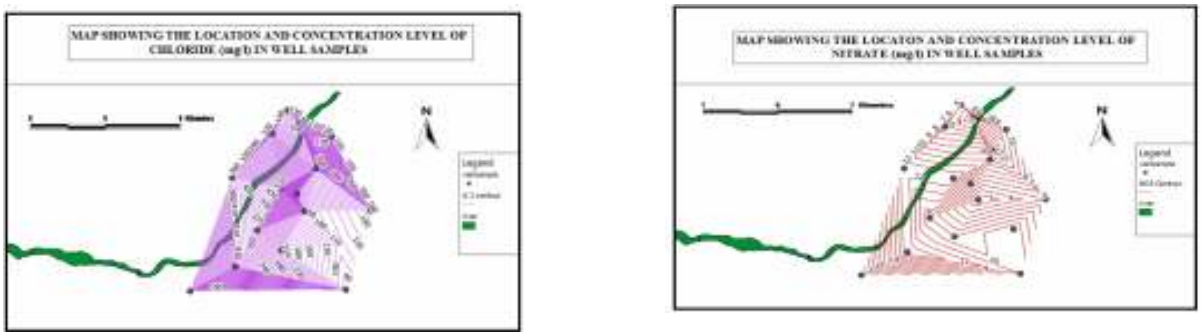

Fig 5 Shows the distribution of Chloride and Nitrate (mg/l) for the ground water samples

Further, Ca/Mg ratios of the most of the ground water samples range from 0.736 to 4.25 indicating that dolomite contributes solutes to the ground water (Fig. 4.2). Sodium shows good correlation with Cl (r=0.34), indicating that these ions have been derived from same source. If halite dissolution is responsible for sodium, Na/Cl ratio should be approximately equal to 1, whereas ratio greater than 1 is typically interpreted as Na released from silicate weathering reaction (Meyback, 1987). In the present study, Na/Cl ratio of ground water samples generally varying from 0.13 to 1.57 mg/l. Samples having Na/Cl ratio less than 1 in the study area indicate that sodium might have come from irrigation return flow and anthropogenic activity.

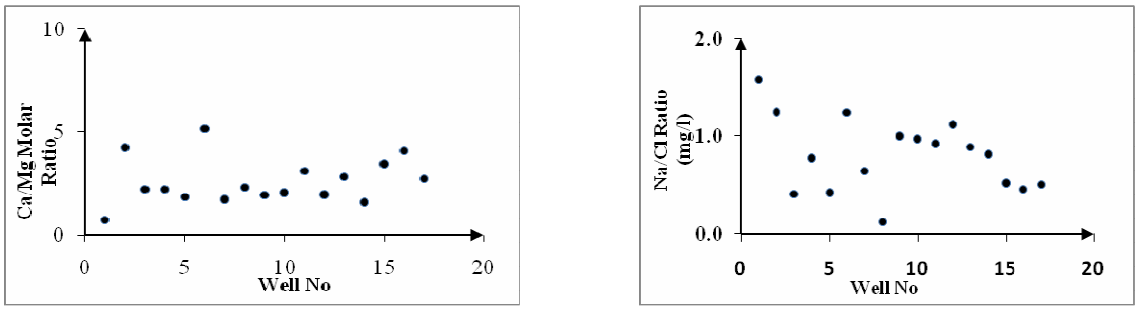

Fig 5.Plot of Ca/Mg Ratio and plot of Na/Cl ratio with ground water samples.

Conclusion

The analysis of the water quality parameters of seventeen ground water samples from different stations and four river water samples in the Tirunelveli region shows that the pH values are well within the permissible limits and the EC value indicates that the samples are classified as fresh to brackish in nature for the ground water. The TDS, Ca, Mn, Cl, K, Mg values of maximum sample was well above the drinking water desirable limit and the average value of alkalinity has exceeded the drinking water desirable limits[5 & 6]. From this study, it may be understood that the ground water of Tirunelveli though fit for domestic and irrigation purpose need treatments to minimize the contamination especially the alkalinity. The values of correlation coefficients and their significance levels will help in selecting the proper treatments to minimize the contaminations of ground water of Tirunelveli. There is an increasing awareness among the people to maintain the ground water at their highest quality and purity levels and the present study may prove to be useful in achieving the same.

Remedial Measures

- Dechlorination and defluridation process is used to remove the chloride and fluoride concentration in the ground water samples, which can be used for drinking purpose (As per WHO and ISI standard).
- Disinfection of community wells, proper sewage drainage systems would reduce water pollution and periodical quality monitoring of drinking water sources is necessary. Simple and economical water treatments like filtration, boiling, reverse osmosis would avoid water pollution in the Tirunelveli region.

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