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Original Research Paper

Groundwater Hydrogeochemical Characterization of Chittar Sub Basin, Tambaraparani River, Tirunelveli District, Tamil Nadu

T. Jeyavel Raja Kumar, A. Balasubramanian*, R. S. Kumar and K. Manoharan
Department of Earth Sciences, Annamalai University, Annamalainagar-608 002, T.N.
*University of Pondicherry, Pondicherry, India

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ABSTRACT

Hydrogeochemical characterization of 82 groundwaters has been done in Chittar sub basin of Tambaraparani river, Tirunelveli District. In this attempt major cations and anions were analysed and other parameters were calculated. The pH and EC varied from 6.60 to 8.50 and 115 µmhos/cm to 9780 µmhos/cm. The TDS and Total hardness varied from 81mg/L to 6846 mg/L and 40 mg/L to 1818 mg/L. The range of chemical concentration of cations such as Ca, Mg, Na, K and anions like Cl, HCO_3, SO_4, NO_3 varied from 12 mg/L to 533 mg/L, 3 mg/L to 116 mg/L, 9 mg/L to 3255 mg/L, 1.0 to 89.0 mg/L and 9 mg/L to 2904 mg/L, 45 mg/L to 691 mg/L, 2 mg/L to 237 mg/L, 1 mg/L to 16 mg/L respectively. SAR ranges from 0.592 to 22.82 and the RSC varied from 32.46 to 5.48. The results show that certain groundwater sample locations exceed the maximum permissible limit but exceeding the desirable limit of WHO standard for drinking. The attempt revealed the present level of element contamination and source of the ionic contribution in the study area.

INTRODUCTION

Groundwater is an invisible natural resource. It is present beneath our feet, in the dark pores and fissures of sands and rocks of the upper portion of the Earth's crust. Due to this hidden dimension, the general public is much less familiar with groundwater than with the more visible components of the water cycle, such as rain and surface water. Without groundwater, the face of the planet would look different. Groundwater is used to meet 23% of all irrigation demands, to feed 53% of all public water supplies and to cover 97% of all rural domestic water demands.

Nowadays, this precious natural water resource is contaminated in many ways, hence the study of groundwater quality and its spatio-temporal distribution are important for drinking, irrigation, and industrial water supply, and for sustaining the ecology of streams and wetlands. Increase and changes in environmental pressure threaten groundwater quality and complicate the assessment of its present and future spatial distribution. The groundwater quality mapping is, thus, equally important for understanding the distribution and abundance of elements, and the changes in their global or local cycles due to spreading of contaminants and its safer use. Hence, to understand the contamination of element concentration in groundwaters, the present study has been taken up in Chittar watershed of Tambaraparani river in Tirunelveli district of Tamil Nadu.

STUDY AREA

The study area of Chittar watershed is a sub-basin of Tamparabarani river originating in the Western Ghats. The area is located between the east longitude 77°10' to 77°35' and the north latitude of 8°52' to 9°10’ of the SOI top sheets 58G/8,12 and 58H/1,5,9,13 (Fig. 1). The area is confined to the hard rocks of charnockite and biotite gneiss (Fig. 2). Since, the river has a seasonal water flow for hardly 2-3 months, the surface water is insufficient during lean period. Hence, most of the water requirements have been fulfilled by the groundwater. As groundwater is widely used for all purposes, the assessment of quality is necessary in the present scenario. Moreover, the hydrogeochemical data give important clues to the geologic history of rocks and indications of groundwater recharge, discharge, movement and storage (Walton 1970).

Hydrogeology and hydrometeorology: All types of groundwater resources evaluation necessarily need the study of the occurrence, behaviour of groundwater system and the evaluation of aquifer parameters. However, in this basin it occurs mainly under water table conditions in the weathered crystalline complex terrains. The plain lands of the basin falls under the semi-arid climatic type and the areas over the adjacent to Western Ghats are of dry to moist sub humid climatic types (Ram

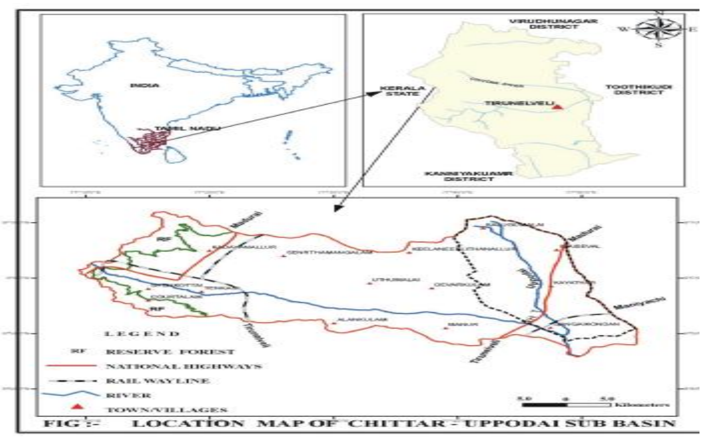

Fig.1: Map of the study area.

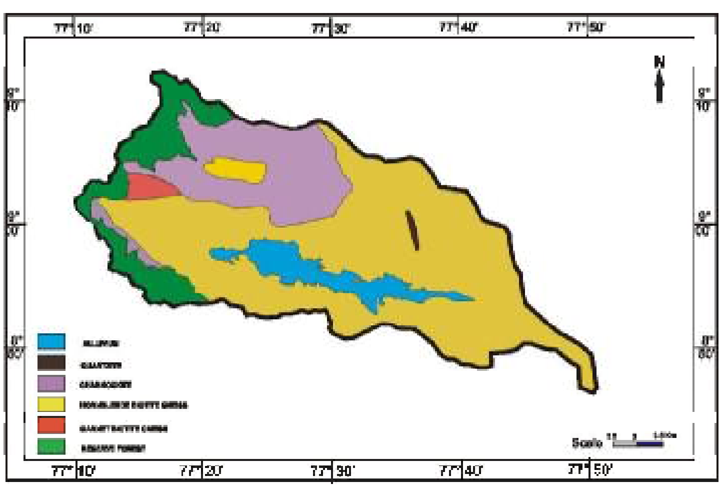

Fig. 2: Geology map of the study area.

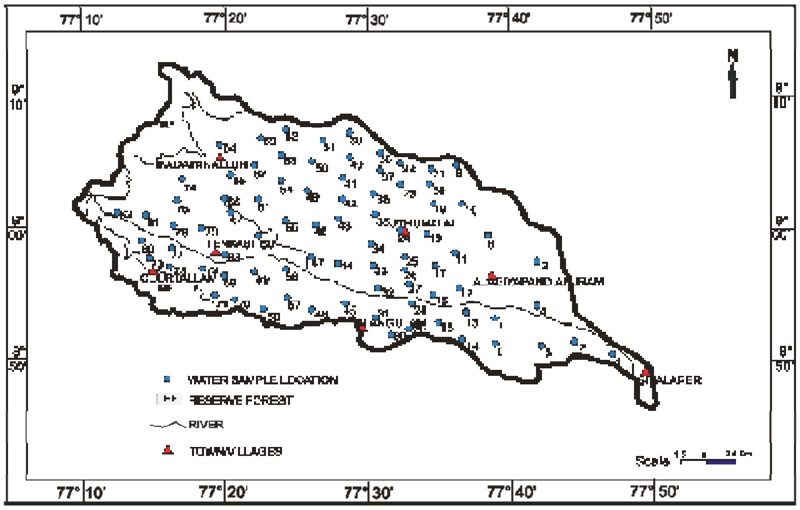

Fig.3: Groundwater sample location map of the study area.

Mohan 1984). In this basin the precipitation is the main source for groundwater recharge. The pattern of precipitation is essentially of a tropical monsoon type where the effect of the winter monsoon is dominant. The average precipitation is 722.5 mm, and the actual annual evapotranspiration 636 mm.

Sampling and analysis: Totally 82 groundwater samples were collected in the watershed during premonsoon season as shown in the Fig. 3. The samples were collected in clean polythene bottles as prescribed by Hem (1975), Brown et al. (1974) and APHA (1996). The analysis has been carried out for pH, electrical conductivity (EC), major cations such as Ca, Mg, Na, K and anions namely HCO3, Cl, SO_4, NO_3 besides, other parameters like TDS, TH, and SAR.

RESULTS AND DISCUSSION

The groundwater chemistry data of the study area are presented in Table 1.

pH: The pH of water is an important indication of its quality and provides important piece of information in many types of geochemical equilibrium or solubility calculations (Hem 1985). The pH of the groundwater in the study area is varying from 6.6 to 8.5. The values for all the samples are within the limits as specified as 6.5 to 8.5 by WHO (1993).

Electrical conductivity (EC): The conductivity measurements provide an indication of ionic concentration. It depends upon temperature, concentration and types of ions present (Hem 1985). The electrical conductivity of the groundwater is varying from 115 to 9780 µS/cm at 25°C. Out of 82 groundwater sample locations 30 samples have been identified as more than maximum limit. The maximum limit of EC in drinking water is prescribed as 1500 µS/cm (WHO 1993). The high conduction observed can be attributed high chloride concentrations in groundwater (Davies & De Wiest 1966).

Total dissolved solids (TDS): As groundwater moves and stays for a longer time in its flow path, increase in total dissolved concentrations and major ions normally occur (Norris et al. 1992). Higher TDS shows longer residence period of water (Davis & De Wiest 1966). The principal ions contribut-

Table 1: Groundwater chemistry data of the study area.

S.No.	pH	EC	TDS	TH	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3
1	7.7	1390	973	170	47	13	204	19	299	228	28	12
2	7.9	545	382	164	44	13	40	6	137	71	13	12
3	7.9	600	420	178	48	14	40	6	182	49	9	13
4	7.4	3400	2380	677	174	58	389	33	194	944	32	10
5	7.2	2310	1617	428	115	34	271	29	210	491	136	13
6	7.9	830	581	250	70	18	77	5	255	65	25	11
7	7.5	3300	2310	788	218	58	323	19	323	798	41	6
8	8.4	510	357	125	34	10	46	5	150	28	11	14
9	7.9	740	518	250	70	18	63	7	230	63	17	14
10	7.6	590	413	182	49	14	54	5	206	38	5	3
11	7.2	440	308	154	41	12	34	4	154	28	12	12
12	8.1	780	546	267	74	20	68	8	226	69	27	11
13	7.7	3000	2100	586	154	49	346	19	182	682	237	13
14	7.1	695	487	242	65	19	59	6	238	51	11	9
15	7.2	3200	2240	727	182	65	3255	34	283	747	106	13
16	7.3	1430	1001	384	105	29	126	9	218	277	41	12
17	7.6	570	399	141	40	10	54	6	174	48	14	6
18	7.9	1700	1190	238	64	19	271	16	162	414	47	10
19	7.7	990	693	242	61	21	94	7	222	204	5	12
20	7.8	490	343	149	42	11	38	4	178	49	6	7
21	6.9	1595	1117	372	100	29	154	15	299	285	47	8
22	7.7	480	336	162	45	12	36	4	154	37	6	8
23	7.2	410	287	137	38	10	21	3	129	39	6	14
24	7.4	250	175	91	25	7	11	2	89	15	3	10
25	7.9	2100	1470	515	142	38	198	17	327	414	46	3
26	7.1	290	203	93	26	7	19	1	105	31	2	1
27	6.8	390	273	131	37	9	24	2	121	35	4	12
28	7.2	4810	3367	889	238	70	589	49	226	1338	168	14
29	8.1	765	536	267	74	20	60	7	242	67	25	12
30	7.4	1480	1036	343	95	25	147	12	166	323	40	14
31	8.1	1320	924	364	102	26	114	8	238	248	24	6
32	8.2	1980	1386	323	89	24	260	13	121	510	69	1
33	7.7	1590	1113	404	112	30	147	9	202	333	44	12
34	7.4	2800	1960	677	178	56	271	24	299	621	94	0
35	7.9	1360	973	347	94	27	165	28	267	240	32	9
36	7.2	1160	812	343	95	26	108	12	267	160	38	11
37	6.7	1625	1138	372	100	29	168	13	202	345	40	8
38	7.4	3290	2303	687	210	39	367	22	242	808	91	15
39	6.9	585	410	180	50	13	39	5	174	52	16	12
40	7.6	550	385	160	44	12	45	6	210	21	10	11
41	7.6	1740	1218	404	112	30	186	13	295	349	52	10
42	7.2	1330	931	323	89	24	127	12	194	283	15	12
43	8.2	520	364	166	46	12	51	6	186	44	6	10
44	7.9	1780	1246	372	103	28	193	16	275	323	72	16
45	7.7	2700	1890	445	117	39	345	24	162	682	148	15
46	7.1	640	448	141	37	12	65	7	263	18	5	10
47	7.3	450	315	83	23	6	52	7	105	58	18	12
48	8.2	545	382	105	124	11	63	7	194	26	12	12
49	6.9	900	630	194	47	18	96	10	255	89	24	10
50	7.1	7950	5565	889	234	73	1210	89	416	2111	207	1
51	7.4	9780	6846	1818	533	116	1224	62	129	2904	192	13

Table cont....

...Cont Table

52	7.6	1900	1330	374	93	34	215	19	250	419	74	6
53	8.1	710	497	263	68	22	51	6	283	34	19	12
54	8.5	370	259	53	12	5	51	6	87	35	6	2
55	8.4	260	182	67	18	5	25	6	73	16	5	11
56	8.2	2520	1764	404	117	27	329	21	570	535	44	11
57	7.2	1890	1323	404	117	29	199	18	190	470	27	8
58	7.5	460	322	162	46	11	35	5	182	21	4	9
59	7.3	840	588	283	82	18	70	11	279	93	17	10
60	7.3	1160	812	283	82	18	107	12	291	188	57	10
61	7.7	725	508	238	61	20	43	6	255	42	12	8
62	7.4	265	186	51	13	4	30	6	81	15	7	13
63	7.7	960	672	125	36	9	141	13	291	79	36	11
64	6.9	535	375	172	53	10	49	7	145	72	6	9
65	8.1	1025	718	182	47	16	129	13	295	154	25	1
66	7.2	2550	1785	600	170	42	251	22	521	404	74	7
67	6.9	3150	2205	667	174	56	332	31	691	646	52	12
68	7.2	1170	819	246	68	18	126	13	295	168	11	8
69	7.7	475	333	117	31	10	43	5	162	45	12	8
70	7.3	1200	840	145	39	12	175	22	356	149	21	8
71	7.2	1380	966	364	103	25	116	13	311	263	19	8
72	8	1190	833	210	57	16	145	15	279	220	19	12
73	7.2	865	606	226	60	18	73	7	174	156	25	10
74	7.1	2060	1442	414	117	29	227	27	327	485	81	4
75	8.1	895	627	250	66	20	73	8	315	69	42	8
76	6.9	330	231	51	12	5	45	6	129	13	10	6
77	6.6	1215	851	303	79	25	108	11	154	263	30	4
78	8.1	115	81	40	12	3	9	1	45	9	4	1
79	7.2	3420	2394	667	187	48	397	16	566	682	18	9
80	7.4	990	693	210	58	16	104	10	178	212	8	6
81	7.7	670	469	218	58	17	64	7	65	40	9	7
82	6.6	355	249	89	25	6	33	1	121	28	12	8

*Except pH and E.C., all values are expressed in mg/L; EC in microSiemens/cm at 25°C.

Table 2: Classification of waters based on TDS.

S. No.	Value range (mg/L)	Characteristics	No. of samples	Percentage
1	Up to 500	Desirable for drinking	30	37
2	500 - 1000	Permissible for drinking	25	30
3	1000 - 3000	Useful for irrigation	25	30
4	Above 3000	Unfit for drinking and irrigation	02	03

ing to TDS are bicarbonate, carbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium (EPA 1976). The TDS of the groundwater varied from 81 mg/L to 6848 mg/L with an average value of 1016.5 mg/L. The water samples have been classified based on the concentration of TDS (ICMR 1975) as given in Table 2.

Total hardness (TH): Hardness results from the presence of divalent cations of which Ca and Mg are most abundant in groundwaters. Hardness in water also derived from the solution of carbon dioxide released in bacterial action in soil and in percolating water. The water hardness is primarily due to the result of interaction between water and geological formations. Total Hardness is varying from 40 mg/L to 1818 mg/L. The TH for drinking water is specified as 300 mg/L, and in the present study area about 33 groundwater samples were above the permissible limit.

Calcium: The Ca ionic concentration ranged from 12 mg/L to 533 mg/L. The limit of Ca for drinking water is specified as 100 mg/L (WHO 1993). The results show that nearly 30% of the samples are exceeding the limit. The concentration of Ca is due to interaction of minerals like feldspar minerals and the weathering process.

Magnesium: The magnesium concentration is varying from 3 mg/L to 116 mg/L with an average value of 23.87mg/L. The limit of Mg for drinking water is 30 mg/L (WHO 1993). In this area nearly 20% of the samples are exceeding the limit. The high concentration of Mg was observed in location number 51, whereas low concentration in sample location 78.

Sodium: The sodium concentration is varying from 9 mg/L to 3255 mg/L with an average value of 196.24mg/L. The limit for drinking water is specified as 175 mg/L (WHO 1993). It is observed that 25 sample locations were exceeding the limit. The sodium concentration in the groundwater is due to the chemical weathering of feldspar minerals in the country rocks. Also, the agricultural activities may have significant influence the concentration of sodium in groundwater.

Potassium: The potassium concentration is varying from 1.0mg/L to 89.0 mg/L. The limit of K for drinking water is specified as 25 mg/L (WHO 1993). When compared with the WHO standard, the concentration of potassium exceeded in 7 samples locations. The potassium concentration in waters is low because of the high degree of stability of potassium bearing minerals.

Chloride: The Cl concentration ranged from 9 mg/L to 2904 mg/L with an average value of 290.5 mg/L. The limit of chloride concentration for drinking water is specified as 600 mg/L (WHO 1993). Only 15% of the sample locations have exceeded the limit. The high concentration of Cl was noticed in location number 51, and low concentration in sample location 78.

Sulphate: The Sulphate concentration is varying from 2 mg/L to 237 mg/L with an average value of 38.28 mg/L. The limit for drinking water is specified as 250 mg/L (WHO 1993). Fortunately, all the sample locations are within the limit in the study area. Apart from the natural rock sources, sulphates could be introduced through the application of sulphatic soil conditioners (Karanth 1987).

Bicarbonate: The bicarbonate concentration varies from 45 mg/L to 691 mg/L with an average value of 228.17 mg/L. The HCO_3 concentration was encountered high in location number 67 as 691 mg/L, and low in location number 78 as 45 mg/L.

Nitrate: The nitrate concentration level varied from 1 mg/L to 16 mg/L. The concentration observed is not higher in almost all the groundwater samples in the study area. The nitrogen fixation by plants, soil and rainwater leaching process could be the source for the present concentration. Moreover, the monsoon season also contributed notable level in the present concentration.

Sodium Adsorption Ratio (SAR): The SAR is useful for judging the quality of groundwater for irrigation purposes (Todd 1980, Balasubramanian 1986, Sastri & Lawrence 1988). Richards (1954) classified the waters in relation to irrigation based on the ranges of SAR values. SAR ranges from 0.592 to 22.82. According to Richard's classification the study area groundwater samples have been classified as follows:

SAR Range	No.of Samples	Water Class
< 10	80	Excellent
10-18	Nil	Good
18-26	02	Fair
> 26	Nil	Poor

Residual Sodium Carbonate (RSC): In addition to total dissolved solids, the relative abundance of sodium with respect to alkaline earths and boron and the quantity of bicarbonate and carbonate in excess of alkaline earths also influence the suitability of water for irrigation purposes. This excess is denoted by residual sodium carbonate (RSC) and determined as suggested by Richards (1954). The water with high RSC has high pH, and land irrigated by such waters becomes infertile owing to deposition of sodium carbonate as known from the black colour of the soil (Eaton 1950). According to U.S Salinity Laboratory (1954), an RSC of less than 1.25 meq/L is safe for irrigation, values between 1.25 and 2.5 meq/L is of marginal quality and a value of more than 2.5 meq/L is unsuitable for irrigation. In the present study the waters showed the RSC values of -32.46 to 5.48. It is observed that the study area samples are suitable for irrigational purposes, because the RSC values of 75 (92%) groundwater samples are within the limit of 1.25 meq/L.

CONCLUSION

The groundwater geochemistry of the study area showed that the concentration of major cations and anions are derived from the source rocks. As the litho unit of the area contains gneissic and charnockite rocks the minerals such as feldspar, pyroxene and biotite are attributed to the present level of ion concentrations in the groundwater. In certain sample locations, the concentration level is observed very high due to the overexploitation of groundwater and low infiltration of rain water or recharge source. However, the SAR and RSC values are within the normal range in almost all the sample locations, and hence, except for few groundwater locations most of the groundwaters are suitable for irrigation purposes to variety of plants. The present study helps to understand the elements contamination level in the groundwater. Besides, from the present study it is revealed that a frequent monitoring and adopting suitable management plan are needed to check further increase in ionic concentration in the study area.

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