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Research Article

SPATIO- TEMPORAL OF GROUNDWATER QUALITY STUDIES IN MANAPPARAI TALUK, TRICHY DISTRICT TAMIL NADU, INDIA

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ABSTRACT

Understanding the groundwater quality is important as it is the main factor determining its suitability for drinking, domestic, agricultural and industrial purposes. In order to assess the groundwater quality, 50 groundwater samples have been collected and analysed various parameters including electrical conductivity, pH, total dissolved solids (TDS), major cations like calcium, magnesium, sodium, potassium and anions like bicarbonate, chloride, nitrate and sulphate, in the laboratory using the standard methods given by the American Public Health Association. The groundwater locations were selected to cover the entire study area and attention was been given to the area where contamination is expected. The expected groundwater contaminations were chloride, nitrate, TDS, etc. The results were evaluated in accordance with the drinking water quality standards given by the World Health Organization (WHO 1993). To know the distribution pattern of the concentration of different parameters and to demarcate the higher concentration zones, the contour maps for various characteristics were also generated, discussed and presented.

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INTRODUCTION

The knowledge of hydrochemistry is essential to determine the origin of chemical composition of groundwater (Zaporozec 1972). The hydrology and geochemistry of waters have been further discussed in the classic works of Hem (1991), Drever (1988), Domenico and Schwartz (1990a). Adverse conditions increase investment in irrigations and health and decrease agricultural production, which, in turn, reduce agrarian economy and retard improvement in living conditions of rural people. Poor quality of water adversely affects the plant growth and human health (Wilcox 1948; Thorne and Peterson 1954; US Salinity Laboratory Staff 1954; Holden 1971; Todd 1980; ISI 1983; WHO 1984; Hem 1991; Karanth 1997). Water quality is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices. The chemical character of any groundwater determines its quality and utilization. The quality is a function of the physical, chemical and biological parameters and could be subjective, since it depends on a particular intended use.

Various workers in our country have carried out extensive studies on water quality. Laluraj et al. (2005) have studied groundwater chemistry of shallow aquifers in the coastal zones of Cochin and concluded that ground waters present in the shallow aquifers of some of the stations were poor in quality and beyond potable limit as per the standard set by WHO and ISI. Rapid increase in urbanization and industrialization leads

in to deterioration in groundwater quality. Srinivas et al. (2000) and Jha and Verma (2000) have reported the degradation of water quality in Hyderabad and Bihar, respectively. Untreated industrial waste effluents when discharged in unlined drains can percolate underground directly affecting the quality of groundwater. Patnaik et al. (2002) have studied water pollution generated from major industries. Similarly, waste effluents discharged in to streams may enter the aquifer body downstream, which also affects the groundwater quality. Abbasi et al. (2002) have studied the impacts of wastewater inputs on the water quality. Jagdap et al. (2002) and Sunitha et al. (2005) classify the water in order to assess the water quality for various purposes. Fluoride levels in drinking water from sources in and around Jaipur and many villages and trace metals have been carried out in our laboratory (Jangir et al. 1990; Sharma et al. 1990) earlier. Study of industrial wastewater, groundwater, and pollution problems in groundwater have also been studied in our laboratory (Sharma et al. 2004; Singh and Chandel 2003, 2006) recently.

Study area

The study area falls in parts of Manapparai Taluk (survey of India toposheet (58 J/6), Tiruchirappalli district (Figure 1) covering an area of 720 sq.km comprising of 28 villages.

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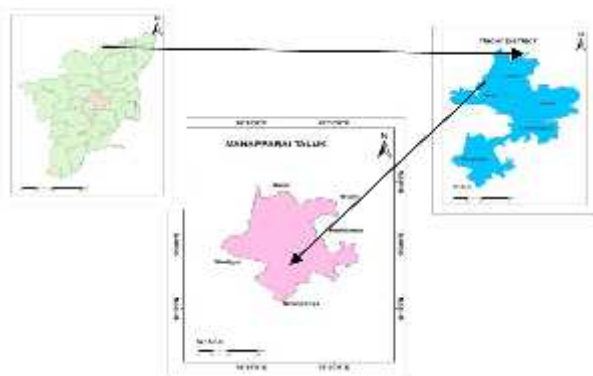


Figure 1 Map Showing of Location Map in Manapparai Taluk, Trichy District

Mostly rain fed area and main source of irrigation are tanks and wells Manapparai Taluk is one among important region of Trichy District with elevation between 350 and 1110 metres in

the western part. It is sloping gently towards the north east Drainage is the natural or artificial removal of surface and sub-surface water from an area. Many agricultural soils need drainage to improve production or to manage water supplies.

The slope is another necessity for the initiation of a stream. Every stream flows down slope. The disposition of a stream, on the earth's surface is adjusted to certain topographic forms, structural features and lithology. The individual stream may be classified, as suggested on the bases of various factors, viz; stages of development, genesis, genetically associated structures, not concerned with the origin of stream and past changes of ground level of these waterways are also sometimes called brooks and/or creeks. Large waterways (at the highest level the stream order) are called exist as a combination of many tributary streams. Streams can also have local names such as bayou or burn.

Table 1 Hydro Geochemical Parameters of Manapparai Taluk, Trichy District (in ppm)

Sl. No	Location	EC	pH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	TDS
1	Alampattipudur	430	7.1	88	6	19	4	44	58	22	19	81.9
2	Maravanur	1460	7.3	66	85	101	29	94	140	68	50	1549.8
3	Edayampatti	810	7.4	74	39	51	3	187	153	112	12	34.3
4	K.Periapatti south	640	6.9	40	13	12	7	204	125	66	22	151.2
5	Utuppatti	990	6.7	30	13	23	7	143	73	77	43	182.7
6	Sathirappatti	860	6.9	52	22	30	1	253	83	115	88	289.8
7	Muthappudaiyanppatti	620	7.5	70	23	88	2	283	87	89	33	264
8	Mannaparai Town	840	7.4	42	41	77	3	348	238	32	31	592.2
9	Malaiyidipatty	900	7.4	70	23	88	3	136	157	79	59	441
10	Pudur	850	7.5	42	41	77	3	278	185	52	44	535
11	Metukalam	1180	7.6	62	44	33	1	278	52	88	55	680
12	Elangakurichi	1520	7.8	88	39	53	1	206	13	53	28	957.6
13	Katuvavattipuram	990	7.7	78	39	101	1	348	203	117	66	560.7
14	Kumaravatti	1640	7.2	70	85	105	4	288	119	177	51	1159
15	Kumaravatti	11110	7.3	80	43	90	4	266	217	125	40	639.3
16	Anankaraipatty	710	7.8	50	34	66	2	205	143	77	22	384.3
17	Kasanur	1100	7.4	80	45	104	1	305	140	25	22	630
18	Sadaiyampatti	1310	7.3	90	124	146	3	520	176	101	17	1455
19	Elamanur	2000	7.5	88	114	184	4	327	228	115	32	1260
20	Kalikattupatti	920	7.7	78	50	58	4	344	235	88	44	453
21	K.puthukottai	1090	7.1	60	340	128	6	281	186	86	32	2576
22	Keranur	910	7.3	42	5	174	2	353	153	110	40	258
23	Kalupati	950	7.7	44	10	123	12	129	128	65	66	157
24	Seegampatti	117	7.6	42	5	116	2	131	135	44	66	107.1
25	Karnampatti	1790	7.1	74	22	187	9	144	249	66	44	497.7
26	Natupatti	1980	7.3	84	73	160	12	489	245	43	44	1877
27	Natupatti	1700	7.1	48	175	61	5	270	202	62	44	1701
28	Sechalur	1990	7.3	78	52	187	11	297	224	76	33	623.7
29	Vaiyampatti	1280	7.4	60	36	59	11	227	270	170	34	743.3
30	Kalungulam	1400	7.5	66	51	104	31	317	388	61	44	756
31	Puthumaniyampatti	1630	6.8	64	40	107	14	260	108	43	34	963.9
32	PeriyAnakaraipatti	2260	7.7	84	107	160	3	321	184	129	31	919.8
33	Anakaraipatti	2800	7.8	88	134	122	4	384	238	158	55	163
34	Chithapatti	2040	7.6	84	107	160	14	410	274	191	30	1915.2
35	Onthapatti	1680	7.8	98	83	59	2	245	144	134	31	1058.4
36	Palayakottai	2480	7.6	82	71	126	1	398	232	153	77	1562.4
37	Velai Pulampatti	1170	7.4	90	16	145	1	388	252	182	67	1052.1
38	Manjampatti	1810	7.8	70	219	221	2	150	222	77	37	2400.3
39	Chithanathan	1620	7	90	64	192	1	258	145	211	47	1146.6
40	Chithanathan west	1170	7.5	60	94	31	1	266	298	126	38	926.1
41	Alakaritiyapatti	1740	7.8	50	79	96	2	239	190	129	31	1159.2
42	Maravanur	1500	7.8	90	43	45	1	214	153	110	33	315
43	Kolapatti	2320	7.8	44	100	162	1	398	147	122	22	1461.6
44	Cherpatti	1840	7.5	54	62	130	1	327	153	16	42	529.2
45	Vataku Cherpatti	1660	8.8	32	29	162	1	420	206	99	42	415.8
46	Kupanarapatti	1820	7.7	64	64	128	4	381	235	55	64	516.6
47	Kupanarapatti	1670	7.8	82	212	38	2	390	323	62	51	1682.1
48	Palipatti	1830	8.2	84	46	155	2	105	310	113	66	522.9
49	Pathiripatti	1240	7.4	98	74	27	1	306	284	213	77	718.2
50	Palanikondampatti	2050	7.9	68	73	188	4	380	169	53	50	1291.5

Geology

Several digital image processing techniques, including standard colour composites, intensity-hue saturation (IHS) transformation and decorrelation stretch (DS) were applied to map rock types. The statistical technique adopted by Sheffield (1985) was employed to select the most effective. Three-band color composite image. The band combination 1, 4 and 5 is the best triplet and was used to create color composites with Landsat TM bands 5, 4 and 1 in red, green and blue respectively. HIS transformation and DS were also applied to the selected band combination in order to enhance the difference between rock types. Better contrast was obtained due to color enhancement, and this facilitated visual discrimination of various rock types. Eleven lithologic units were mapped and could be distinguished by distinct colors in the processed images.

MATERIALS AND METHODS

In order to assess the groundwater pollution, 50 groundwater samples have been collected in the field were analyzed for electrical conductivity (EC), pH, total dissolved solids (TDS), major cations like calcium, magnesium, sodium, potassium and anions like bicarbonate, carbonate, chloride, nitrate and sulphate in the laboratory using the standard methods given by the American Public Health Association (APHA 1995). The groundwater locations were selected to cover the entire study area, and attention was given to the area where contamination is expected. The expected groundwater contaminations were chloride, nitrate, TDS, etc. Sampling was carried out using precleaned polyethylene containers. The results were evaluated in accordance with the drinking water quality standards given by the World Health Organization (WHO 1993).

Table 2 Hydro Geochemical Parameters of Manapparai Taluk, Trichy District (in epm)

Sl. No	Location	EC	pH	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	TDS
1	Alampattipudur	430	7.1	4.39	0.44	0.83	0.10	0.72	1.63	0.46	0.31	81.9
2	Maravanur	1460	7.3	3.29	6.99	4.39	0.74	1.54	3.95	1.41	0.81	1549.8
3	Edayampatti	810	7.4	3.69	3.21	2.22	0.08	3.06	4.31	2.33	0.19	34.3
4	K.Periapatti south	640	6.9	2	1.07	0.52	0.18	3.34	3.52	1.37	0.35	151.2
5	Utuppatti	990	6.7	1.50	1.07	1	0.18	2.34	2.06	1.60	0.69	182.7
6	Sathirappatti	860	6.9	2.60	1.81	1.30	0.02	4.15	2.34	2.39	1.42	289.8
7	Muthappudaiyanppatti	620	7.5	3.49	1.89	3.81	0.05	4.64	2.45	1.85	0.53	264
8	Mannaparai Town	840	7.4	2.09	3.37	3.35	0.08	5.70	6.71	0.67	0.50	592.2
9	Malaiyidipatty	900	7.4	3.49	1.89	3.83	0.08	2.23	4.43	1.64	0.95	441
10	Pudur	850	7.5	2.09	3.37	3.35	0.08	4.55	5.22	1.08	0.71	535
11	Metukalam	1180	7.6	3.09	3.62	1.43	0.02	4.55	1.47	1.83	0.89	680
12	Elangakurichi	1520	7.8	4.39	3.21	2.30	0.02	3.37	0.37	1.10	0.45	957.6
13	Katumavatipuram	990	7.7	3.89	3.21	4.39	0.02	5.70	5.72	2.43	1.06	560.7
14	Kumaravatti	1640	7.2	3.49	6.99	4.56	0.10	4.72	3.35	3.682	0.82	1159
15	Kumaravatti	11110	7.3	3.99	3.54	3.91	0.10	4.36	6.12	2.60	0.64	639.3
16	Anankaraipatty	710	7.8	2.49	2.80	2.87	0.05	3.36	4.03	1.60	0.35	384.3
17	Kasanur	1100	7.4	3.99	3.70	4.52	0.02	5	3.95	0.52	0.35	630
18	Sadaiyampatti	1310	7.3	4.49	10.20	6.35	0.08	8.52	4.96	2.10	0.27	1455
19	Elamanur	2000	7.5	4.39	9.375	8	0.10	5.36	6.43	2.39	0.52	1260
20	Kalikattupatti	920	7.7	3.89	4.11	2.52	0.10	5.64	6.63	1.83	0.71	453
21	K.puthukottai	1090	7.1	2.99	27.96	5.56	0.15	4.60	5.24	1.79	0.52	2576
22	Keranur	910	7.3	2.09	0.41	7.56	0.05	5.78	4.31	2.29	0.64	258
23	Kalupati	950	7.7	2.19	0.82	5.35	0.30	2.11	3.61	1.35	1.07	157
24	Seegampatti	117	7.6	2.09	0.41	5.04	0.05	2.15	3.80	0.91	1.06	107.1
25	Karnampatti	1790	7.1	3.69	1.81	8.13	0.23	2.36	7.02	1.37	0.71	497.7
26	Natupatti	1980	7.3	4.19	6.00	6.96	0.31	8.01	6.91	0.89	0.71	1877
27	Natupatti	1700	7.1	2.39	14.39	2.65	0.13	4.42	5.70	1.29	0.71	1701
28	Sechalur	1990	7.3	3.89	4.28	8.13	0.28	4.87	6.32	1.58	0.53	623.7
29	Vaiyampatti	1280	7.4	2.99	2.96	2.56	0.28	3.72	7.61	3.54	0.55	743.3
30	Kalungulam	1400	7.5	3.29	4.19	4.52	0.79	5.19	10.94	1.27	0.71	756
31	Puthumaniyampatti	1630	6.8	3.19	3.29	4.65	0.36	4.26	3.04	0.89	0.55	963.9
32	PeriyAnakaraipatti	2260	7.7	4.19	8.80	6.96	0.08	5.26	5.19	2.68	0.50	919.8
33	Anakaraipatti	2800	7.8	4.39	11.02	5.30	0.10	6.29	6.71	3.29	0.89	163
34	Chithapatti	2040	7.6	4.19	8.80	6.96	0.36	6.72	7.73	3.98	0.48	1915.2
35	Onthapatti	1680	7.8	4.89	6.82	2.56	0.05	4.01	4.06	2.79	0.50	1058.4
36	Palayakottai	2480	7.6	4.09	5.84	5.48	0.02	6.52	6.54	3.18	1.24	1562.4
37	Velai Pulampatti	1170	7.4	4.49	1.31	6.30	0.02	6.36	7.11	3.79	1.08	1052.1
38	Manjampatti	1810	7.8	3.49	18.01	9.61	0.05	2.46	6.26	1.60	0.60	2400.3
39	Chithanathan	1620	7	4.49	5.26	8.35	0.02	4.23	4.09	4.39	0.76	1146.6
40	Chithanathan west	1170	7.5	2.99	7.73	1.35	0.02	4.36	8.40	2.62	0.61	926.1
41	Alakaritiyapatti	1740	7.8	2.49	6.50	4.17	0.05	3.92	5.36	2.68	0.50	1159.2
42	Maravanur	1500	7.8	4.49	3.54	1.96	0.02	3.51	4.31	2.29	0.53	315
43	Kolapatti	2320	7.8	2.19	8.22	7.04	0.02	6.52	4.14	2.54	0.35	1461.6
44	Cherpatti	1840	7.5	2.69	5.10	5.65	0.02	5.36	4.31	0.33	0.68	529.2
45	Vataku Cherpatti	1660	8.8	1.60	2.38	7.04	0.02	6.88	5.81	2.06	0.68	415.8
46	Kupanarapatti	1820	7.7	3.19	5.26	5.56	0.10	6.24	6.63	1.14	1.03	516.6
47	Kupanarapatti	1670	7.8	4.09	17.43	1.65	0.05	6.39	9.11	1.29	0.82	1682.1
48	Palipatti	1830	8.2	4.19	3.78	6.74	0.05	1.72	8.74	2.35	1.06	522.9
49	Pathiripatti	1240	7.4	4.89	6.08	1.17	0.02	5.01	8.01	4.43	1.24	718.2
50	Palanikondampatti	2050	7.9	3.39	6.00	8.17	0.10	6.23	4.76	1.10	0.81	1291.5

RESULTS AND DISCUSSION

Groundwater chemistry

Result of the various physiochemical parameters is shown in Table 1 and their statistical measures such as minimum, maximum, average, median and mode are given in Table 1.

Electrical Conductivity

In the study area, total concentration of Electrical Conductivity ranges from 117 to 2800 ppm in the groundwater samples within Manapparai Taluk. To know the distribution pattern of the concentration different elements and to demarcate the higher concentration zones, the contour maps for various elements were also generated, discussed and presented.

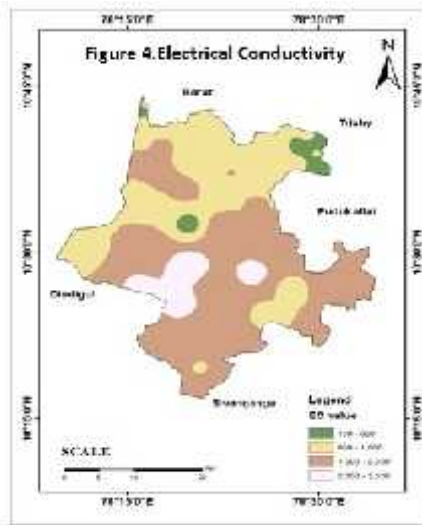


Figure 2 Map Showing Electrical Conductivity in Manapparai Taluk, Trichy District,

Calcium (Ca)

In the study area, total concentration of Calcium ranges from 30 to 98 ppm in the groundwater samples within the Manapparai Taluk.

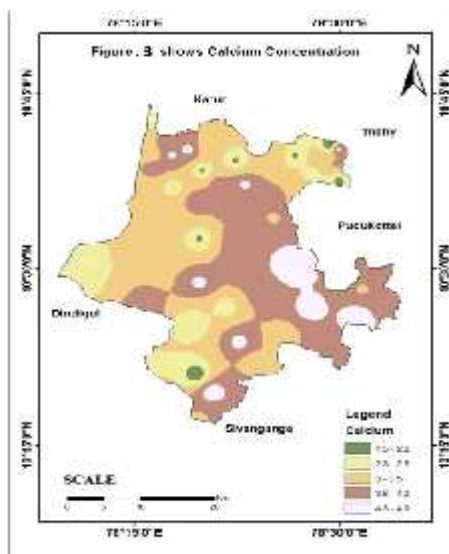


Figure 3 Map Showing Calcium Concentration in Manapparai Taluk, Trichy District,

The samples are 42% of falls within the permissible limit and 58% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur, Nadupatti, Periyankaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti. In the study area, total concentration of Magnesium ranges from 5 to 340 ppm in the groundwater samples within the Manapparai Taluk. The samples are 76% of falls within the permissible limit and 24% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Maravaur, Edayampatti, and Kilinjumedu and minimum exists in the areas of Darasuram, Ariyapuram, Chettimandapam, Kuthanur and Injigudi.

Sodium (Na)

In the study area, total concentration of Sodium ranges from 12 to 221 ppm in the groundwater samples within the Manapparai Taluk. The samples are 56% of falls within the permissible limit and 44% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur, Nadupatti, Periyankaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti.

Potassium

As per WHO (1993), the maximum allowable limit for potassium is 12 mg/l. From the analysis of water samples of the study area, 20% of the collected samples (i.e., six sampling stations) exceed this permissible limit. The spatial distribution map for potassium is shown in the study area.

In the study area, total concentration of Potassium ranges from 1 to 31 ppm in the groundwater samples within the Manapparai Taluk. The samples are 16% of falls within the permissible limit and 84% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur,

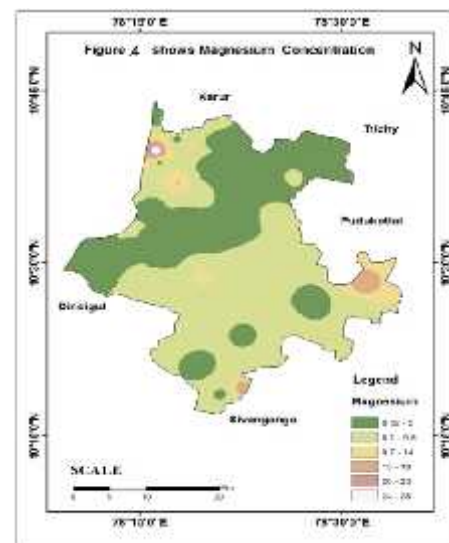


Figure 4 Map Showing Magnesium Concentration in Manapparai Taluk, Trichy District,

Nadupatti, Periyankaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti

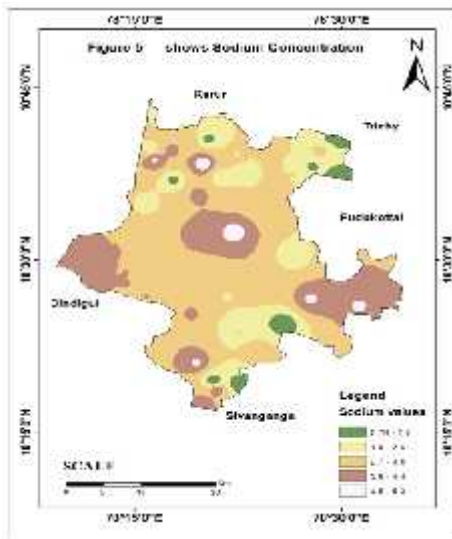


Figure 5 Map Showing Sodium Concentration in Manapparai Taluk, Trichy District,

Bicarbonate (HCO₃)

In the study area, total concentration of Bicarbonate ranges from 44 to 520 ppm in the groundwater samples within the Manapparai Taluk. The samples are 80% of falls within the permissible limit and 20% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur, Nadupatti, Periyankaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti. In the study area, total concentration of Chloride ranges from 13 to 388 ppm in the groundwater samples within the Manapparai Taluk. The samples are 16% of falls within the permissible limit and 84% of the sample falls more than the permissible limit.

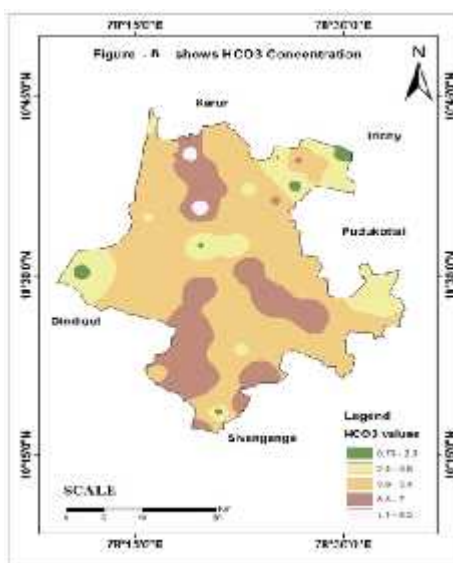


Figure 6 Map Showing Bicarbonate in Manapparai Taluk, Trichy District,

Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur, Nadupatti, Periyankaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti.

Sulphate (SO₄)

In the study area, total concentration of Sulphate ranges from 22 to 213 ppm in the groundwater samples within the Manapparai Taluk. The samples are 4% of falls within the permissible limit and 96% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur, Nadupatti, Periyankaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti.

In the study area, total concentration of Nitrate ranges from 12 to 88 ppm in the groundwater samples within the Manapparai Taluk. The samples are 32% of falls within the permissible limit and 68% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur, Nadupatti, Periyankaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti. The concentration of nitrogen in groundwater is derived from the biosphere (Saleh et al. 1999). Nitrogen is originally fixed from the atmosphere and then mineralized by soil bacteria into ammonium. Three samples exceed the desirable limit of 45 mg/l as per WHO standard. The high concentration of nitrate in drinking water is toxic and causes blue baby disease/methaemoglobinemia in children and gastric carcinomas (Comly 1945). The high Nitrate concentration is due to the intensive urbanization and industrialization.

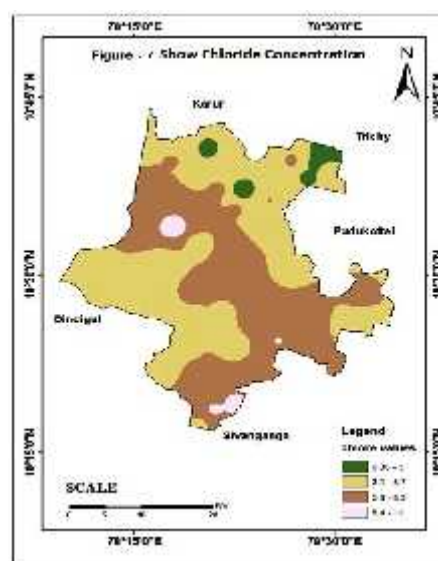


Figure 7 Map Showing Chloride Concentration in Manapparai Taluk, Trichy District,

Total Dissolved Solids (TDS)

To ascertain the suitability of groundwater for any purposes, it is essential to classify the groundwater depending upon their hydro chemical properties based on their TDS values (Davis and DeWiest 1966; Freeze and Cherry 1979) which are represented in Tables 5 and 6 and displayed spatially in Figs. 7 and 8, respectively. The groundwater of the area is fresh water for 56.7% of the sample locations, and the rest of the samples represent brackish water based on Freeze and Cherry (1979). In the study area, total concentration of Total Dissolved Concentration ranges from 34.3 to 2576 ppm in the groundwater samples within the Manapparai Taluk. The samples are 70% of falls within the permissible limit and 30% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Alampattipudur, Elangakurichi, Kumaravatti, Kasanur, Nadupatti, Periyanakaraipatti and Maravanur and minimum exists in the areas of Udupatti, Manapparai taluk, Anankaipatti, Keeranur, Seegampatti, Vaiyampatti and Palanikondampatti.

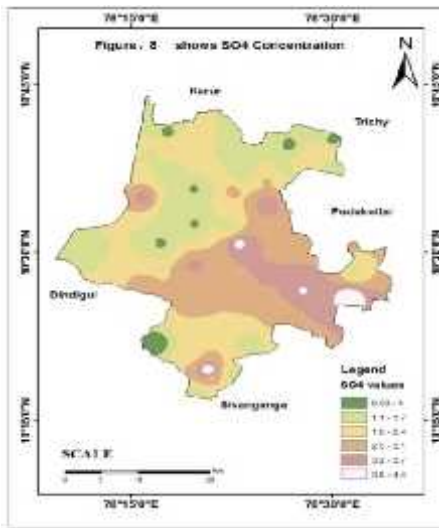


Figure 8 Map Showing Sulphate Concentration in Manapparai Taluk, Trichy District,

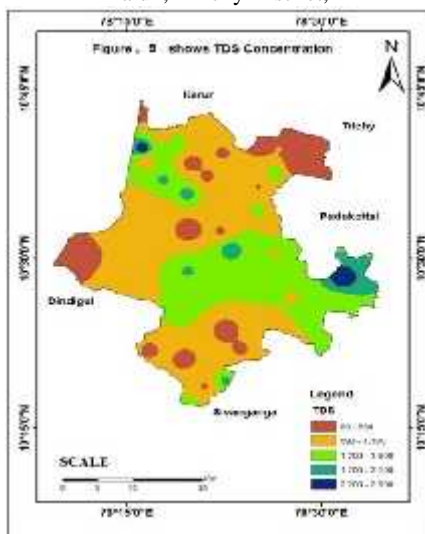


Figure 9 Map Showing TDS Concentration in Manapparai Taluk, Trichy District,

Table 3 Groundwater classification on the basis of TDS

Total Dissolved Solids (mg/l)	Category	Number of Wells
Up to 10,000	Fresh Water	32
1000 – 10,000	Brackish Water	18
10,000 – 100,000	Saline Water	Nil
Above 100,000	Brine Water	Nil

Total Hardness

The classification of groundwater based on total hardness (TH) shows that a majority of the groundwater samples fall in the very hard water category.

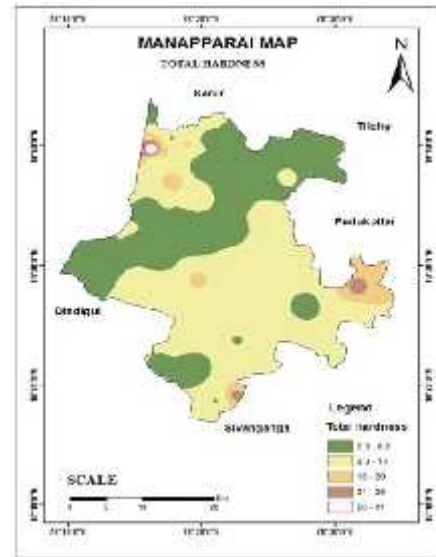


Figure 10 Map Showing of Total Hardness in Manapparai Taluk, Trichy District

The hardness values range from 20 to 1,300 mg/l with an average value of 438.33 mg/l (Table 2). The maximum allowable limit of TH for drinking purpose is 500 mg/l and the most desirable limit is 100 mg/l as per the WHO international standard. For total hardness, the most desirable limit is 80-100 mg/l (Freeze and Cherry 1979). Groundwater exceeding the limit of 300 mg/l is considered to be very hard (Sawyer et al. 2003). Approximately 37% of groundwater samples out of 30 collected exceeds the maximum allowable limit of 500 mg/l.

Excessive amount of dissolved ion such as sodium, bicarbonate, and carbonate in irrigation water affects plants and agricultural soil physically and chemically, thus reducing the productivity. The physical effects of these ions are to lower the osmotic pressure in the plant structural cells, thus preventing water from reaching the branches and leaves. The chemical affects disrupt plant metabolism. It is the quantity of certain ions, such as sodium and boron, rather than the total salt concentration that affects plant development (Sahinci 1991). Excess salinity reduces the osmotic activity of plants and thus interferes with the adsorption of water and nutrients from the soil (Saleh et al. 1999).

Sodium concentration plays an important role in evaluating the groundwater quality for irrigation because sodium causes an increase in the hardness of soil as well as a reduction in its permeability (Tijani 1994). Na% in eight groundwater samples (viz. 1, 16, 20, 22, 24, 25, 26, 30) are high and are not suitable for irrigation.

Table.4 Geochemical Characteristics of Manapparai Taluk, Trichy District

Sl. No	Location	SAR	Na%	RSC	TH	MR	NCH	CR	CAI-I	CAI-II	GIBBS-I	GIBBS-II
01	Alampattipudur	1.43	15.97	-4.16	4.88	60.57	-31.16	5.32	0.55	0.47	0.69	0.17
02	Maravanur	2.60	33.29	-8.74	10.28	911.25	-66.74	4.59	0.076	-0.31	0.17	0.60
03	Edayampatti	1.90	24.95	-3.83	6.9	407.57	-146.32	2.47	0.50	0.36	0.58	0.38
04	K.Periappatti south	0.83	18.60	0.27	3.06	160.46	-164.09	1.94	0.90	0.55	0.51	0.26
05	Utuppatti	1.39	31.48	-0.22	2.56	178.32	-114.60	1.89	0.60	0.19	0.47	0.44
06	Sathirappatti	1.47	23.19	-0.25	4.40	250.64	-202.90	1.16	0.45	0.12	0.36	0.33
07	Muthappudaiyanpatti	3.2	41.86	-0.74	5.38	243.29	-226.50	1.07	-0.53	-0.20	0.35	0.52
08	Mannaparai Town	2.58	38.51	0.23	5.46	498.05	-279.68	1.91	0.51	0.47	0.54	0.62
09	Malaiyidipatty	3.2	42.02	-3.15	5.38	243.29	-106.05	3.47	0.15	0.10	0.66	0.52
10	Pudur	2.58	38.51	-0.91	5.46	498.05	-222.32	1.94	0.37	0.28	0.53	0.62
11	Metukalam	1.27	17.86	-2.15	6.71	478.79	-221.08	0.79	0.03	0.00	0.24	0.32
12	Elangakurichi	1.96	23.46	-4.22	7.59	393.76	-161.19	0.61	5.22	-0.40	0.10	0.5
13	Katumavatipuram	3.18	38.35	-1.39	7.09	403.12	-278.05	1.67	0.24	0.14	0.50	0.53
14	Kumaravatti	2.68	30.80	-5.76	10.48	899.13	-225.50	1.32	-0.33	-0.14	0.42	0.57
15	Kumaravatti	2.86	34.78	-3.16	7.52	442.2	-210.43	2.32	0.38	0.27	0.58	0.50
16	Anankaraipatty	2.41	35.56	-1.93	5.29	391.67	-162.68	2.14	0.30	0.21	0.55	0.54
17	Kasanur	3.15	37.15	-2.69	7.69	462.76	-242.22	1.41	0.14	-0.10	0.44	0.53
18	Sadaiyampatti	3.12	30.42	-6.16	14.68	1246.79	-411.40	0.99	-0.26	-0.13	0.37	0.59
19	Elamanur	3.83	37.05	8.41	13.77	1150.99	254.18	1.97	0.23	-0.20	-0.54	0.65
20	Kalikattupatti	1.96	24.69	-2.37	8	516.83	273.87	1.92	0.63	0.49	0.54	0.60
21	K.puthukottai	1.92	15.59	-26.35	3.95	3729.93	-199.30	1.03	-0.03	-0.07	0.53	0.66
22	Keranur	5.36	75.24	3.28	2.51	60.74	-286.74	1.31	-0.74	-0.38	0.42	0.78
23	Kalupati	4.31	65.20	-0.90	3.02	119.69	-102.68	3.12	-0.40	-0.45	0.63	0.72
24	Seegampatti	4.32	67.02	-0.36	2.51	60.74	-104.83	3.20	-0.31	-0.31	0.64	0.71
25	Karnampatti	5.16	60.31	-3.14	5.50	229.92	-112.49	4.82	-0.12	-0.04	0.75	0.63
26	Natupatti	3.57	41.60	-2.18	10.19	743.55	-390.49	1.4	0.03	0.3	0.46	0.54
27	Natupatti	1.28	14.20	-12.36	16.79	2039.99	-204.45	2.15	0.56	0.61	0.56	0.68
28	Sechalur	4.62	50.73	-3.30	8.17	537.5	-235.19	2.13	-0.24	0.78	0.56	0.49
29	Vaiyampatti	2.18	32.34	-.23	5.95	394.93	-180.05	3.28	0.7	-0.34	0.56	0.62
30	Kalungulam	3.06	41.51	-2.29	7.49	546.75	-252.26	3.25	0.66	-0.21	0.67	0.61
31	Puthumaniyarampatti	3.30	43.59	-2.22	6.48	431.95	-206.56	1.36	-0.41	0.12	0.68	0.62
32	PeriyAnakaraipatti	3.50	35.12	-7.73	12.99	1089.86	-250.03	1.68	-0.33	0.04	0.42	0.55
33	Anakaraipatti	2.63	25.97	-9.11	15.41	1352.92	-299.24	1.74	0.22	0.20	0.50	0.64
34	Chithapatti	3.50	36.02	-6.27	12.99	1089.86	-322.96	1.84	0.14	0.09	0.52	0.34
35	Onthapatti	1.67	18.25	-7.70	11.72	822.14	-189.04	1.80	0.38	0.07	0.53	0.57
36	Palayakottai	3.26	35.66	-3.41	9.93	726.58	-316.19	4.20	0.17	-0.73	0.50	0.58
37	Velai Pulampatti	4.57	52.15	0.55	5.81	160.88	312.12	1.72	0.11	-0.46	0.50	0.73
38	Manjampatti	3.66	31	-19.04	21.50	2316.58	-101.41	4.20	-0.53	0.92	0.53	0.65
39	Chithanathan	4.52	46.19	-5.53	9.75	643.51	-201.65	1.7	-1.03	0.16	0.72	0.31
40	Chithanathan west	0.89	11.35	6.36	10.72	1031.22	-207.24	3.05	0.84	0.37	0.49	0.63
41	Alakaritiyapatti	2.56	31.97	-5.07	8.99	910.06	-186.85	2.31	0.23	0.16	0.58	0.63
42	Maravanur	1.67	19.80	-4.52	8.03	432.36	-167.32	2.16	0.55	0.67	0.55	0.31
43	Kolapatti	3.60	40.42	-3.90	10.42	1196.92	-315.70	1.13	0.69	-0.31	0.39	0.076
44	Cherpatti	3.45	42.15	-2.43	7.79	699.09	-260.15	1.42	-0.30	-0.21	0.45	0.68
45	Vataku Cherpatti	4.59	63.97	2.90	3.98	387.84	-340.17	1.41	-0.21	-0.13	0.46	0.82
46	Kupanarapatti	3.38	40.12	-2.21	8.46	691.12	-303.74	1.73	0.18	0.11	0.51	0.64
47	Kupanarapatti	0.76	7.33	-15.13	21.53	2169.50	-298.04	2.24	0.82	0.87	0.59	0.29
48	Palipatti	4.15	45.99	-6.25	7.97	468.54	-78.06	7.01	0.23	0.38	0.84	0.62
49	Pathiripatti	0.87	9.85	-5.96	10.98	732.99	-239.76	2.54	0.86	0.64	0.61	0.20
50	Palanikondampatti	4.34	46.83	-3.17	9.40	777.25	-301.98	1.32	-0.69	-0.43	0.43	0.71

U.S. Salinity Diagram

Irrigation water containing excessive amount of dissolved ion such as sodium, bicarbonate and carbonate affect plants and agricultural soil physically and chemically, thus is reducing the productivity. The physical effects of these ions are to lower the osmotic pressure in the plant structural cells, thus preventing water from reaching the branches and leaves. The chemical effects disrupt plant metabolism. It is the quantity of certain ions, such as sodium and boron, rather than the total salt concentration that affects plant development (Sahinci 1991). Excess salinity reduces the osmotic activity of plants and thus interferes with the absorption of water and nutrients from the soil (Saleh et al.1999) Sodium adsorption ratio (SAR) is an important parameter for determining the suitability of groundwater for irrigation because it is a measure of alkali/sodium hazard to crops.

Table.5 Range of Concentration of chemical parameters of the study area and WHO and Indian Standard for drinking water

Sl.No	Parameter	Range in	(BIS, 2012)
		Concentration	Desirable limit
		Manapparai Taluk	Manapparai Taluk
1	pH	6.7-8.8	6.5-8.5
2	EC	117-2800	*
3	TDS	34.3-2576	500
4	Ca	30-98	75
5	Mg	5-340	30
6	Na	12-221	100
7	HCO3	44-520	200
8	K	1-31	10
9	Cl	13-388	250
10	SO4	22-213	200
11	NO3	12-88	45
12	TH	*	300

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

Where all ionic concentrations are expressed in epm.

Clearly shows that Sodium Absorption Ratio of the Manapparai Taluk is classified into two zones viz., as less than 1 and greater than one, Greater than one is found along the eastern edge of Manapparai Taluk. Rest of study area is covered with less than one.

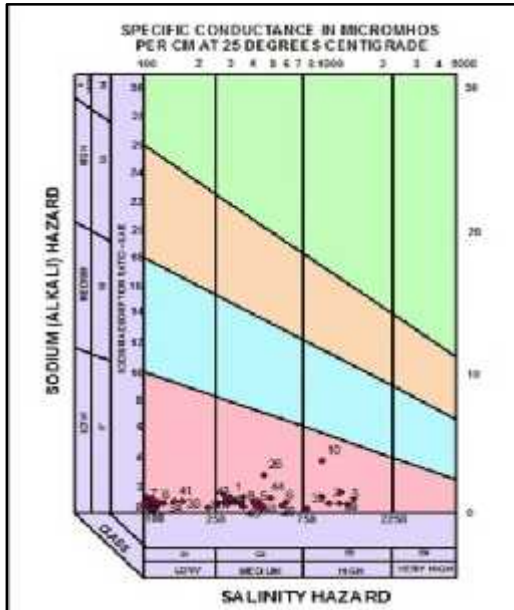


Figure.11 Map Showing of USSL Diagram in Manapparai Taluk, Trichy District

Piper’s Trilinear Diagram

Piper’s diagrams, also called trilinear diagrams (Piper, 1953), are drawn by plotting the proportions (in equivalents) of the major cations ((Ca, Mg, (Na+K)) on one triangular diagram, the proportions of the major anions (Alkalinity CO₃+HCO₃, Cl, SO₄) on another, and combining the information from the two triangles on a quadrilateral. The position of this plotting indicates the relative composition of a groundwater in terms of the cation–anion pairs that correspond to four vertices of the field.

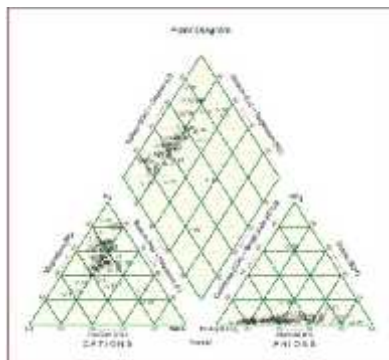


Figure.12 Map Showing of Piper Diagram in Manapparai Taluk, Trichy District

The main drawback that Piper’s trilinear diagrams have in their plotting shows the chemical character of the groundwater according to the relative concentration of its constituents, but not according to the absolute concentrations.

Gibb’s Ratio

The chemistry of the groundwater may be dominated due to rock dominance, evaporation dominance or precipitation dominance or the mixture of these factors. In this diagram, two ratios have been calculated for anions and cations respectively. (Hem 1980; Karanth 1997).

For anion,

$$\text{Gibbs Ratio I} = \text{Cl}/(\text{Cl} + \text{HCO}_3)$$

For cation,

$$\text{Gibbs Ratio II} = (\text{Na} + \text{K})/(\text{Na} + \text{K} + \text{Ca})$$

In both the ratios, all the ions are expressed in epm

Gibbs I and Gibbs II respectively shown in the indicate that most of the groundwater samples of Manapparai Taluk reveal that most of the groundwater samples falls under the rock water interaction i.e weathering of parent rocks primarily controls the major ion chemistry of groundwater in the study area and also a few water samples exists in Precipitation dominance due to intensity of rain fall in the Manapparai Taluk, Salem District, Tamil Nadu.

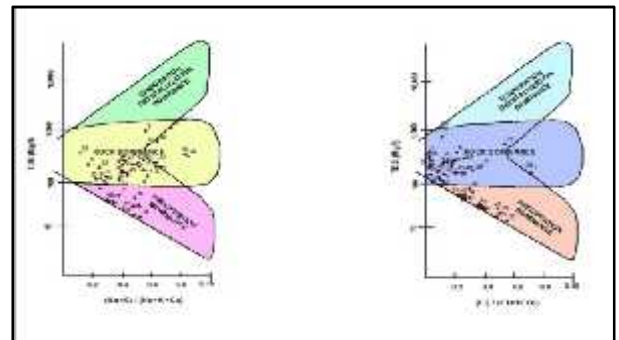


Figure.13 Map Showing of Gibbs Plot Diagram in Manapparai Taluk, Trichy District

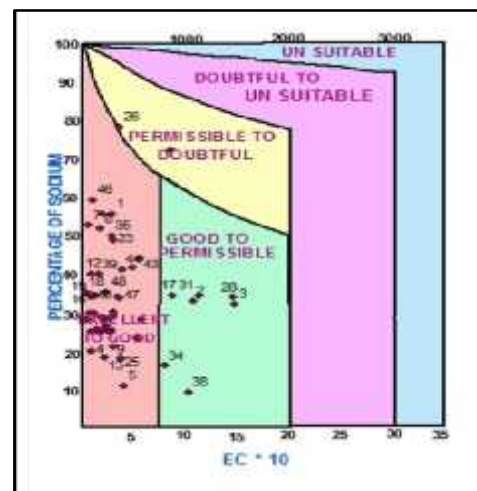


Figure.14 Map Showing of Wilcox Diagram in Manapparai Taluk, Trichy District

Wilcox's Diagram

Wilcox (1955) used sodium percentage and specific conductance in evaluating the suitability of groundwater to irrigation. Sodium-percentage determines the ratio of sodium to total cations viz., sodium, potassium, calcium and magnesium. All concentration values are expressed in equivalents per million.

CONCLUSION

In the study area characteristics of physiochemical parameters in Electrical Conductivity in the Manapparai Taluk the maximum concentration is 2400 (chithampatti) seen in my the study area whereas minimum concentration 117 (Sengampatti) seen in the direction of East and North Western of the study area. pH concentration in the Manapparai Taluk could be seen the maximum concentration is 8.8 (Vetapuricherpatti) seen in of the study area whereas minimum concentration is 6.7 (Utupatti) seen in the direction of North-West position of the study area. Calcium Concentration in the Manapparai Taluk the maximum concentration are seen in Onthapatti with the value of 98 the study area whereas minimum concentration is 30 (Utupatti) seen in the direction of West of the study area. Magnesium in the Manapparai Taluk the maximum concentration are seen in the area K. puthukottai with value of 7.575 epm the study area whereas minimum concentration are seen in Keranur with the value of 0.411 epm the direction of South part of the study area. Sodium in the Manapparai Taluk the maximum concentration is 9.609 in Manjampatti in the of the study area whereas minimum concentration is 0.522 K. perriapatti south. Bicarbonate in the Manapparai Taluk the maximum concentration is 8.522 seen in the Sadaiyampatti area whereas minimum concentration are seen in Alampattipudur with the value of 0.72. Chloride in the Manapparai Taluk the maximum concentration are seen in the area of Kalungulam with the value of 10.942 epm in the study area whereas minimum concentration are seen in Elangakurich with value of 0.369 epm. Sulphate in the Manapparai Taluk the maximum concentration are seen in the area of Pathiripatti with value of 4.435 epm of the study area whereas minimum concentration are seen in Cherpatti with value of 0.333 epm. Hydrochemical facies diagrams reveals that Gibbs plots the aquifer horizons are being stayed a quite lot of time in the underground regions because stagnation ground water.

Percent of Sodium is low 7.4% (Kaparnappatti) and hence the quality of groundwater is good for irrigation. The concentration of Residual Sodium Carbonate (RSC) in the study area within the allowable limit (26.349). These indicate that the ground water of the Manapparai Taluk area is good for irrigation, other agricultural purposes. The Groundwater geochemistry in the Manapparai Taluk are showing the pH values ranges from 6.7 to 8.8 and concentrations of EC, TDS and other major cations and anions of groundwater in the Manapparai Taluk depicts and is well suited for domestic and irrigational purposes.

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