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Geochemical Characterization of Groundwater in Veppanthattai Block of Perambalur, Tamilnadu, India

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Abstract

Perambalur is the backward administrative district in the state of Tamilnadu India. It has 4 blocks namely Alathur, Perambalur, Veppanthattai and Veppur. Among these Veppanthattai block has the historical importance and is blessed with good agricultural land. The people used the groundwater mostly for drinking and agricultural purposes. Groundwater samples from bore wells were collected from various areas in the Veppanthattai block in Perambalur district during monsoon season and were analyzed for their physical-chemical characteristics. The present study was undertaken to characterize the physico-chemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Total Alkalinity (TA), Calcium, Magnesium, Chloride, Sulphate, Nitrate, Iron, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Phosphate. Each parameter was compared with the standard permissible limit of the parameter as prescribed by World Health Organization (WHO, 2005) and suitable suggestions were reported.

Keywords: *Groundwater; Veppanthattai Block; Physico chemical Parameters; Monsoon Season.*

1. INTRODUCTION

Water is very important to our day today life and for all living organisms. Without water our life cannot function. Two- third of the earth surface is covered with water. Availability of quality freshwater is one of the most critical environmental issues of the twenty first century. Water pollution is a major problem in this new generation. The problems like growing population, sewage disposal, industrial waste, radioactive waste, etc. have polluted our water resources so much. Now it is time the Groundwater is an important water resource for domestic and agriculture needs in both rural and urban parts of India. The chemical composition of groundwater is very important one that determines the quality of water. Water quality is very significant and often polluted due to agricultural, industrial and human activities. Even though the natural environmental processes provide means of removing pollutants from water, there are definite limits. It is up to the people to provide security to protect and maintain quality of water (Ikhane Philips et al 2010). Now the pollution of groundwater comes from many sources. The main sources of groundwater pollution are Discharge of waste disposal from agriculture, industries and municipalities. Sometimes surface run-off also brings mud, leaves, and human and animal wastes into surface water bodies. These pollutants may enter directly into the groundwater and contaminate it (Mohamed Hanipha et al 2013). Groundwater with good quality is very important to improve the life of people. The present study was undertaken to investigate the qualitative analysis of some physicochemical parameters at Veppanthattai Block in Perambalur District of Tamilnadu.

2. WATER QUALITY INDEX

For better understanding and managing of water resources, the quality of water in an area of interest should be determined in terms of either its physical, chemical or biological parameters or all of these factors. Additionally, the integrated situation of water in a study area should be evaluated using an appropriate technique, such as the water quality index (WQI) which is regarded as one of the most effective ways to communicate water quality. The data of

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quantitative analysis and W.H.O. standards are used for calculating water quality indices (Pradhan et al 2001).

WQI is a tool widely used in different parts of the world to solve the problems of data management and to evaluate success and failures in management strategies for improving water quality. A number of indices have been developed to summarize water quality data for communication to the general public in an effective way. In general water quality indices incorporate data from multiple water quality parameters in to a mathematical equation that rates the health of water body with a single number. That number is placed on a relative scale to justify the water quality in categories ranging from very bad to excellent. This number can be easily interpreted and understood by political decision makers, non-technical water managers and the general public.

1.1 Calculation of water Quality Index

For assessing the quality of water in this study, the quality rating scale (Qi) for each parameter was calculated by using the following equation;

$$Qi = \{[(Va - Vi) / (Vs - Vi)] * 100\}$$

Where,
Qi = Quality rating of i^{th} parameter for a total of n water quality parameters
Va = Actual value of the water quality parameter obtained from laboratory analysis
Vi = Ideal value of that water quality parameter obtained from the standard Tables.
Vi for pH = 7 and for other parameters it is equivalent to zero, but for DO Vi = 14.6 mg/L
Vs = Recommended WHO standard of the water quality parameter.

Then, after calculating the quality rating scale (Qi), the Relative (unit) weight (Wi) is calculated by a value inversely proportional to the recommended standard (Si) for the corresponding parameter using the following expression;

$$Wi = K/Sn$$

Where,
K [constant] = $1/[(1/S1) + (1/S2) + (1/S3) + \ldots + (1/Sn)]$

Here,
Wi = Relative (unit) weight for nth parameter
Sn = Standard permissible value for nth parameter

Finally, the overall WQI is calculated by aggregating the quality rating with the unit weight linearly by using the following equation:

$$\mathbf{WQI = \Sigma^{n}_{i=1}(QiWi) / \Sigma^{n}_{i=1}Wi}$$

In general, WQI is defined for a specific and intended use of water For human consumption or uses the WQI values is classified as five types. The value from 0 to 24 indicates quality of water is excellent, the value from 25 to 49 indicates quality of water is good, the value from 50 to 74 indicates quality of water is poor, the value from 75 to 100 indicates quality of water is very poor, the value greater than 100 indicates quality of water is unfit for drinking. These types are summarized in table 1.

Table 1: Water quality scale with reference to WQI by using the Weighted Arithmetic Index method

WQI Value	Quality of water
00-24	EXCELLENT
25-49	GOOD
50-74	POOR
75-100	VERY POOR
>100	UNFIT FOR DRINKING

1.2 Study Area

Perambalur is an under developed district in the state of Tamilnadu, India. It is a centrally located inland district, (spread over 3,69,007 ha) which was trifurcated from the erstwhile composite Tiruchirappalli district and was formed on 1st November, 1995. The district is bounded by Cuddalore district in the north, Tiruchirappalli district in the south, Thanjavur in the east and Namakkal and Tiruchirappalli districts in the west. The total geographical area of the district is 3,69,007 ha, and net sown area and gross sown area are 2,16,422 ha and 2,37,136 ha, respectively. The net area under irrigation is 71,624 ha.

The district lies in the Southern plateau and hill zone of Agro-climate regional planning with characteristics of semi-arid climate. The soil is predominantly red loamy and black soil. The normal rainfall of the district is 908 mm which is less than 946.9 mm, the normal rainfall of the State. The precipitation during northeast monsoon, southwest monsoon and remaining winter and hot weather period account for 52%, 34% and 14% of annual rainfall, respectively. 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. The ground water resource through tube wells and open wells contribute nearly 68% of irrigated area command. The major crops grown in the district are paddy, groundnut, sugarcane and millets. Cashew is the major plantation crop.

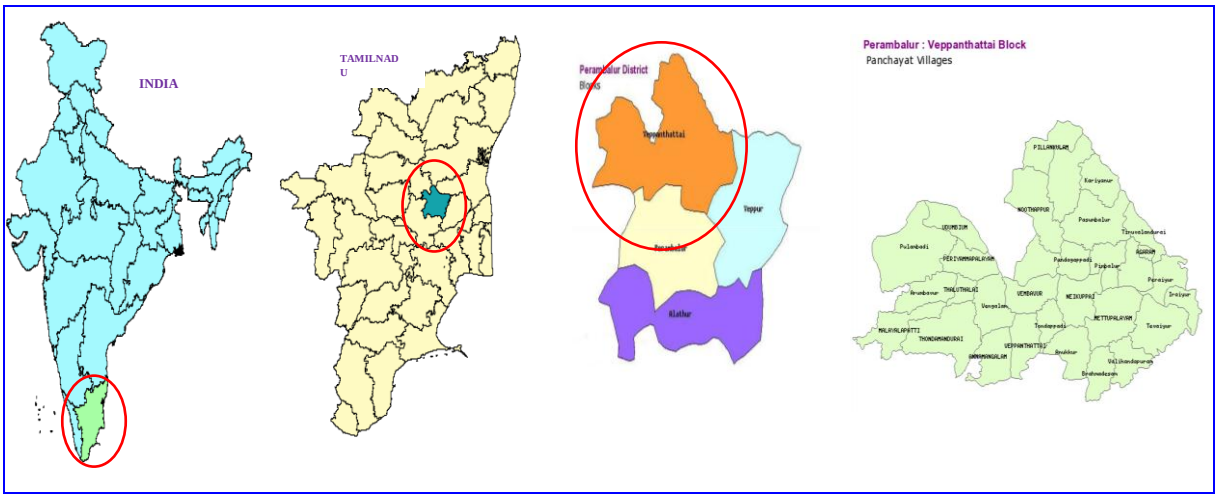


Fig. 1: Location map of the Study Area

The district for administrative purpose has been divided into three taluks (Perambalur, Kunnam and Veppanthattai) which is further sub-divided into four blocks viz. Perambalur, Veppanthattai, Veppur and Alathur. The district comprises of 121 village panchayats, four town panchayats and one municipality (pure enviro engineering pvt. Ltd. 2011). Veppanthattai is one of the prominent block in Perambalur district of state of Tamilnadu. This area is located 13 km away from Perambalur on the way to Attur. The area faces Krishnapuram in the northern side, Esanai in the southern side and Valikandapuram in the eastern side.

3. MATERIALS AND METHOD

Groundwater samples were collected from 41 representative bore wells, during July 2013. samples were collected in 2 L polythene bottles which were previously cleaned. Each bottle was rinsed to avoid any possible contamination with distilled water. The analysis was carried out systematically both volumetrically and by instrumental techniques. The Procedures were followed from standard books and manuals. The analysis was carried out immediately for pH, EC, Odour, DO and for all other parameters within three hours of the sampling time. All concentrations are expressed in milligrams per litre (mg/L) except pH and EC in µS.

The temperature of water samples was recorded on the spot using thermometer. pH meter (Systronicsdigital model 335) was used to determine the hydrogen ion concentration. The samples were analyzed for EC using Conductivity meter. Total Alkalinity (TA) was estimated by volumetrically neutralizing with Standard HCl acid. Salinity and Total Dissolved Solids (TDS) were estimated using Systronics water analyzer. Total Hardness (TH) and Calcium Hardness (CH) as CaCO3 were determined volumetrically by using standard EDTA soln. The calculation of Magnesium Hardness (MH) was done by subtracting the CH from TH value. Phosphate and Nitrates are determined by using colorimeter. Sulphate and Dissolved Oxygen (DO) are estimated by precipitation method by using BOD bottle and Chloride, volumetrically by using standard $AgNO_3$ Solution.

4. RESULT AND DISCUSSION

The results of the analysis are exposed in the Table 2. The pH value is from 6.98 to 8.45. The pH value of all samples falls within the permissible limit of WHO. The permissible limit of pH for drinking water is 7.0 - 8.5. most of the groundwater are alkali in nature.

Electrical conductivity value is from 73.87 to 599.27 µS/cm. About 80% samples are in permissible limit. EC value is a manifestation to signify the total

concentration of soluble salts in water. The electrical conductance is a good indication of total dissolved solids which is a measure of salinity that affects the taste of potable water. High concentration of EC in groundwater is due to ionic mobility and ionic valences of the ions. EC is 100% correlate with TDS. And also best correlates with Cl, TH and Mg. Total dissolved solid value is from 51.41 to 417.09 mg/L.All samples are within the permissible limit

Table 2. Groundwater Quality Parameters of Study Area

S. No	STATION	PH	EC	TDS	TH	TA	Ca	Mg	Cl	SO_4	NO_3	Fe	DO	COD	PO_4
1	AGARAM	8.06	284.03	197.68	232	850	28.06	49.76	312.4	34.18	0.11	0.15	4.29	50	2.1
2	ANUKKUR	7.92	159.18	110.79	594	350	172.34	102.88	234.3	60.17	0	0.15	4.08	36	0.58
3	ERAIYUR	7.95	86.35	60.10	298	300	32.06	64.89	92.3	34.66	0	0.46	4.08	34	0.41
4	ERAKARAI	7.81	171.67	119.48	394	255	76.15	77.55	191.7	9.21	0.06	0.00	5.10	48	0.44
5	ESANAI	7.83	206.00	143.38	560	325	116.23	108.28	298.2	33.69	0.06	0.77	3.67	46	0.6
6	K PURAM	7.82	152.94	106.45	640	420	120.24	126.82	198.8	12.03	0.06	0.31	5.10	34	0.22
7	KADAMBUR	7.64	177.91	123.82	480	535	79.36	97.76	227.2	25.99	0.11	0.15	3.88	66	0.17
8	KAI KALATHUR	7.88	236.17	164.37	326	555	66.53	63.31	241.4	2.98	0.17	0.77	3.47	70	0.67
9	KALARAMPATTI	7.9	176.87	123.10	512	310	97.80	101.07	163.3	47.65	0.22	0.15	3.67	30	0.35
10	KONERIPALAYAM	7.82	249.70	173.79	610	700	92.18	126.35	326.6	9.63	0.06	0.15	4.49	54	0.32
11	KOTTARAKUNRU	7.9	112.36	78.20	516	250	80.16	106.34	127.8	9.63	0.06	0.15	3.47	44	0.33
12	MALAYALAPATTI	7.91	111.32	77.48	430	340	73.75	86.93	106.5	21.18	0.03	0.07	4.90	32	1.7
13	MANGALAMEDU	8.25	73.87	51.41	340	330	62.52	67.70	56.8	28.98	0.06	0.88	3.06	38	0.42
14	MARAVANATHAM	7.92	163.76	113.98	366	255	228.46	33.56	170.4	42.84	0.09	0.15	5.10	54	0.26
15	MILLATH NAGAR	7.85	122.77	85.45	360	500	59.32	73.37	127.8	4.77	0.17	0.31	4.08	54	0.3
16	NEIKUPPAI	7.5	320.44	223.03	1020	525	88.18	227.37	468.6	11.07	0.03	0.15	3.88	62	2.5
17	NOOTHAPUR	7.5	249.70	173.79	620	545	123.45	121.16	248.5	19.25	0.06	0.31	3.88	34	0.55
18	PALAYUR	7.95	296.51	206.37	810	650	96.19	174.17	468.6	45.25	0.11	0.15	4.49	48	0.26
19	PANDAGAPADI	8.45	242.41	168.72	494	515	104.21	95.11	305.3	84.24	0.06	0.46	3.27	68	0.3
20	PASUMBALUR	7.83	139.41	97.03	490	330	115.43	91.39	156.2	2.34	0.06	0.31	4.08	48	0.58
21	PIMBALUR	7.64	266.34	185.37	546	625	100.20	108.78	312.4	42.36	0.03	0.15	3.88	82	1.13
22	PUTHUR	6.98	83.23	57.93	290	300	76.15	52.18	85.2	36.58	0.03	0.99	4.90	48	0.35
23	RAYAPPA NAGAR	8.35	112.36	78.20	288	450	49.70	58.15	99.4	69.80	0.11	0.31	3.88	28	0.3
24	THALUTHALAI	7.4	145.66	101.38	408	445	68.14	82.93	198.8	74.61	0.06	0.31	3.27	62	0.56
25	THAMBAI	7.43	164.38	114.41	548	535	38.48	124.32	170.4	23.10	0.06	0.15	4.49	44	0.42
26	THEVAIUR	7.74	190.39	132.51	758	485	120.24	155.61	276.9	72.20	0.14	0.31	4.29	54	0.35
27	THIRUVALANDURAI	7.81	599.27	417.09	1340	225	374.35	235.62	1065	71.72	0.25	0.31	3.67	74	0.08
28	THONDAPADI	7.79	265.30	184.65	756	575	80.16	164.90	319.5	7.22	0.09	0.15	4.08	34	0.11
29	THONMANDURAI	7.65	263.22	183.20	416	540	56.11	87.81	312.4	38.51	0.11	0.46	4.08	28	0.4
30	UDUMBIAM	7.59	209.12	145.55	402	515	84.17	77.55	205.9	45.73	0.2	0.32	4.08	42	0.44
31	V MATHAVI	8.29	342.29	238.23	544	685	77.76	113.76	511.2	26.96	0.09	0.31	3.47	44	0.09
32	V MATHAVI 2	7.95	88.43	61.55	340	435	120.24	53.62	63.9	84.24	0.06	0.00	3.67	66	0.41
33	V.KALATHUR	7.56	269.46	187.55	600	735	48.10	134.66	305.3	47.17	0.11	0.15	3.27	30	0.44
34	VADAGARAI	7.67	225.77	157.13	586	630	67.33	126.55	148.9	21.66	0.09	0.15	2.04	44	0.9
35	VALIKANDAPURAM	7.99	184.15	128.17	436	750	32.06	98.56	163.3	36.58	0.09	0.31	2.86	54	0.1
36	VALLAPURAM	7.75	156.06	108.62	280	360	84.17	47.78	184.6	36.10	0.09	0.00	5.10	66	0.24
37	VALLIYUR	7.58	234.09	162.93	904	350	72.14	202.97	340.8	16.85	0.03	0.46	3.88	44	0.13
38	VANNARAMPOONDI	8.15	109.24	76.03	154	390	32.06	29.75	113.6	25.51	0	0.15	5.10	34	1.9
39	VENBAVUR	8.31	104.04	72.41	334	460	56.11	67.80	149.1	22.14	0.06	0.77	3.67	28	1.7
40	VENGALAM	7.88	91.56	63.72	376	375	88.18	70.23	99.4	18.29	0.06	0.83	3.27	42	0.27
41	VEPANTHATTAI	7.88	211.20	147.00	574	475	60.92	125.19	248.5	26.47	0.11	0.31	4.69	44	0.14

All the values are expressed in mg/L, except pH and EC in µS/cm

The total dissolved solids in water are due to the presence of sodium, potassium, calcium, magnesium, manganese, carbonates, bicarbonates, chlorides, phosphate, organic matter, and other particles (Bhattacharya et al, 2012). EC and TDS are best correlate with Cl ion therefore both values are mostly depends on chloride ion. Total Hardness is from 154 to 1340 mg/L in the study area. 85% of the stations fall above the standard level. The hardness in the water is due to dissolved minerals from sedimentary rocks seepage and runoff (Milovanovic et al, 2007**)**. From the correlation analysis, Total Hardness is best correlate with Magnesium ion. This shows that the excess hardness is mostly depends on Mg ion concentration.

Total Alkalinity value is from 225 to 850 mg/L in the study area. Alkalinity of water is the capacity to neutralize acidic nature and is characterized by the presence of hydroxyl ions. Almost all the samples are above the permissible limit of WHO. The high alkalinity may be due to the usage of basic fertilizers and the hydroxide, carbonates and bicarbonate salts probably released from limestone sedimentary rocks, carbonate rich soils, cleaning agents contributes to the alkalinity.

Calcium value is from 28.05 to 374.34 mg/L. 26.8 % of the stations fall above the standard level. Calcium is very essential for nervous system and for formation of bones and teeth. Excess causes concretions in the body such as kidney or bladder stones and irritation in urinary passages.Ca is Essential for nervous and muscular system, cardiac functions and in coagulation of blood. The excess of calcium in groundwater may be due to the lime stone in ground soil.

Magnesium value is from 29.75 to 235.62 mg/L. 90% of the stations fall above the standard level. Magnesium is a beneficial metal. It is essential as an activator of many enzyme systems. High concentration may cause laxative effect particularly on new users. Higher the concentration gives unpleasant taste to the groundwater. The higher concentration may be due to the dissolution of magnesium calcite. Calcium and magnesium plays an important role in human body. Regulatory action is exercised by calcium and magnesium. The flux of these ions through cell membranes and other boundary layers sends signals that turn metabolic reactions on and off. The chloride ions are ranged from 56.8 to 1065 mg/L. about 34% of groundwater samples are having above the permissible limit. It may be due to the presence of domestic sewage disposal and the presence of soluble chlorides from rocks (Sahu et al, 2000). And may be due to anthropogenic activity like septic tanks effluents, usage of bleaching agents by people nearby bore well.

The sulphate value is from 2.34 to 84.24 mg/L. The sulphate values for all the groundwater samples are well within the permissible limit (200 mg/L) of WHO.

Nitrate value is from 0 to 0.25 mg/L. The standard value of nitrate is 45 mg/L according to WHO. All the groundwater samples are containing very minimum amount of nitrate.

Iron value range is from 0.00 – 0.99 mg/L. It is biologically important element which is essential to all organisms and present in hemoglobin system. In traces it is essential for nutrition. Most of the samples are within the permissible limit (0.3 mg/L) of WHO. 14.6 % of the stations fall above the standard level. High concentration of iron causes slight toxicity (Mohamed Ibraheem et al, 2013).

The DO values in the groundwater range from 2.04 to 5.10 mg/L. The standard value of dissolved oxygen in ground water is 5 mg/L, almost all the samples are below the required limit of WHO. It may be due to certain inorganic oxidizable substances, biological decomposition of organic matter, rise in temperature and oxygen demanding wastes etc.

COD value is from 28 to 82 mg/L. It is a measure of the oxygen required for the chemical oxidation of organic matter. The COD values at all sampling stations are exceeded the permissible limit (10 mg/L) according to WHO. High COD may be due the disposal of agricultural, cattle wastes and sewage near the source of water. Phosphate in the groundwater samples lies between 0.08 to 2.5 mg/L. About 90% samples are in the permissible limit. Normally groundwater contains only a minimum phosphorus level because of the low solubility of native phosphate minerals and the ability of soils to retain phosphate (Rajmohan et al, 2005). High conc. may cause vomiting and diarrhoea, stimulate secondary hyperthyroidism and bone loss. High concentration may be due to the usage of

fertilizer close to the water source.

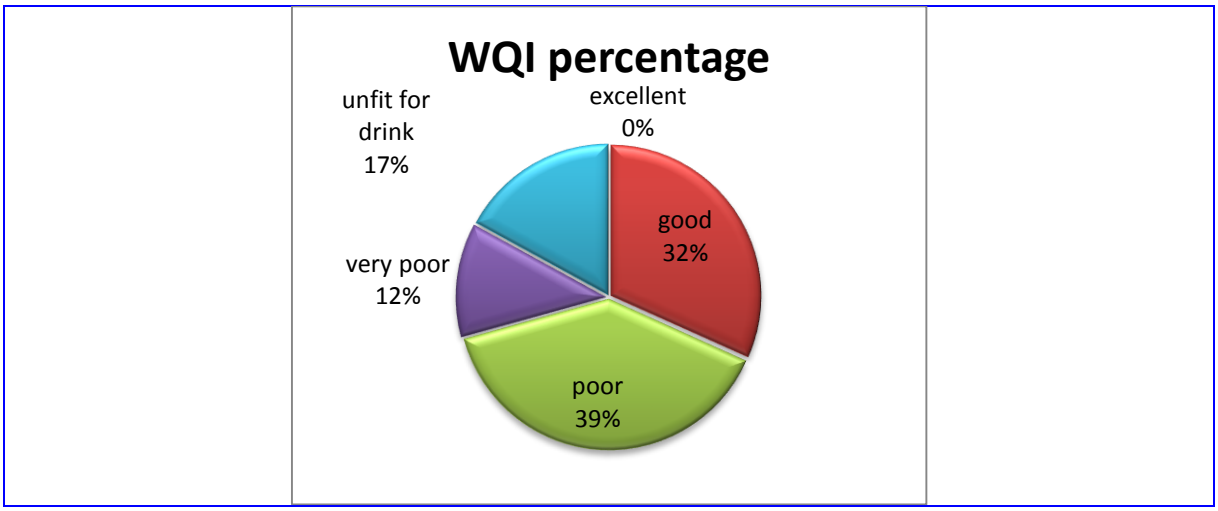


Fig. 2: Graphical data of WQI percentage

Table 4. Correlation Matrix for Different Quality Parameters

	PH	TA	TH	DO	Fe	SO_4	Ca	Mg	PO_4	EC	TDS	NO_3	Cl	COD
PH	1.000													
TA	0.075	1.000												
TH	-0.156	0.004	1.000											
DO	-0.181	-0.282	-0.132	1.000										
Fe	-0.107	-0.194	-0.168	-0.260	1.000									
SO4	0.112	-0.040	0.053	-0.162	-0.087	1.000								
Ca	-0.020	-0.410	0.586	0.073	-0.086	0.332	1.000							
Mg	-0.172	0.128	0.970	-0.173	-0.167	-0.039	0.371	1.000						
PO4	0.068	0.165	-0.126	0.083	-0.097	-0.177	-0.235	-0.074	1.000					
EC	-0.013	0.321	0.748	-0.148	-0.196	0.127	0.530	0.698	-0.025	1.000				
TDS	-0.013	0.321	0.748	-0.148	-0.196	0.127	0.530	0.698	-0.025	1.000	1.000			
NO3	0.062	0.113	0.243	-0.165	-0.043	0.184	0.332	0.179	-0.312	0.468	0.468	1.000		
Cl	0.006	0.141	0.799	-0.067	-0.121	0.181	0.631	0.726	-0.058	0.956	0.956	0.413	1.000	
COD	-0.127	0.087	0.207	-0.085	-0.125	0.226	0.351	0.132	-0.040	0.345	0.345	0.163	0.356	1.000

Table 3. WQI value of the sampling stations

S. No	STATION	WQI
1	AGARAM	94.59
2	ANUKKUR	47.12
3	ERAIYUR	76.17
4	ERAKARAI	27.18
5	ESANAI	121.67
6	K PURAM	53.27
7	KADAMBUR	43.17
8	KAI KALATHUR	130.25
9	KALARAMPATTI	38.60
10	KONERIPALAYAM	44.71
11	KOTTARAKUNRU	42.07
12	MALAYALAPATTI	67.51
13	MANGALAMEDU	127.32
14	MARAVANATHAM	41.68
15	MILLATH NAGAR	61.12
16	NEIKUPPAI	110.90
17	NOOTHAPUR	62.87
18	PALAYUR	42.24
19	PANDAGAPADI	85.41
20	PASUMBALUR	67.74
21	PIMBALUR	75.91
22	PUTHUR	135.03
23	RAYAPPA NAGAR	54.62
24	THALUTHALAI	70.58
25	THAMBAI	43.40
26	THEVAIUR	63.60
27	THIRUVALANDURAI	64.32
28	THONDAPADI	33.39
29	THONMANDURAI	74.22
30	UDUMBIAM	62.39
31	V MATHAVI	54.52
32	V MATHAVI 2	32.55
33	V.KALATHUR	41.35
34	VADAGARAI	59.39
35	VALIKANDAPURAM	56.83
36	VALLAPURAM	26.19
37	VALLIYUR	72.37
38	VANNARAMPOONDI	83.16
39	VENBAVUR	148.59
40	VENGALAM	118.16
41	VEPANTHATTAI	54.10

5. COCLUSION

The analysis of physico chemical characters of groundwater it is concluded that the parameters like total alkalinity, total hardness, magnesium and chemical oxygen demand are above the permissible limit. These parameters minimize the suitability of drinking purpose without treatment. The Water quality index value above 100 indicated the unsuitability of water for drinking and domestic purpose.

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