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WATER QUALITY INDEX AND CORRELATION STUDY FOR THE ASSESSMENT OF WATER QUALITY AND ITS PARAMETERS OF MADATHUKULAM TALUK, TIRUPPUR DISTRICT, TAMILNADU, INDIA

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Abstract:

Groundwater samples of bore wells (BW), Open wells (OW), Hand Pumps (HP), Lakes and Streams collected from different locations in Madathukulam Taluk in Tiruppur District, Tamilnadu were analyzed for their physico-chemical characteristics. The ground water samples were studied during Post-monsoon (October – December 2016) season from 20 different villages. The present study was undertaken to characterize the physicochemical parameters such as temperature, pH, Total Alkalinity (TA), Electrical conductivity (EC), Salinity, Calcium Hardness (CH), Magnesium Hardness (MH), Total Hardness (TH), Total Dissolved Solids (TDS), Total Suspended Solids (TSS) and Total Solids (TS). Each parameter was compared with its standard permissible limit as prescribed by world Health Organization (WHO). The Water Quality Index (WQI) reflected that most of the samples are of good and excellent quality. The study reveals that all the villages have hardness within the desirable limit prescribed by WHO. The Karl Pearson Correlation matrix has approved the influence of EC on TH, TDS and Chloride with significantly positive correlation.

Key Words: Ground Water, Karl Pearson Correlation, Madathukulam, Physico-Chemical Analysis & Water Quality Index.

Introduction:

Water quality monitoring has one of the highest priorities in environmental protection policy [1]. Due to pressure of human activity, urbanization and industrialization, the groundwater sources are degraded gradually, therefore pure, safe, healthy and odourless drinking water is a matter of deep concern. There are many pollutants in groundwater due to seepages viz. organic and inorganic pollutants, heavy metals, pesticides, fluorides etc. The quality of water is identified in terms of its physical, chemical and biological parameters [2-5].

The quality of water is identified in terms of its physical, chemical and biological parameters [6]. The physico-chemical contaminants that adversely affected the quality of groundwater is likely to arise from the variety of sources, including land application of agricultural chemicals and organic wastes, infiltration of irrigation water, septic tanks, and infiltration of effluent from sewage treatment plants, pits, and ponds used for storage. The rapid growth of urban areas has further affected the groundwater quality due to over exploitation of resources and improper waste disposal practices. According to WHO organization [7] about 80% of all the diseases in human beings are caused by contaminated water. Once the groundwater is polluted, its quality cannot be restored by renovated by preventing the pollutants from the source. It is therefore vital to regularly monitor the quality of groundwater. Ground water pollution by heavy metals has been given much attention due to their low biodegradability and toxic effects [8, 9]. The water from the sources viz., streams, falls, lakes, hand pumps, open wells and bore wells are contaminated with domestic, agricultural and industrial wastes and likely to cause water related diseases [10]. Also, Bullard [11] inferred that polluted surface water always results in a detrimental social-economic environment. In this study, physico-chemical parameters are determined to draw a conclusion on the quality of water whether it is good or unfit for drinking purposes.

Statistical analysis of physico-chemical parameters of water has been reported from the different parts of World and India [10]. C.R. Ramakrishnaiah et al. [12] have assessed the Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka state, India. Linear correlation analysis of drinking water quality for Al-Mukalla city, Hadhramout, Yemen was carried out by Sami G. Daraigan et al. [13] which showed that all the physico-chemical parameters of drinking water in Al-Mukalla city are more or less correlated with each other. The water quality characteristics of River Ganga at Kolkata Region, India have been studied by Papita Das Saha et al., using water quality index and ANN simulation method [14]. The suitability of groundwater for drinking and irrigation purposes have been studied by Umaran et al. [15] in East Coastal Region of Tamilnadu by Water Quality Index, Chemical indices permeability index and Kelley's ratio and found to be majority of the groundwater in this area are unfit for domestic and irrigation purposes. The groundwater quality of Aligarh city in Uttar Pradesh was studied in relation with physico-chemical parameters by Ummatul Fatima et al. [16] and

found to need some treatment before consumption. Based on these, an attempt is made to study the physico-chemical parameters of water samples taken from Madathukulam Taluk in Tiruppur, Tamilnadu, India.

The main objectives of the study are

- ✓ Collection of groundwater samples from open wells, bore wells, hand pumps, streams and lakes in Madathukulam Taluk, Tirupur District, Tamilnadu.
- ✓ Analysis of a few quality parameters, *viz.*, Hardness, Total dissolved solids, Total alkalinity, Electrical conductivity, pH etc., as recommended by World Health Organization.
- ✓ To establish the nature of the relationship between the water quality parameters using correlation analysis.
- ✓ Assessment of water quality using water quality index (WQI).

Salient Features of the Study Area:

Tiruppur District in Tamil Nadu, India lies on the western part of Tamil Nadu bordering the Western Ghats and hence the district enjoys a moderate climate. Tiruppur District is geographically situated between the North latitudes 11° 10′ 48″ and East longitudes 77° 15′. The district is surrounded by Coimbatore district in the west, Erode district to the North and northeast and Karur district in the east and Dindigul district in the south east. To the south the district is surrounded by Kerala state (idukki district). The district has an area of 516.12 square kilometers. The southern and south western parts of the district enjoy maximum rainfall, due to the surrounding of Western Ghats. The rest of the district lies in the rain shadow region of the Western Ghats and experiences salubrious climate most parts of the year, except the extreme east part of the district. The mean maximum and minimum temperatures for Tiruppur during summer and winter vary between 35°C to 18°C. The average annual rainfall in the plains is around 700 mm with the North East and the South West monsoons contributing to 47% and 28% respectively to the total rainfall. The major rivers flowing through the district are Noyyal and Amaravathi. The Amaravati river is the main source of irrigation in the district. Amaravathi Dam, which created Amaravathi Reservoir, is located at Amaravathinagar. Tiruppur district consists of 6 taluks, viz, Avinashi, Madathukulam, Palladam, Udumalpet, Kangeyam and Dharapuram. The area chosen for our research study is Madathukulam taluk in Tiruppur district.

Madathukulam is geographically situated between the North latitudes 10° 34′ 0.12″ and East longitudes 77° 21′ 0″. Madathukulam is part of a Tiruppur district and the surrounding area is mainly based on agriculture. The area has six paper mills nearby, and one dying mill, one tannery and one dairy industry. Madathukulam is located between Udumalpet and Palani. Madathukulam is 12 km from Udumalpet, on the way to Palani. The Amaravathi River runs through the town.

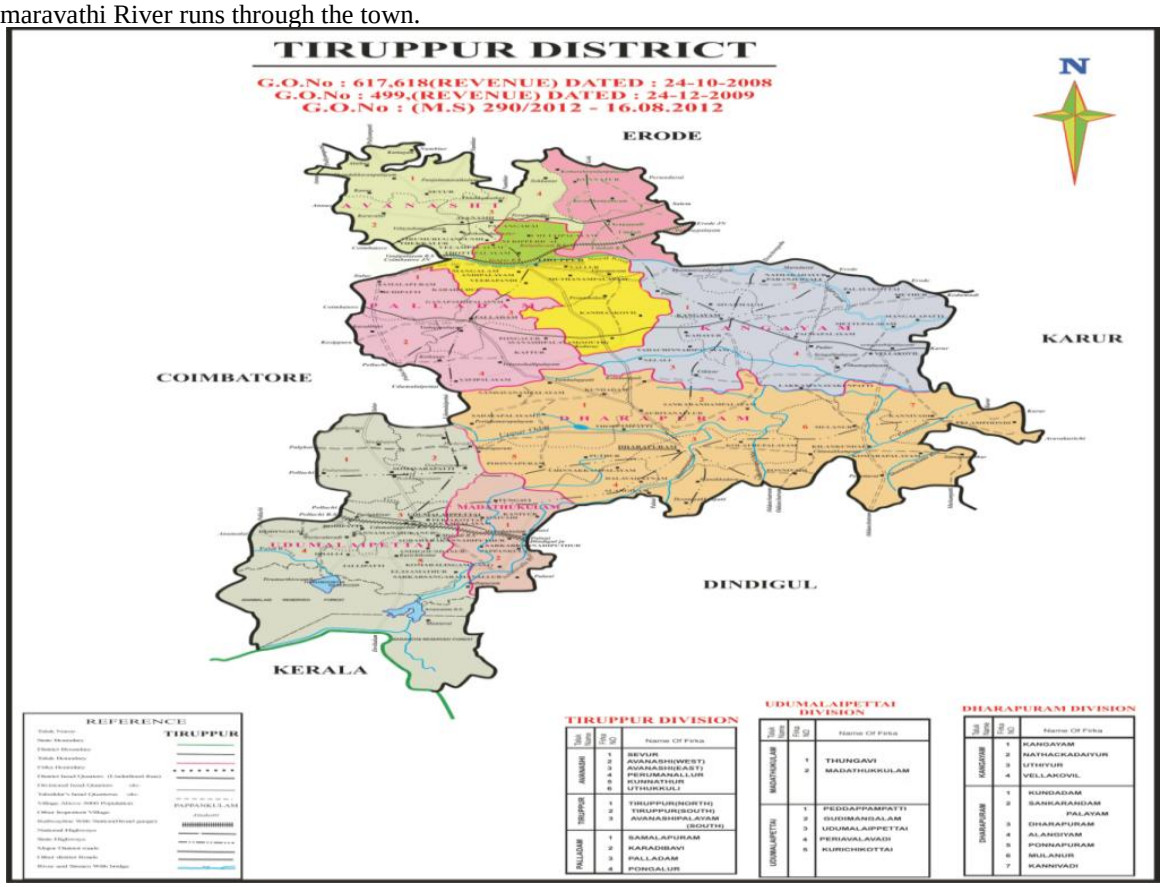

Figure 1: Location of Tiruppur District in Tamilnadu

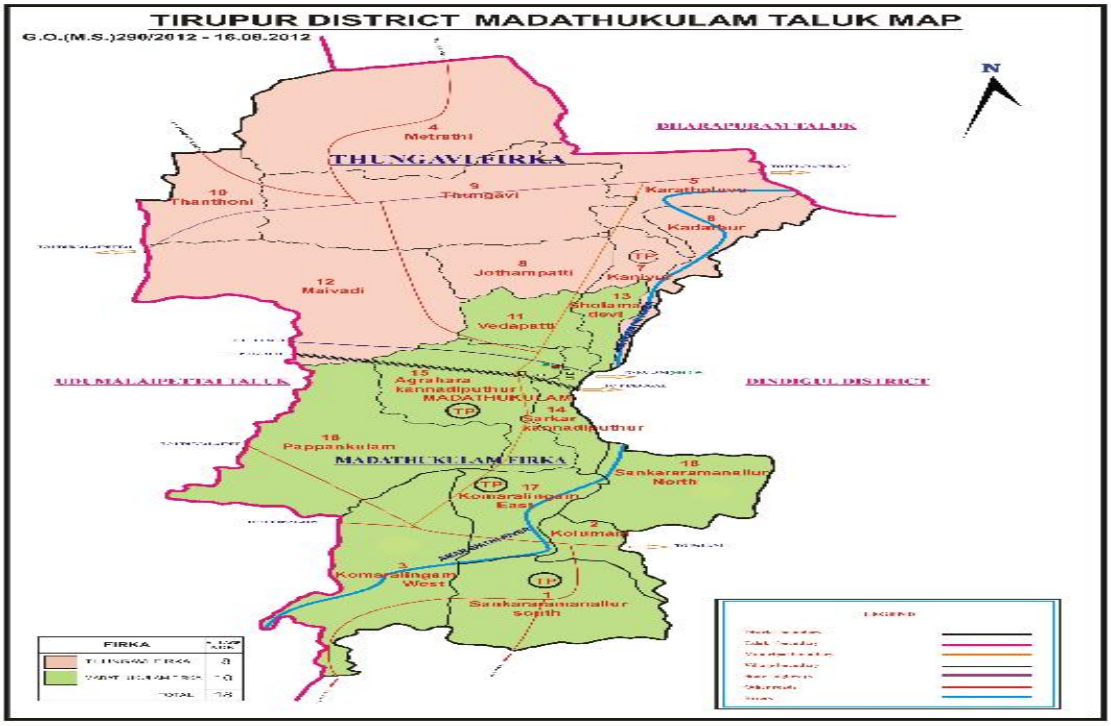

Figure 2: Location of Madathukulam Taluk in Tirupur District

Experimental Section:

The water samples were collected from bore wells (BW), open wells (OW), Hand Pumps (HP), streams and lakes of Madathukulam Taluk in Tiruppur District, Tamilnadu during Post-monsoon (October – December 2016) periods. Out of 20 water samples, 6 were from bore wells, 5 were from hand pumps, 5 were from open wells, 2 were from streams and 2 were from lakes. The samples were collected in sterilized bottles and were analyzed just after the sampling. The analysis was carried out [17] for various physico-chemical parameters such as Temperature, pH, Electrical conductivity (EC), Total alkalinity (TA), Calcium hardness (CH), Magnesium hardness (MH), Total hardness (TH), Total dissolved solids (TDS), Total solids (TS) and Chloride content.

Methodology:

The temperature of water samples was recorded on the spot using digital thermometer (Digital thermometer – DTM 902). pH meter (Digital, Elico model 135) was used to determine the hydrogen ion concentration. The samples were analyzed for EC using digital conductivity meter (Elico model 605). Total dissolved solids (TDS) and Total solids (TS) were observed with the help of digital water kit [18]. Total hardness (TH) and Calcium hardness (CH) as $CaCO_3$ were determined titrimetrically, using standard EDTA. The magnesium hardness (MH) was calculated by subtracting the CH from TH value. The chloride ion was estimated using $AgNO_3$ by Mohr's method [19].

Statistical Analysis:

Statistical analysis was carried out using statistical packages for social sciences (SPSS – Version 22). Statistical parameters viz., mean, SD, SE and correlation coefficient for physico-chemical parameters. The mean and standard deviations are calculated to know the chemical parameters which are deviating from WHO standard. Correlation analysis measures the closeness of the relationship between chosen variables. If the correlation coefficient is nearer to +1 or -1, it shows the perfect linear relationship between the two variables. This way of analysis attempts to establish the nature of the relationship between the water quality parameters.

Water Quality Index:

Water Quality Index is computed to reduce the enormous amount of water quality data to a single numerical value. WQI reflects the composite influence of different water quality parameters on the overall quality of water. Water quality index was calculated to determine the suitability of the groundwater for drinking purposes. It can be computed using the formula,

$$WQI = \text{Antilog} [SW^{n}_{n=1} \log 10\ q_n] \quad (1)$$

Where, W_n, Weightage = K / S_n and K, constant = 1 / ($S^{n}_{n=1}$ 1 / S_i), S_n and S_i correspond to the WHO / ICMR standard value of the parameters.

Quality rating (q) is calculated as $Q_{ni} = [(V_{actual} - V_{ideal}) / (V_{standard} - V_{ideal})] \times 100$, where Q_{ni} = Quality rating of i^{th} parameter for a total of n water samples, V_{actual}= Value of the water quality parameter obtained from the laboratory analysis, $V_{standard}$= Value of the water quality parameter obtained from the standard tables. $V_{ideal}$for pH = 7 and for the other parameters it is equivalent to zero. The quality of the water can be determined based on WQI.

Results and Discussion:

The chemical compositions of 20 water samples of Madathukulam Taluk, Tiruppur District in the Post – monsoon season is presented in Table 1.

Table 1: Physico-chemical parameters of water samples of Madathukulam Taluk in the post Monsoon season

Place	Source	T. (˚C)	pH	EC (mS)	TA (mg/L)	CH (mg/L)	MH (mg/L)	TH (mg/L)	TDS (mg/L)	TS (mg/L)	Cl (mg/L)
Sundakkampalayam	BW	30.1	7.23	0.80	424.4	327.6	17.2	344.8	382.4	424.6	255.2
Sundakkampalayam	OW	27.8	7.41	0.60	235.8	120.7	17.3	138.0	172.0	198.4	184.3
Kolumam	OW	27.9	7.47	0.50	377.2	103.4	43.1	146.7	170.1	198.9	297.8
Rudhrapalayam	HP	29.1	7.84	0.50	542.2	77.5	138.0	215.5	252.1	299.8	191.4
Salarapatti	BW	30.8	7.60	2.00	372.2	284.4	51.8	336.2	372.1	398.7	684.1
Pappankulam	Lake	28.9	8.38	1.04	598.9	197.3	168.1	365.4	459.0	478.2	492.7
Malaiyandipattinam	BW	28.8	8.36	1.07	400.0	212.8	133.4	346.2	479.0	495.8	684.1
Andiyagoundanur	HP	28.8	7.95	2.88	302.1	402.4	213.0	615.4	1300.0	1385.2	748.2
Kurichikottai	HP	28.8	7.81	2.65	501.4	1287.4	154.9	1442.3	742.0	795.1	209.2
Pallapalayam	Stream	28.9	7.56	0.10	298.9	138.9	34.2	173.1	46.2	102.3	187.9
Bodipatti	HP	28.9	7.99	1.05	599.2	218.7	108.2	326.9	443.0	476.9	350.9
Kottamangalam	HP	28.9	8.20	0.25	300.6	126.5	46.6	173.1	114.1	145.8	148.7
Poolavadi	BW	28.7	8.53	3.37	604.4	291.4	170.1	461.5	1570.6	1602.3	798.7
Metratthi	BW	28.8	7.93	0.07	402.1	84.5	30.9	115.4	34.0	66.4	241.1
Jothampatti	BW	28.8	8.37	0.99	299.9	414.1	162.8	576.9	401.2	428.2	258.8
Kaniyur	OW	28.9	8.68	1.17	604.2	318.2	143.3	461.5	495.0	507.7	357.7
Cholamadevi	Lake	28.9	8.17	0.75	510.1	191.2	155.0	346.2	317.0	342.5	209.1
Kannadiputhur	OW	28.9	8.47	0.42	605.9	237.8	127.6	365.4	183.0	201.9	184.3
Samarayapatti	Stream	28.8	7.97	1.63	800.2	570.6	179.4	750.0	651.0	699.7	492.7
Uralpatti	OW	28.7	7.59	3.06	498.7	979.5	193.6	1173.1	1350.2	1369.7	699.7

The temperature mean value of Madathukulam Taluk water samples was 28.9˚C. It is obvious that the samples collected from bore wells were found to have higher temperature than hand pumps, open wells, lakes and streams. The increase in temperature decreases the potability of water due to the unpleasant taste produced by CO_2 and other gases. Thus, the taste of samples differs from place to place [20]. The pH mean value of the water samples was 7.98 and this approves that the nature of ground water samples vary from neutral to slightly alkaline. All the samples were registered within the pH values between 7.23 and 8.68as per WHO. Of all the registered samples, Sundakkampalayam bore well water has low pH of 7.23 whereas Kaniyur open well water has high pH of 8.68.

EC value is an index to represent the total concentration of soluble salts in water. From the table 1, Pallapalayam stream water has very low electrical conductivity of 0.1 mS indicates the presence of low concentration of soluble salts while Poolavadi bore well water has high electrical conductivity of 3.37 mS indicates the presence of high concentration of soluble salts. The mean total alkalinity (TA) of the water samples of Madathukulam area was 463.9 mg/L. The TA values ranged from 235.8 mg/L to 800.2 mg/L and the higher TA value than the values recommended by WHO (TA=200mg/L). The impact of rainfall at the sampling stations has influenced marginal changes with respect to carbonate and bicarbonate ions.

The Ca^{2+} ion was observed with the mean value of 329.2 mg/L and the Mg^{2+} ion mean value of the water samples was 114.4 mg/L. The presence of CH and MH in almost all water samples is more than the recommended limit of WHO (CH = 75mg/L; MH = 30mg/L) except few sampling stations. The total hardness of the water samples varied between 115.4 mg/L and 1442.3 mg/L with a mean value of 443.7 mg/L.

Most of the ground water samples of Madathukulam Taluk were found to be hard (100-300 mg/L) as suggested by Sawyer and Mc Carty in 1967 [21]. The soft nature of water in the study area Metratthi revealed the good quality of soil and the water table gets raised. The TDS values of water samples were found within the desirable limit of WHO (TDS = 500mg/L) except few sampling stations. The total ground water samples of study area were registered with 100% belonging to fresh water type (TDS<1000 mg/L) as per TDS classification given by Fetter [22] except Andiyagoundanur, Poolavadi and Uralpatti.

The chloride ion content of the water samples varied from 148.7 mg/L to 798.7 mg/L indicated that the chloride content was exceeded the permissible limit of 250 mg/L. Chloride content increases the electrical conductivity of water and thus increases its corrosivity. In metal pipes, chloride reacts with metal ions to form soluble salts [23] thus increasing levels of metals in drinking water. Chloride concentrations in excess of about 250 mg/L can give rise to detectable taste in water. No health bases guideline value is proposed for chloride in drinking water.

The statistical reports of the physicochemical parameters are given in table 2.

Table 2: Statistical summary of physicochemical parameters

Parameters	Max.	Min.	Mean	Sum	SD	σ^2
pH	8.68	7.23	27.8	159.51	0.4133	0.1708
EC	3.37	0.10	1.245	24.90	1.0180	1.0363
TA	800.2	235.8	463.9	9278.4	145.91	21289.7
CH	1287.4	77.5	329.2	6584.9	306.16	93733.9
MH	213.0	17.2	114.4	2288.5	64.76	4193.9
TH	1442.3	115.4	443.7	8873.6	342.22	117114.5
TDS	1570.6	34.0	496.7	9934.0	436.46	190497.3
TS	1602.3	66.4	530.9	10618.1	440.82	194322.3
Cl	798.7	148.7	383.8	7676.6	222.63	49564.1
Temp.	30.8	27.8	28.91	578.2	0.6257	0.3915

The Karl Pearson correlation matrix calculated for the water qualitative parameters is shown in Table. 3. The parameters, highly interrelated with each other, are EC – TH: 0.7102; EC – Cl^- : 0.6745; CH – TDS: 0.7116; TH – TDS: 0.9828. The values account for greater percentage of TDS and the influence of EC on TH, TDS and chloride content were also observed with significantly positive correlation. The parameters Cl – EC; Cl – TH; Cl – TDS were positively correlated and the values indicate the association of calcium with bicarbonate, carbonate and chloride.

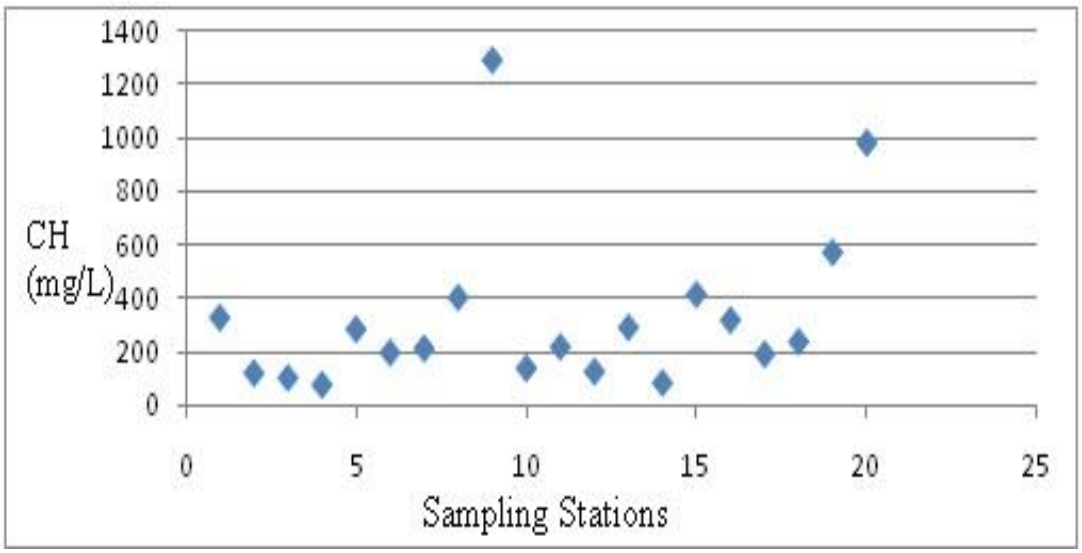

Figure 1: Scatter diagram showing correlation for CH with sampling stations

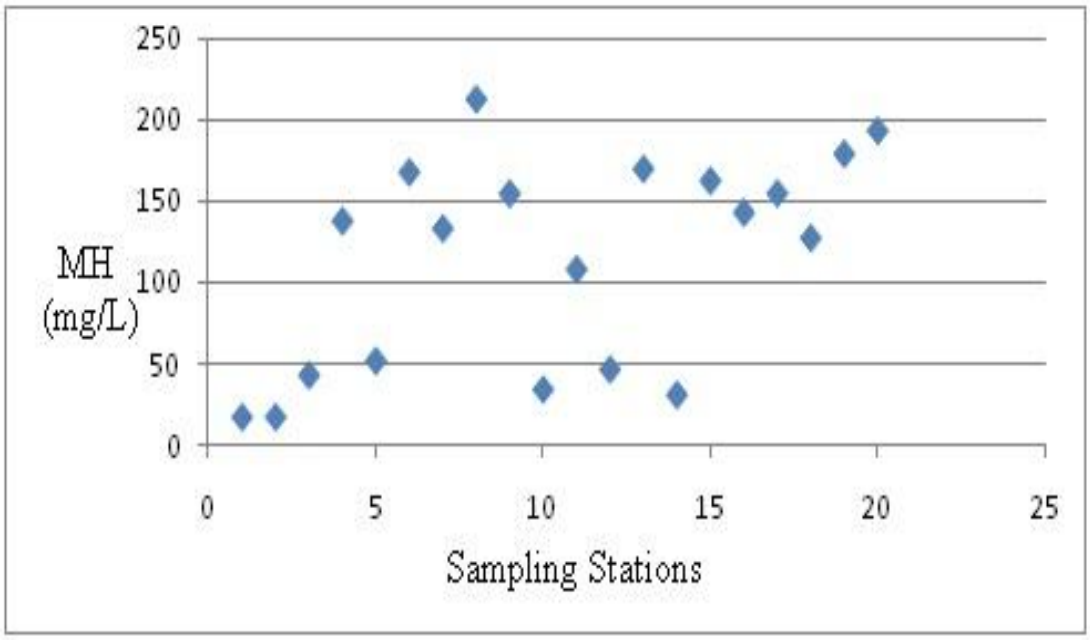

Figure 2: Scatter diagram showing correlation for MH with sampling stations

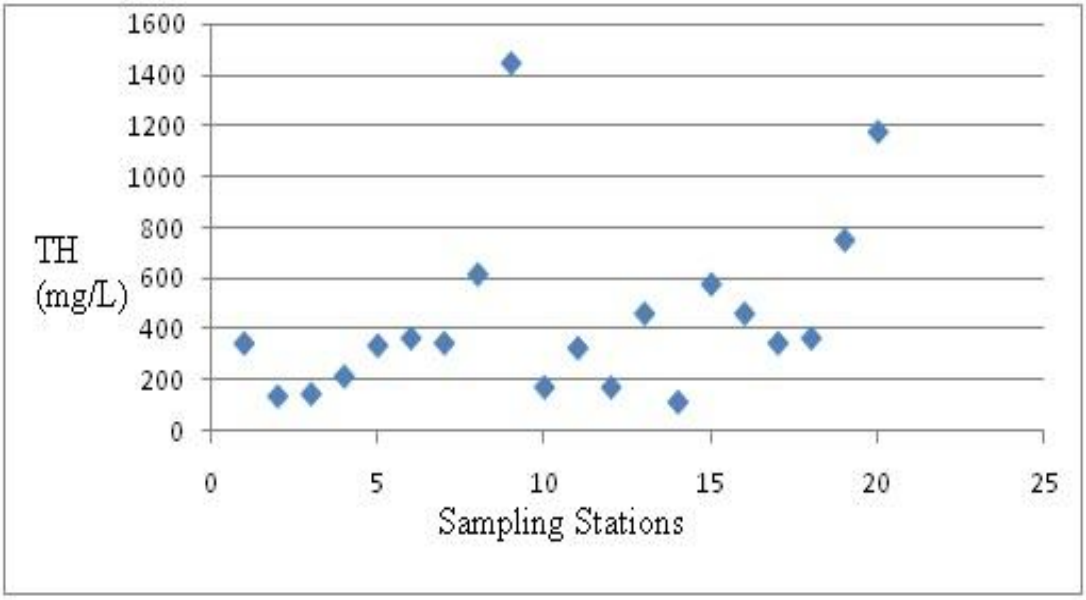

Figure 3: Scatter diagram showing correlation for TH with sampling stations

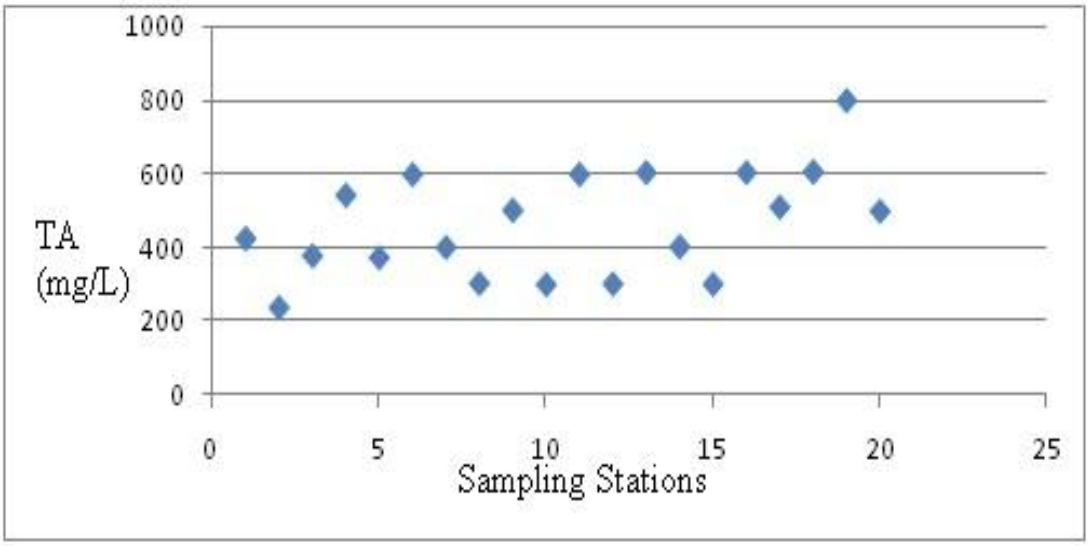

Figure 4: Scatter diagram showing correlation for TA with sampling stations

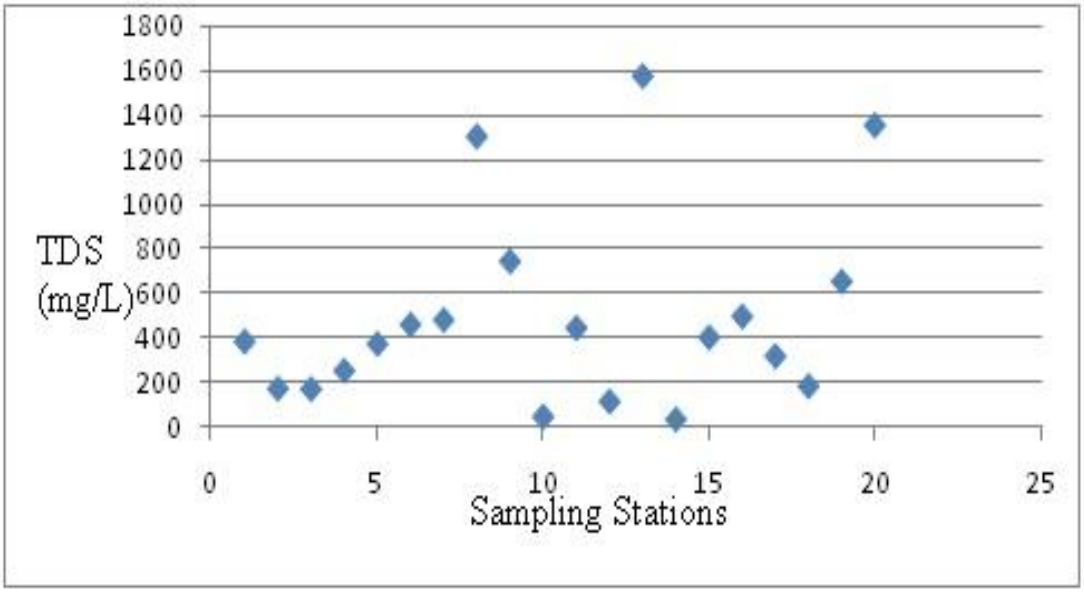

Figure 5: Scatter diagram showing correlation for TDS with sampling stations

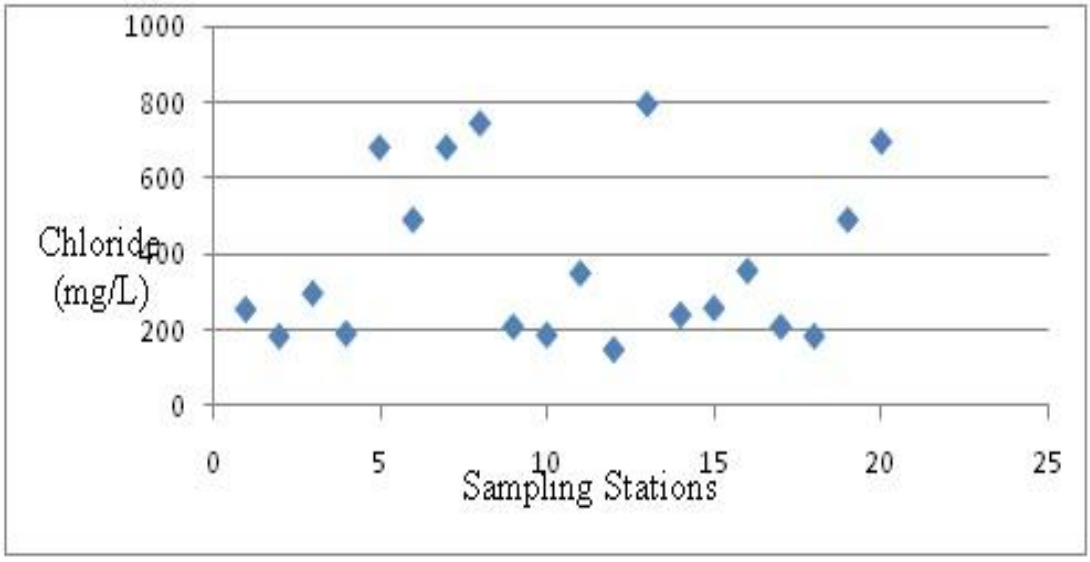

Figure 6: Scatter diagram showing correlation for Chloride with sampling stations

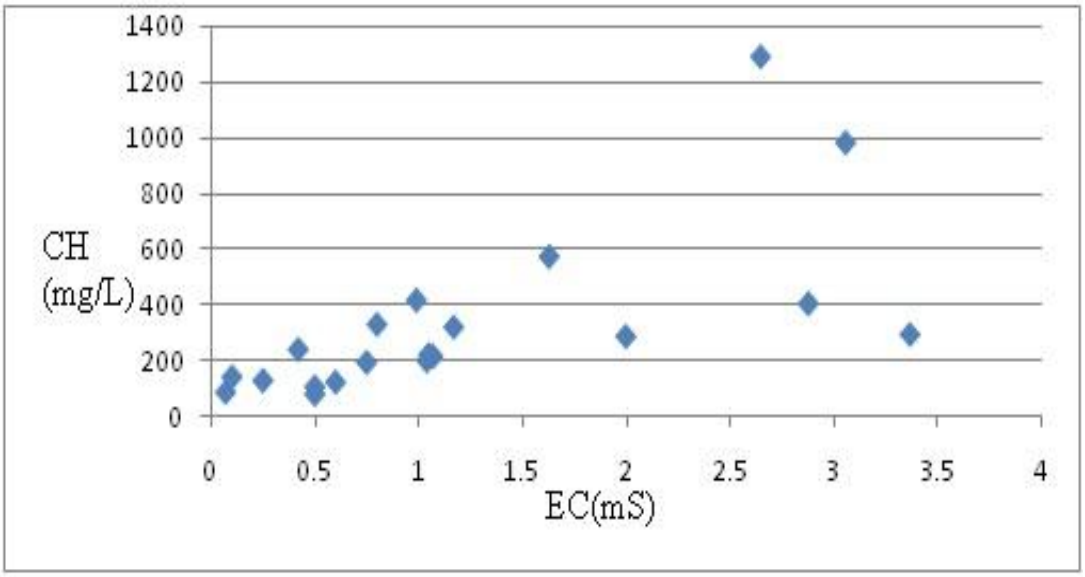

Figure 7: Scatter diagram showing correlation for CH and EC

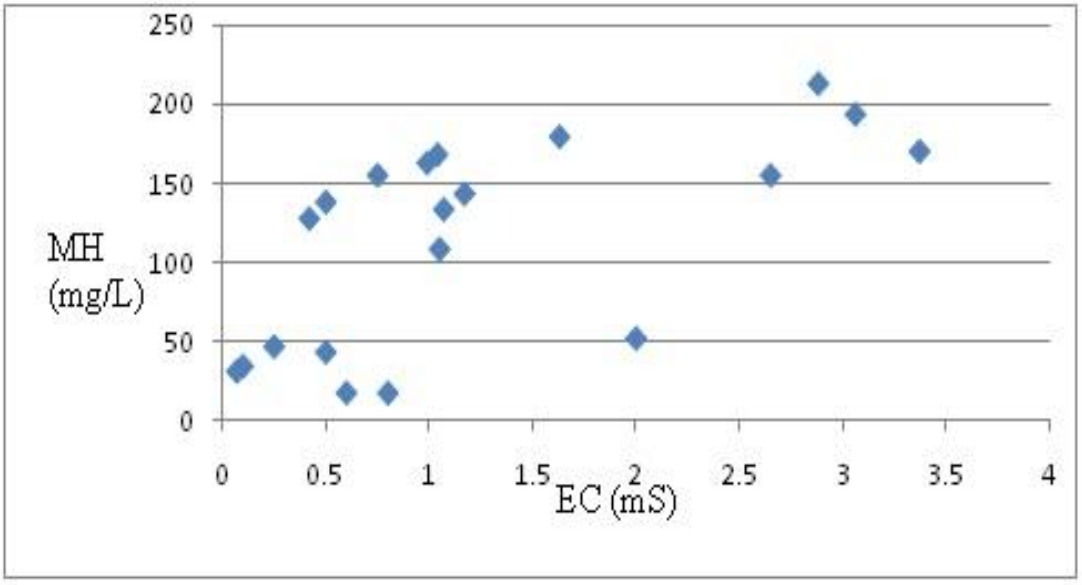

Figure 8: Scatter diagram showing correlation for MH and EC

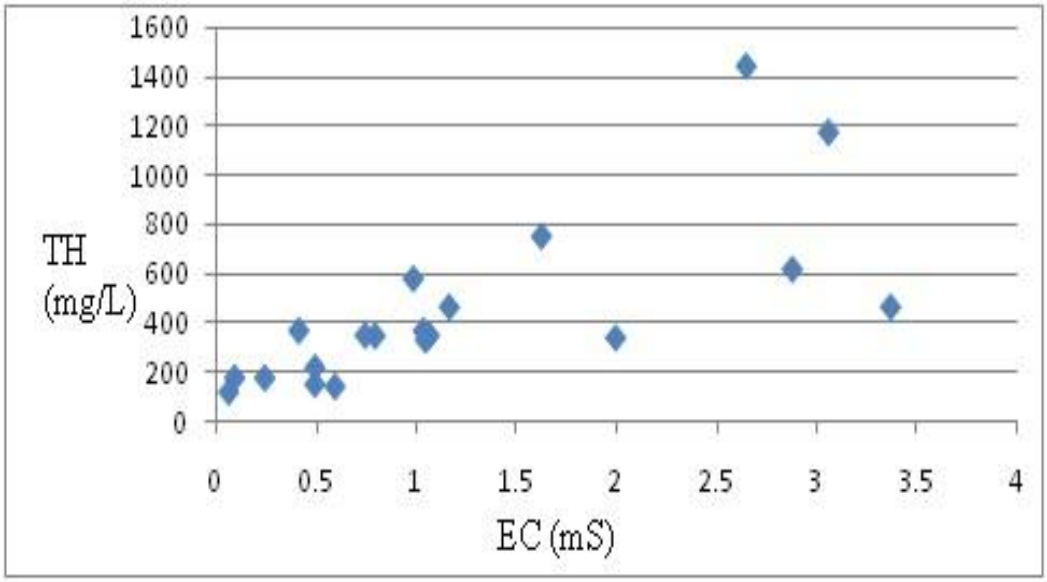

Figure 9: Scatter diagram showing correlation for TH and EC

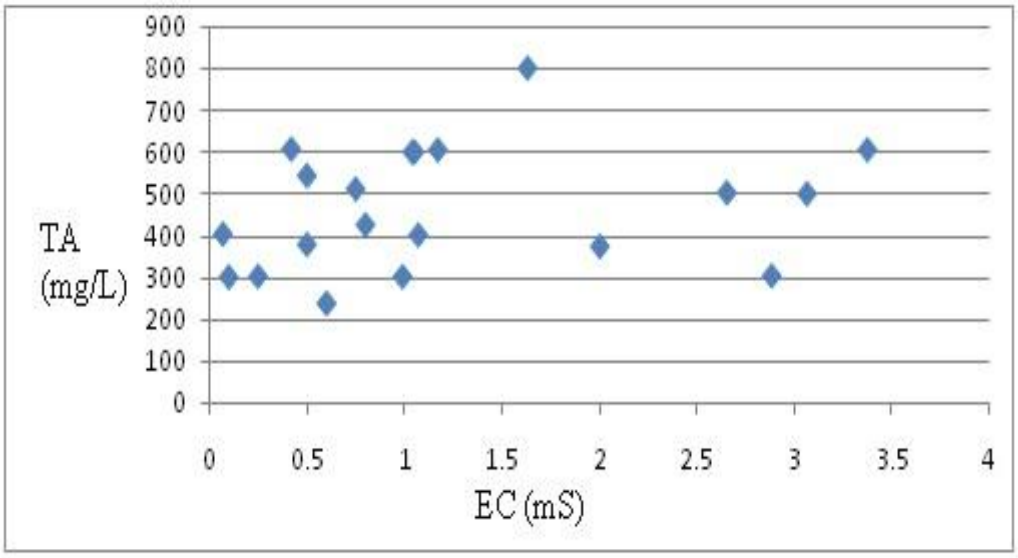

Figure 10: Scatter diagram showing correlation for TA and EC

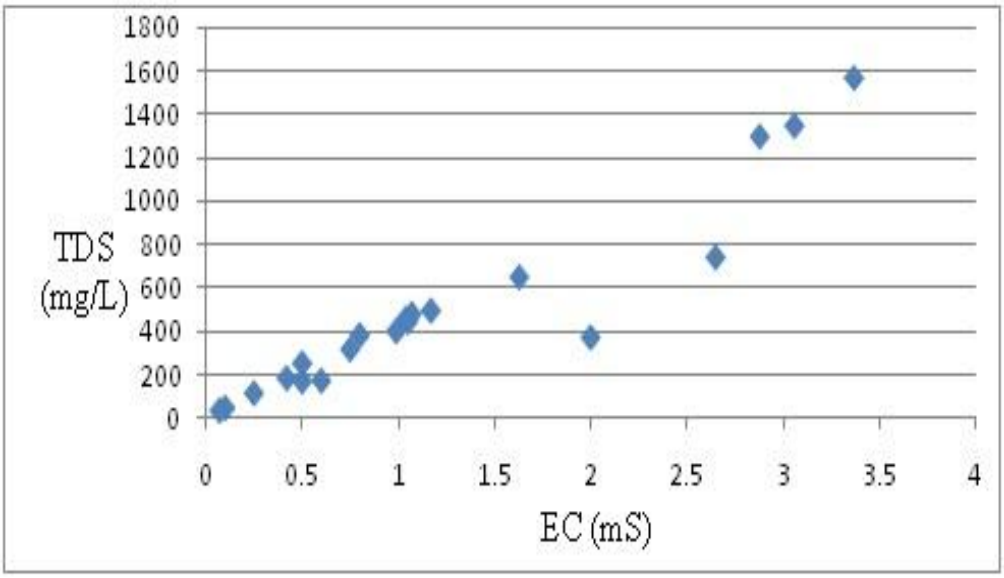

Figure 11: Scatter diagram showing correlation for TDS and EC

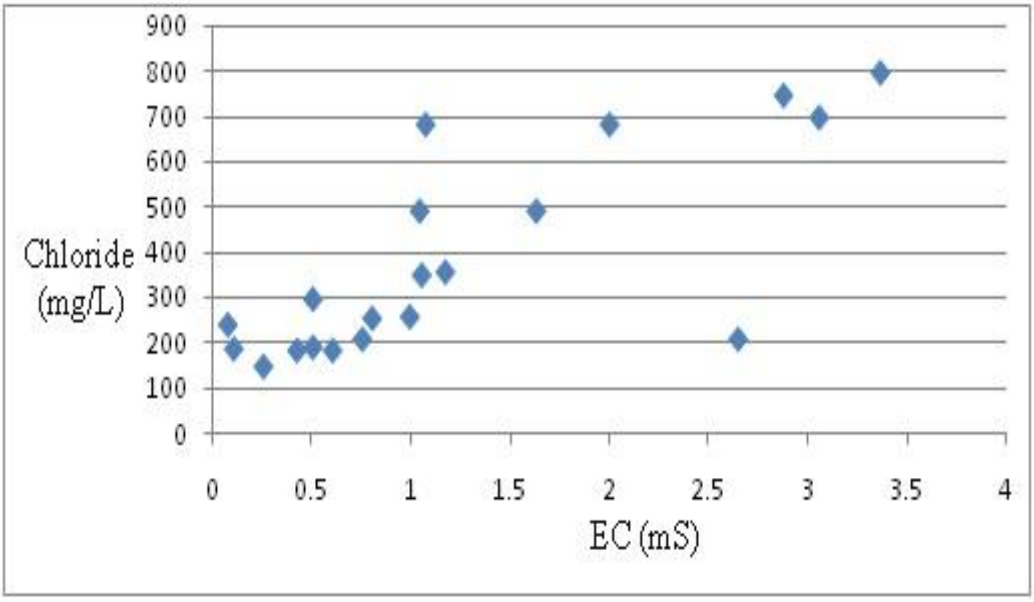

Figure 12: Scatter diagram showing correlation for Chloride and EC

Table 3: Karl Pearson correlation matrix for water samples of Madathukulam Taluk

Parameters	Temp.	pH	EC	TA	CH	MH	TH	TDS	TS	Cl
Temp.	1									
pH	-0.3592	1								
EC	0.0566	-0.2783	1							
TA	0.4461	-0.0212	-0.1808	1						
CH	0.2953	-0.1966	0.3810	0.3306	1					
MH	-0.0340	-0.0206	0.3758	-0.0093	-0.4629	1				
TH	0.2904	-0.2279	0.7102	0.3484	0.7060	0.3009	1			
TDS	0.3052	-0.1956	0.6673	0.3504	0.7116	0.2720	0.9828	1		
TS	0.3120	-0.2226	0.6020	0.3992	0.6901	0.2661	0.9551	0.9796	1	
Cl	0.4148	-0.2597	0.6745	0.0149	0.4215	0.0774	0.5153	0.5316	0.4731	1

Table 4: Comparison of ground water quality at the study areas with drinking water standards (ICMR)

Parameter	Minimum	Maximum	Mean	ICMR (Desirable Limits)
pH	7.23	8.68	7.98	7.0 – 8.5
EC	0.10	3.37	1.245	-
TA	235.8	800.2	463.9	600
CH	77.5	1287.4	329.2	75
MH	17.2	213.0	114.4	60
TH	115.4	1442.3	443.7	300
TDS	34	1570.6	496.7	500
TS	66.4	1602.3	530.9	-
Cl^-	148.7	798.7	383.8	200

Table 5: Classification of the water samples in the study area on the basis of TDS

S.No	Classification of Ground Water	Total Dissolved solid (mg/L)	No. of Samples
1.	Non-saline	<1000	17
2.	Slightly saline	1000-3000	03
3.	Moderately saline	3000-10000	NIL
4.	Very saline	>10000	NIL

Table 6: Classification of the water samples in the study area on the basis of TH

S.No	Description	Hardness (mg/L)	No. of Samples
1.	Soft	0-60	NIL
2.	Moderately hard	61-120	1
3.	Hard	121-180	4
4.	Very hard	>180	15

Conclusion:

The physico-chemical parameters of the ground water have been assessed in order to know the quality of water and the present study was confined to Madathukulam taluk. The pH of all the study areas is slightly alkaline in the range of 7.23 to 8.68. The influence of rain fall on the carbonate and bicarbonate ions of water samples was observed. The water samples were found to be moderately hard (5%), hard (20%) and very hard

nature (75%). The study reveals that all the villages have hardness within the desirable limit prescribed by WHO. The TDS values of total water samples of study area have been registered with 85% belonging to fresh water and 15% belonging to slightly alkaline nature. Nearly 75% of the area where the chloride content of water is more than the permissible limit of 200 mg/L (WHO) which reveals that the water becomes unpleasant odour and taste. From the Karl – Pearson correlation matrix, good correlation is observed between the parameters EC andTH, Chloride, TS and TDS and also between CH and TH, TDS and TS. The poor correlation is observed for TA and CH, TH and TDS. The total hardness is recorded in all the study areas is with the desirable limit and it is more than the maximum permissible limit in the areas of Andiyagoundanur, Kurichikottai, Jothampatti, Samarayapatti and Uralpatti. The results indicated that the water using for potable purposes by the rural people of the study area doen't meet the required standards and unfit for potable purpose and hence prior treatment is necessary for potable purposes.

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