



**APPLICATIONS OF PIPER DIAGRAM AND WATER QUALITY INDEX FOR THE
QUALITY ASSESSMENT OF GROUNDWATER IN SENTHANEER PURAM
ANDSEMPATTU AREAS, TIRUCHIRAPPALLI DISTRICT, TAMILNADU, INDIA**

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ABSTRACT

Groundwater samples were collected from different locations around Tiruchirappalli area and analyzed for their physicochemical characteristics. Ten groundwater samples were collected from five Senthaneerpuram and five from Sempattu for the period of December 2017. The present investigation is focused on the determination of physicochemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Total Hardness (TH), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Bicarbonate (HCO_3^-), Calcium (Ca), Magnesium (Mg), Chloride (Cl^-), Nitrate (NO_3^-), Phosphate (PO_4), Sodium (Na), potassium (K) & Sulphate (SO_4^{2-}). Groundwater suitability for domestic and irrigation purposes was examined by using WHO and BIS standards. Thus, the objective of this study is to identify the quality of groundwater especially in the Senthaneerpuram and Sempattu nearby area whether the groundwater is used for drinking and domestic purposes.

KEYWORDS: Groundwater, water quality index, physico-chemical parameters.

I. INTRODUCTION

Everything originated from the water and everything is sustained by water. All the life on earth depends on water. The origin of water on the earth is not clear so far. However, the current presumption is that the primordial earth had no oceans and perhaps very little atmosphere.^[2] It is believed that the volatile constituents bound in the earth's crust oozing to the surface through volcanoes, rock movements and hot springs condensed to form the ocean and the atmosphere. This way perhaps the remarkable combination of hydrogen and oxygen called water came into being and eventually became an indispensable component of the earth's crust. Water is not only essential to life but is the predominant inorganic constituent of living matter forming in general nearly three quarters of the weight of the living cell. The various forms of water are found in every section of ecosphere, the atmosphere, the lithosphere and the hydrosphere.^[4, 5] Water is universal solvent and renewable resource. These unique properties of water make it to get polluted. The knowledge of hydrochemistry is essential to determine the origin of chemical composition of groundwater. 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. Rapid increase in urbanization and industrialization leads in to deterioration in groundwater quality.^[8, 9] Water can be regarded polluted when it changes its quality or composition either naturally or as a result of human activities. The sources for ground water supply mostly depend upon the rainfall and the resulting percolation of the water into the earth. Another important factor is quality of the soil. A total of ten ground water samples were analyzed pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Total Hardness (TH), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Bicarbonate (HCO_3^-), Calcium (Ca), Magnesium (Mg), Chloride (Cl^-), Nitrate (NO_3^-), Phosphate (PO_4), Sodium (Na), potassium (K) and Sulphate (SO_4^{2-}). The quality of ground water was interpreted in terms of Water Quality Index (WQI).

II. MATERIAL AND METHODS

a. study area

Tiruchirappalli district is located along the Caveri River in Tamil Nadu, India. The main town in Tiruchirappalli District is the city of Tiruchirappalli, also known as Trichy. It's one of the delta districts in Tamilnadu.

b. Geography

Tiruchirappalli district lies at the Heart of Tamil Nadu. The district has an area of 4,404 square kilometers. It is bounded in the north by Salem district, in the northwest by Namakkal district, in the northeast by Perambalur district and Ariyalur district, in the east by Thanjavur District, in the southeast by Pudukkottai district, in the south by Madurai district and Sivagangai district, in the southwest by Dindigul district and, in the west by Karur district. Kaveririverflows through the length of the district and is the principal source of irrigation and water supply.

III. SAMPLE COLLECTION

The physico-chemical analysis for the ground water samples were performed during December-2017. The physico-chemical parameters such as pH, EC, TDS, DO, TH, BOD, COD, HCO₃, Ca, Mg, Cl, NO₃, PO₄, Na, K, SO₄ were analyzed. The areas in and around Tiruchirappalli were taken for our study ten water samples were collected at various stations shown below. Water samples were collected in Polythene bottles of 2.5litres. The samples were collected from bore wells as well as from deep hand pumps at December-2017. It was ensured that the concentrations of various water quality parameters do not changes in time that elapses between drawing of samples and the analysis in the laboratory. For DO, BOD and COD separate 2 litres polythene bottles were used. The bottles were thoroughly cleaned with hydrochloric acid and then washed with tap water

rendered free of acid and then washed with distilled water twice and again rinsed with the water sample to be collected and then filled up the bottle with the sample leaving only a small air gap at the top, stoppered and sealed the bottle with paraffin wax. Some samples which were first cleaned with tap water thoroughly and finally with deionized distilled water. The pipettes and burette were rinsed with solution before final use. The chemicals and reagent were used for analysis were of analar grade. The pH meter, conductivity meter, spectrophotometer, flame photometer instruments were used to analyze these parameters. The groundwater samples were determined using standard methods and the results were compared with the values of World Health Organization 2007.^[6, 7]

Table I: Sampling Locations and Sources.

Sample no.	Sampling locations	Source
1	Senthaneerpuram	Bore well
2	Ariyamangalam	Bore well
3	Ganthi street	Bore well
4	Kalaiivanar street	Bore well
5	Kumaran street	Bore well
6	Sempattu	Bore well
7	Amman kovil street	Bore well
8	Sempattumajid street	Bore well
9	Sempattu (near Tannery)	Bore well
10	Sempattu (Bus stop)	Bore well

IV. RESULTS AND DISCUSSION

Table ii: Physico-Chemical Parameters of Ground Water Collected From Senthneerpuram And Sempattu During December 2017.

parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
pH	7.2	7.5	7.8	7.8	7.2	7.6	7.9	8.1	7.1	7.8
EC	1260	1060	1190	2900	2100	1095	1087	1106	1154	1158
TDS	816	678	761	780	680	608	557	682	650	587
DO	2	4	2	5	3	4	5	4	3	2
TH	116	179	175	225	195	376	343	372	399	368
BOD	27	22	19	30	22	32	26	20	28	24
COD	42	39	37	53	45	56	52	42	46	49
HCO ₃	125	124	102	128	125	256	248	262	234	267
Ca	110	125	123	140	90	250	214	236	276	190
Mg	56	54	52	85	105	126	129	136	123	178
Cl	86	84	87	158	163	189	178	196	158	163
NO ₃	0.10	0.9	0.5	0.7	0.9	0.23	0.21	0.21	0.32	0.35
PO ₄	0.06	0.05	0.02	0.05	0.01	0.06	0.02	0.03	0.05	0.04
Na	23	21	20	11	14	65	67	54	45	75
K	19	16	13	7	5	0.13	0.18	0.16	0.18	0.16
SO ₄	11.5	17.4	9.6	19.2	14.2	11.5	17.4	9.6	19.2	14.2

All the values are expressed in ppm except pH

A. Water Quality Index (WQI)

Water Quality index (WQI) is defined as a technique of rating which provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human

consumption. The average means concentration of the twelve physico-chemical parameters such as pH, EC, TDS, DO, TH, BOD, COD, HCO₃, Ca, Mg, Cl, NO₃, PO₄, Na, K, SO₄ was used for the calculation of WQI.^[1]

The calculation involves the following steps

First, the calculation of weightage of i^{th} parameter. Second, the calculation of the quality rating for each of the water quality parameters. Third, the summation of these sub-indices in the overall index.^[3]

The weight age of i^{th} parameter

$$W_i = k/S_i \quad (1)$$

Where W_i is the unit weight age and S_i the recommended standard for i^{th} parameter, ($i=5$), While k is the constant of proportionality.

Individual quality rating is given by the expression

$$Q_i = 100v_i / S_i \quad (2)$$

Where Q_i is the sub index of i^{th} parameter, v_i is the monitored value of the i^{th} parameter in $\mu\text{g/l}$ and S_i the standard or permissible limit for the i^{th} parameter.

The Water Quality Index (WQI) is then calculated as follows

$$WQI = \frac{\sum_{i=1}^n (Q_i W_i)}{\sum_{i=1}^n W_i} \quad (3)$$

Where Q_i is the sub index of i^{th} parameter. W_i is the unit weight age for i^{th} parameter, n is the number of parameters considered.

Table I ii: Calculation of Wqi Values For Groundwater Samples Collected In December 2017.

Parameters	Mean value in ppm (v_i)	Highest permitted value (WHO) (s_i)	Unit weightage (W_i)	$W_i \times Q_i$
pH	7.6	8.5	0.0111	9.9425
EC	1411	500	0.0042	0.9877
TDS	679.9	500	0.0147	1.9924
DO	3.4	5	0.0182	1.2376
TH	274.2	500	0.0017	0.0934
BOD	25	10	0.0014	0.3500
COD	46.1	15	0.0147	4.5177
HCO ₃	187.1	500	0.0267	0.9991
Mg	104.4	250	0.0239	1.6602
Cl	146.2	250	0.0164	0.9590
NO ₃	0.442	50	1.1312	0.9999
SO ₄	14.38	200	0.1390	0.9994
PO ₄	0.039	0.01	0.0256	9.9840

$$WQI = \frac{\sum_{i=1}^n (Q_i W_i)}{\sum_{i=1}^n W_i} = 32.65$$

Table V: Status Categories of Wqi.

WQI	Quality of Water
0-25	Very Good
26-50	Good
51-75	Poor
Above 75	Very Poor (Unsuitable for Drinking)

In the present study, the Water Quality Index is tabulated in Table: IV. The computed WQI value is 32.65. This value is found to be 26-50 as per WQI (Table: V) which shows the nature of the water quality of the areas seems to be good. It is clearly understood that the groundwater of our study area is recommended for drinking as well as civic purposes as per the WQI standard values.

PIPER DIAGRAM

Water sampling analytical results plotted in the piper diagram. Pipers diagram includes construction of cation and anion triangles from the results obtained. The two data points from the cation and anion triangles are then combined into the quadrilateral field that shows the overall chemical property of the water sample. The geochemical evolution of groundwater can be understood by plotting the concentrations of major cations (Ca, Mg, Na and K) and anions (CO₃, HCO₃, SO₄ and Cl) in in

milliequivalents per liter to evaluate the geochemical evolution/ hydrochemistry of groundwater in the study area in the Piper trilinear diagram. These diagrams reveal the analogies, dissimilarities and different types of waters in the study area, which are identified and listed in the concept of hydrochemicalfacies was developed in order to understand and identify the water composition in different classes. The Aquachem software was used for plotting the piper diagram.^[10]

Water types

A Piper diagram was created for the Tiruchirappalli area using the analytical data obtained from the hydrochemical analysis. In general, we can classify the sample points in the piper diagram based on anion and cation dominance: A - Ca type, B - No Dominant type, C - Na and K type, D - Mg type, E - HCO₃ type, F - Cl type and G - SO₄ type.^[11, 12]

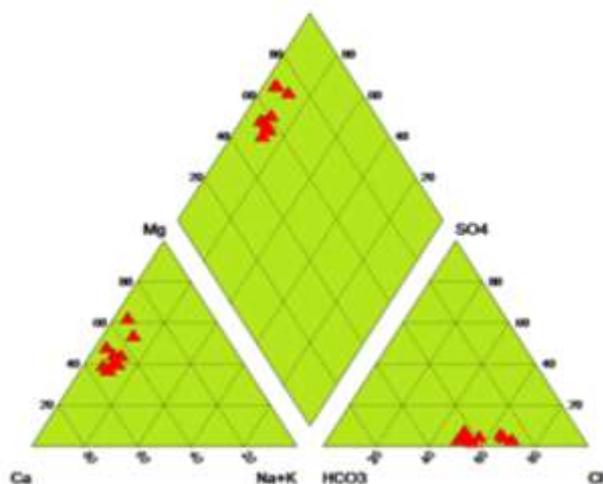


Figure I: Piper Trilinear Diagram – Percentage Of Cation And Anion Dominance In The Study Area During December 2017.

Hydrogeochemical Facies Analysis

The Na-K, Mg, HCO₃ and SO₄ contents of the water samples are confined in the triangles marked by the numbers 5 and 6, respectively in the diamond part of the diagram (Fig. I). The majority of the samples (80%) falls within the triangle 5, representing Mg-HCO₃ type water. Similarly the triangle 6 represents Ca-Cl type of water covering 20% area. Within the Cation triangle (left side diagram), A represents Ca type water with the coverage of 80% area, D represents Mg type of water of 10% area while B represents no dominant ion type water with the coverage of 10% area. Within the Anion triangle (right side diagram) F represents Cl type of water of 30% area while B represents the 70% area belonging to no dominant ion type of water.

V. CONCLUSION

The WQI calculated values ranged good category, which shows that the water quality of the study area is suitable for drinking purpose. In this research paper the applications of WQI and Piper diagram approach to groundwater quality in Tiruchirappalli area had the purpose of providing a simple, valid method for expressing the results of several parameters in order to assess the groundwater quality. In most of the states, the problem of groundwater depletion and quality deterioration has appeared in last few years. Monitoring of groundwater quality should be undertaken regularly to identify the sources of principal contaminants and other inhibitory compounds that affect the potability of water and also to identify the wells which are safe for drinking water and protecting them from further contamination.

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