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Assessment of Groundwater Quality and Development of Water Quality Index in Tiruppur Region

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Abstract: ***The present study is aimed at developing a water quality index (WQI) for the groundwater of Tiruppur region. This has been determined by collecting 90 groundwater samples from different areas of Tiruppur region and subjecting the samples to a comprehensive physicochemical analysis. For calculating the WQI, the following 9 parameters have been considered: pH, electrical conductivity, total dissolved solids, total solids, hardness, chloride, sulphate, alkalinity, fluoride. The WQI for these samples ranges from 52.18 to387.53. The high value of WQI has been found to be mainly from the higher values of electrical conductivity, total dissolved solids, hardness, fluorides, and sulphate in the groundwater. Correlation coefficients were determined to identify the highly correlated and interrelated water quality parameters. Regression equations relating these correlated parameters were formulated. This provides an easy and rapid method of monitoring of water quality.***

I. INTRODUCTION

India is endowed with a rich and vast diversity of natural resources, water being one of them. Water is nature's most wonderful, abundant and useful compound. Of the many essential elements for the existence of human beings, animals and plants, water is rated to be of the greatest importance.

Groundwater is an important source of water supply throughout the world. Due to inadequate supply of surface waters, most of the people in India are depending mainly on groundwater resources for drinking and domestic, industrial, and irrigation uses. The groundwater is believed to be comparatively much clean and free from pollution than surface water.

But prolonged discharge of industrial effluents, domestic sewage and solid waste dump causes the groundwater to become polluted and created health problems.

Mangukiya Rupal and Et Al [7] used arithmetic index method for calculating water quality index and found that 33.3% of the samples exceeded the value 100, the upper limit for drinking purpose.

Chitradevi [3] investigated the groundwater in the proximity of river Noyyal and used Trend line diagram depicting the linear relationship among various parameters and concluded that Linear relationship is observed at almost all stations between TDS and Cl- as well as TDS and Na+ throughout the study area.

Elangovan [5] studied the contamination of ground water by analysing for major cations and anions and found that most of the locations are contaminated by higher concentration of EC,TDS.

Daraigan [4] calculated the correlation coefficients between various physiochemical parameters of drinking water at study area and concluded that systematic caluations of correlation coefficient between paramenter and regression equation useful for rapid monitoring of water quality.

II. STUDY AREA

The present study was carried out in Tiruppur block of Tiruppur District, Tamil Nadu. It lies between Latitude 11˚ 02'N to 11˚ 18'N and Longitude 77˚ 14'E to 77˚ 26'E. Tirupur is in a dry, water-scarce region, and the rapid expansion of the textile industry has taken place in an unplanned manner.

The rainfall in the area is scanty. The Noyyal river runs all across the 27 sq km town, virtually dividing it into two halves. The ground water in Tiruppur is undrinkable because it is very saline and polluted with chemical dyes. Many dyeing units in Tiruppur are within a radius of 5 km from the Noyyal River. Usage of toxic chemicals for dyeing and processing of fabrics is one of the major threats to groundwater.

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III. MATERIALS AND METHODS

Water samples were collected from bore wells of different areas of Tiruppur region as shown in Figure.1. Samples were collected in polythene bottles and analyzed for various water quality parameters as per standard procedures (Table.1).

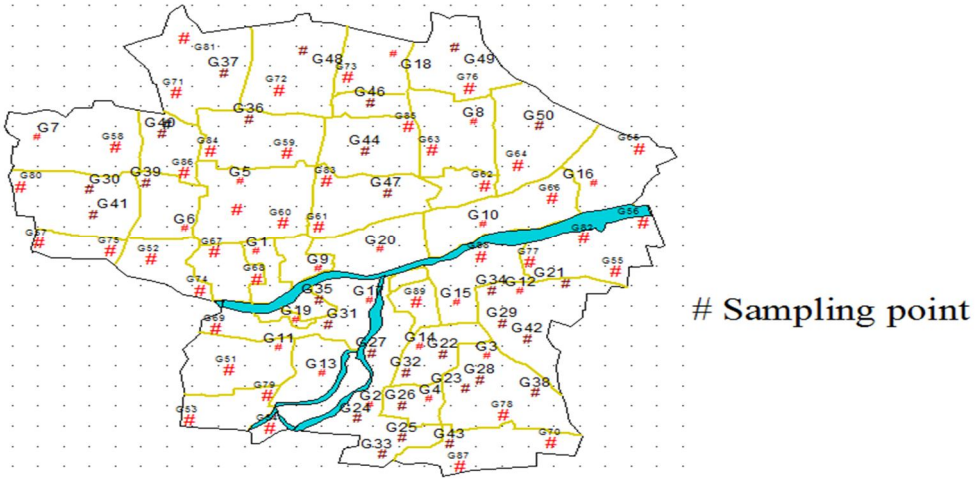

Figure 1. Groundwater sampling locations

The experimental values were compared with standard values recommended by Indian standards for drinking purposes. The calculation of Water Quality Index (WQI) was done by Weighted Arithmetic Index method. The statistical analyses such as mean, standard deviation (SD), correlation and regression of obtained data were carried out using Microsoft offices excel 2007.

Table.1 Parameters studied

Parameters	Method to be adopted
pH	Recorded by pH meter
EC(µmohs/cm)	Recorded by Conductivity meter
TDS(ppm)	Recorded by TDS meter
Total solids (ppm)	Evaporation method
Chloride (ppm)	Argentometric Titrimetric method
Hardness (ppm)	EDTA titration
Sulphate (ppm)	Gravimetric method
Alkalinity (ppm)	Neutralising with standard HCL
Fluoride (ppm)	Colorimetric method

The mean and standard deviations are calculated to know the chemical parameters which are deviating from BIS standard. Correlation analysis measures the closeness of the relationship between the parameter.

A. Water Quality Index

Water quality index is one of the most effective tools to monitor the surface as well as ground water pollution and can be used efficiently in the implementation of water quality upgrading programmes. The objective of an index is to turn multifaceted water quality data into simple information that is comprehensible and useable by the public. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics. Higher value of WQI indicates poor quality of water and lower value shows better water quality. For computing WQI three steps are followed. In the first step, each of the all parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes (table-2).

The maximum weight of 5 has been assigned to the parameter fluoride due to its major importance in water quality assessment. Hardness and alkalinity which is given the minimum weight of 2 as by it may not be harmful. In the second step, the relative weight (Wi) is computed from the following equation:

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$$

Where, Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters. Calculated relative weight (Wi) values of each parameter are also given in Table -2. In the third step, a quality rating scale (qi**)** for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the BIS and the result multiplied by 100.

$$Q_i = \frac{Ci}{Si} * 100$$

Where, Qi is the quality rating Ci is the concentration of each chemical parameter in each water sample in mg/L, Si is the Indian drinking water standard for each chemical parameter in mg/L. For computing the WQI, the SI is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation.

$SI_i = W_i * Q_i$

$WQI = \sum SI_i$

Where, SI_i is the subindex of ith parameter, qi is the rating based on concentration of ith parameter, n is the number of parameters.

Table.2 Relative weight (Wi) of each chemical parameter

Parameter	Indian Standard	Weight (wi)	Relative weight (Wi)
pH	6.5-8.5	4	0.125
EC	1400	4	0.125
TDS	500-1000	4	0.125
Total solids	500-1000	4	0.125
Chloride	250-1000	3	0.0937
Hardness	300-600	2	0.0625
Sulphate	200-400	4	0.125
Alkalinity	200-600	2	0.0625
Fluoride	1-1.5	5	0.15625
		∑wi=32	∑Wi = 1

The computed WQI values are classified into five types, “excellent water” to “water, unsuitable for drinking”.

IV. RESULTS AND DISCUSSION

The pH variation was observed to be in the range 6.91 and 8.6. Maximum pH was noted for the sample collected at KVR nagar,which is 8.6. Minimum pH 0f 6.91was found in ground water sample of Mangalam road.

The electrical conductivity was ranging from 230 to 5860 µmho/cm. Maximum electrical conductivity was noted for the sample collected at Samundipuram,which is 5860µmho/cm. Minimum electrical conductivity of 230µmho/cmwas found in ground water sample of KPN colony.

The total dissolved solids ranging from 174 to 4387 mg/L .Maximum concentration is found in sample collected from Palladam road, which is 4387mg /L. Minimum concentration, is 174 mg/L found in ground water sample of Vijayapuram.

The total solids value ranges from 100 to 6350 Maximum concentration is found in ground water sample collected from KVR Nagar, which is 6350mg /L. Minimum concentration, is 100mg/L found in ground water sample of Amarjothi Garden.

The total hardness was observed to be in the range of 70 to 1400 mg/L. Maximum total hardness concentration was noted for the sample collected at Eswaran Kovil Street, which is 1400mg/L. Minimum concentration, is 70mg/L found in ground water sample of Mangalam road.

Chloride present in ground water samples are in the range from 68 to 2462mg/L. Minimum chlorides concentration was noted for the sample collected at Amarjothi Garden and maximum chloride value was observed for sample collected at KVR Nagar.

The sulphates concentration was ranging from 42 to 995mg/L. Minimum sulphates concentration was noted for the sample collected at Kongu Nagar and maximum chloride value was observed for the sample collected at Gandhi Nagar.
Alkalinity present in ground water samples are in the range from 50 to 210mg/L. Minimum alkalinity concentration was noted for the sample collected at Samundipuram and maximum alkalinity value was observed for the sample collected at Palaniapa Nagar.
The fluoride concentration was ranging from 0.2 to 3.4 mg/L. Minimum fluoride value was noted for the sample collected at Amajothi Garden and maximum fluoride value was observed for the sample collected at KVR Nagar.
The statistics of water quality parameters of groundwater samples are shown in Table.3

Table.3 Normal statistics of water quality parameters of groundwater samples

Parameter	Range	Mean	S.D	CV
pH	6.91-8.6	7.46	0.31	4.1
EC	230-5860	2128.6	1096	51.5
TDS	174 -4387	1166.0	669.5	57.4
Total solids	100– 635(	1583.1	901.4	56.9
Chloride	68 - 2462	444.13	367.6	82.7
Hardness	70– 1480	585.11	283.8	48.4
Sulphate	42 - 995	391.98	209.4	53.4
Alkalinity	50 - 210	110.33	34.3	31.1
Fluoride	0.2 – 3.4	1.67	0.73	43.7

SD – Standard Deviation, CV – Coefficinet of variation
Note: All the units are expressed as in mg/L except pH and Electrical Conductivity (EC) is expressed in µmhos/cm.

In this study, the computed WQI values ranges from 52.18 to387.53 and therefore, can be categorized into five types “excellent water” to“ water unsuitable for drinking”. Table. 4, shows the percentage of water sample. The high value of WQI at these stations has been found to be mainly from the higher values of electrical conductivity, sulphate, total dissolved solids, hardness,and fluorides in the groundwater.

Table.4 Water quality classification based on WQI value

WQI value	Water quality	Percentage of water samples
<50	Excellent	0
50-100	Good water	20
100-200	Poor water	67.78
200-300	Very poor water	11.11
>300	Water unsuitable for drinking	1.11

Correlation is the mutual relationship between two variables. The linear correlation coefficient r has a value between +1 and -1. A A value of -1 represents a perfect when it is in the range of 0.0 to +0.5 and 0.0 to -0.5. The degree of a linear association between any two of the water quality parameters, as measured by the simple correlation coefficient (r), is presented in Table. 5. Out of 45 correlation coefficients, 1 strong correlation between EC and TDS (0.89) was found. Correlation coefficients between EC and Total solids (0.85), EC and chloride (0.58), EC and Hardness (0.78), TDS and Total solids (0.84), TDS and Hardness (0.83), TDS and Chloride (0.59), Hardness and Chloride (0.58) were found to be of moderate correlation. Remaining cases were showing weak correlation.

Table.5 Correlation coefficient matrix of water quality parameters

Parameters	pH	EC	TDS	Total Solids	Hardness	Ch;oride	Sulphate	Alkalinity	Fluoride
pH	1.00								
EC	0.04	1.00							
TDS	0.06	0.89	1.00						
Total solids	0.05	0.85	0.84	1.00					
Hardness	0.04	0.58	0.59	0.62	1.00				
Ch;oride	0.20	0.74	0.83	0.53	0.58	1.00			
Sulphate	0.04	0.19	0.18	0.23	0.06	0.13	1.00		
Alkalinity	0.25	0.31	0.30	0.31	0.02	0.33	0.05	1.00	
Fluoride	0.11	0.17	0.19	0.19	0.16	0.11	0.03	0.31	1.00

The regression models have been obtained from the results of analysis of water samples. Considering a known value of TDS, the percentage contribution of each ion can be obtained by substituting an average ionic value for the entire study area. Table.6 shows the regression equations obtained from the analysis.

Table – 6 Regression equations for various parameters

Parameters	Regression Coefficients		Regression Equation
	a	**b**	
pH	7.19	0.009	7.19+0.009(TDS)
EC	514.6	1.384	514.6 +1.384(TDS)
Total solids	168.1	1.213	168.1 + 1.213(TDS)
Chloride	106.3	0.472	106.3 + 0.472(TDS)
Hardness	293.8	0.249	293.8 + 0249(TDS)
Sulphate	324.6	0.057	324.6 + 0.057(TDS)
Alkalinity	92.2	0.015`	92.22 + 0.015(TDS)
Fluoride	1.436	0.008	1.436+ 0.008(TDS)

V. CONCLUSIONS

A. The WQI values ranges from 52.18 to 387.53 almost 80 percent of the samples exceeded 100, the upper limit for drinking water.

B. About 67.78% of water samples are poor in quality, since these samples were collected from the location where there is cluster of industries are more.

C. And 11.1% of water samples are of very poor quality because the industries in sampling locations do not treat the effluent before discharging.

D. 1.11% of water samples collected at KVR nagar is unsuitable for drinking. Only 20% of the water samples are of good quality.

E. In this part, the groundwater quality may improve due to inflow of freshwater of good quality during rainy season.

F. Regression analyses have been obtained which can be used to find the percentage contribution of each ion by substituting an average ionic value for the entire study area.

G. Results of correlation analysis show that electrical conductivity and total dissolved solids are having high correlation with most of the other parameters.

VI. ACKNOWLEDGEMENT

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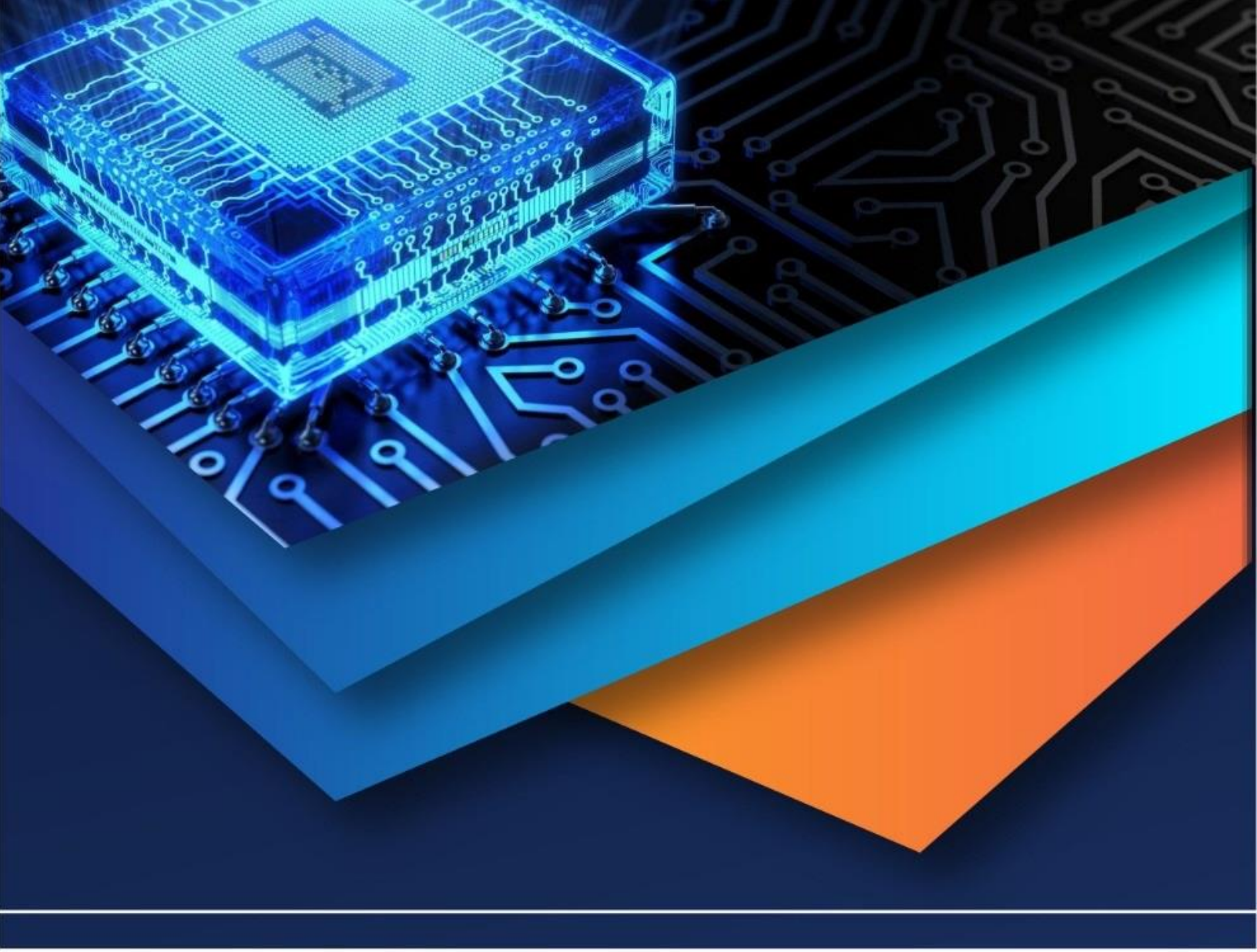

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