Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: **www.environmentaljournal.org**
Volume 3, Issue 2: 137-140

Open Access **Research Article**

Assessment of Water Quality Index in Cauvery River Basin: A Case Study on Tiruchchirappalli District, Tamil Nadu, India

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Abstract:

Maintaining the quality of water is very essential in order to utilize the resource effectively. Rapid industrial and urban development's often witness deterioration of water quality. It is important to assess the baseline characteristics of river water quality so that, sustainable development can be pursued. This study emphasizes on Cauvery River Basin, Tamil Nadu, India. Data has been collected for twenty years for different physiochemical parameters of water quality for about seventy five villages in Tiruchchirappalli district. Water Quality Index is a means to summarize large amounts of water quality data into simple terms for reporting to management and the public in a consistent manner. The Water Quality Index has been evaluated using Microsoft Excel for the parameters considered. The variables of interest are Total Dissolved Solids, Chloride, Sulphate, Bicarbonates, Nitrates, Fluoride, pH, Total Hardness, Calcium and Magnesium. The WQI obtained from the result ranged from 34.47 to 730.96. The analysis reveals that none of the villages have excellent quality of water. About 20% of the villages have moderately polluted water. In about 28% of villages, water is very poor and 52% of the villages have water which is unsuitable for drinking in Tiruchchirappalli district, Tamil Nadu, India.

Keywords: Physiochemical parameters, Water Quality Index, Geographical Information System, Cauvery river basin.

1.0 Introduction:

Water, the precious gift of nature for human beings, is being polluted day-by-day with increasing urbanization. Although three-fourth of the earth is being surrounded by water, a little portion of it can be used for drinking purpose. Water pollution is a phenomenon that is characterized by the deterioration of its quality as a result of various human activities. In India, around 62.5 million people are suffering from disorder of teeth or bones through fluorosis, which is due to consumption of Fluoride-rich water (Mayur, *et. al*., 2008). Only 12% of people get good drinking water. Inadequate management of water resources directly or indirectly has resulted in the degradation of hydrological environment (Chandaluri, *et. al.,* 2010). Many researchers have developed number of indices to summarize water quality data in an easily expressible and understandable format (Coullard and Lefebvre, 1985, Gajendran *et.al.,* 2007, and Mahesh Kumar and Raju, 2012). The first WQI was developed by Horton (1965).

Virtually almost all the surface water in India is unfit for direct consumption. In spite of the fact that the municipal water supply in most of the cities is through treated surface water, due to over contamination, more stringent treatments would be required to make the surface water potable. The prominent source of surface water pollution is domestic sewage, industrial waste water and agricultural run-off. So, we must turn to our ground water. A water quality index, common with many other index systems, relate a group of water quality parameters to a common scale and combines them into a single number in accordance with the chosen method of computation (Gajendran, *et. al.,* 2007). Water Quality Index indicates a single number like a grade that expresses the overall water quality at a certain area and time based on several water quality parameters. It is also defined as a rating reflecting a composite influence, on overall quality of water, of a number of water quality parameters (Ramakrishnaiah, 2009). In formulation of Water Quality Index the relative importance of various

parameters depends on intended use of water. Mostly it is done from the point of view of its suitability for human consumption. But the uses of water are manifold and quality of water required for each use varies tremendously. The main purpose of WQI is to turn complex water quality data into information that is understandable and usable by the public (Yogendra, 2008). It gives the public a general idea of the possible problem with water in a particular region.

2.0 Study Area:

The Cauvery River rises in the Western Ghats and flows in eastwardly direction passing through the states of Karnataka, Tamil Nadu, Kerala and Pondicherry before it drains into Bay of Bengal. The total length of the river from the source to its outfall into Bay of Bengal is about 800 km. Of this, 320 km is in Karnataka, 416 km is in Tamil Nadu and 64 km forms the common boundary between Karnataka and Tamil Nadu States. The Cauvery basin extends over an area of 81,155 km^2, which is nearly 24.7% of the total geographical area of the country. The shape of the basin is somewhat rectangular with a maximum length and breadth of 360 km and 200 km, respectively.

2.1 Methodology:

2.1.1 Water Quality Index:

A Water Quality Index is a means to summarize large amounts of water quality data into simple terms for reporting to management and the public in a consistent manner. Data on the physical and chemical water quality parameters of Cauvery River Basin has been collected for twenty years (1990-2009) for about fifty villages in Tiruchchirappalli district from the Public Works Department (P.W.D), Tamil Nadu, India.

Table 1: Water Quality Index scale

Standard WQI	Quality Rating
0-25	Excellent
25-50	Good
50-75	Moderately polluted
75-100	Very poor
100-above	Unsuitable for drinking

For computing WQI, three steps are followed,

In the first step, each of the 4 parameters has been assigned a weight (w_i) according to its relative importance in the overall quality of water for drinking purposes.

In the second step, the relative weight (W_i) is computed from the following equation:

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

Where, W_i is the relative weight,

w_i is the weight of each parameter

n is the number of parameters.

Relative weight (W_i) values of each parameter are calculated.

Table 2: Relative Weight of chemical parameters

Chemical parameters	Indian Standards	Weight (wi)	Relative weight (Wi)
pH	6.5 - 8.5	4	0.114285714
Hardness	300 – 600	3	0.085714286
Ca	75 – 200	2	0.057142857
Mg	30 – 100	2	0.057142857
HCO_3	244 – 732	3	0.085714286
Cl	250 - 1000	4	0.114285714
TDS	500 - 2000	4	0.114285714
F	1- 1.5	4	0.114285714
NO_3	45 - 100	5	0.142857143
SO	200 - 400	4	0.114285714
Total		35	1

In the third step, a quality rating scale (q_i) 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:

$Q_i = (C_i / S_i) \times 100$

Where,

qi is the quality rating,

C_i is the concentration of each chemical parameter in each water sample in mg/L,

S_i is the Indian drinking water standard for each chemical parameter in mg/L according to the guidelines of the BIS7 10500:1991.

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

$$SI_i = W_i . q_i$$
$$WQI = SI_i$$

Where,

SI_i is the subindex of i^{th} parameter;

q_i is the rating based on concentration of i^{th} parameter

n is the number of parameters.

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

3.0 Result and Discussion:

In this study, Water Quality Index was obtained for parameters such as Total Dissolved Solids, Nitrate, Calcium, Magnesium, Chloride, Sulphate, Bicarbonate, Fluorine, pH and Total Hardness so that the suitability of water quality can be understood well. The computed WQI values ranges from 34.47 to 730.96 and therefore, can be categorized into four types “good water” to “water unsuitable for drinking”. Comparing the values obtained with the water quality standards (BIS 10500:1991), the water quality rating clearly shows that none of the villages have the value of Water Quality Index within the range 0-25 and 25-50. From this it is observed that none of the villages could be rated for excellent to good quality of water which is fit for drinking purpose. This shows that the metals and salt content present in water has generally exceeded the permissible limits as per IS 10500:1991. The analysis revealed that the Water Quality Index of 10 villages lie under the range of 50-75. The present investigation shows that there is a slight decline in the amount of Total Dissolved Solids, Nitrate, Calcium, Chloride, Sulphates, Bicarbonates and Total Hardness in water this year as compared with the previous observations of (Umamaheswari, and Anbusaravanan, 2009), which records the increase in these salts. This shows that water is moderately polluted in these villages. About 20% of the villages fall under this category. It is observed that the Water Quality Index of around 14 villages lie between the range of 75-100. 28% of villages fall under this category. The present study shows that there is a sharp decline in the values of Nitrate, Calcium, Chloride, Sulphates, Fluorides and slightly lower values in Bicarbonates. This indicates that there is a large difference in the values when compared with respect to Ramakrishnaiah, *et. al.,* 2009.

Table 3: Number of villages and percentage of villages that fall under different water quality

Standard WQI	No.of villages	% of villages
0-25	0	0
25-50	0	0
50-75	10	20
75-100	14	28
100-above	26	52

This shows that water in these villages is very poor. Steps should be taken to treat the water for useful purposes and prevent further pollution.

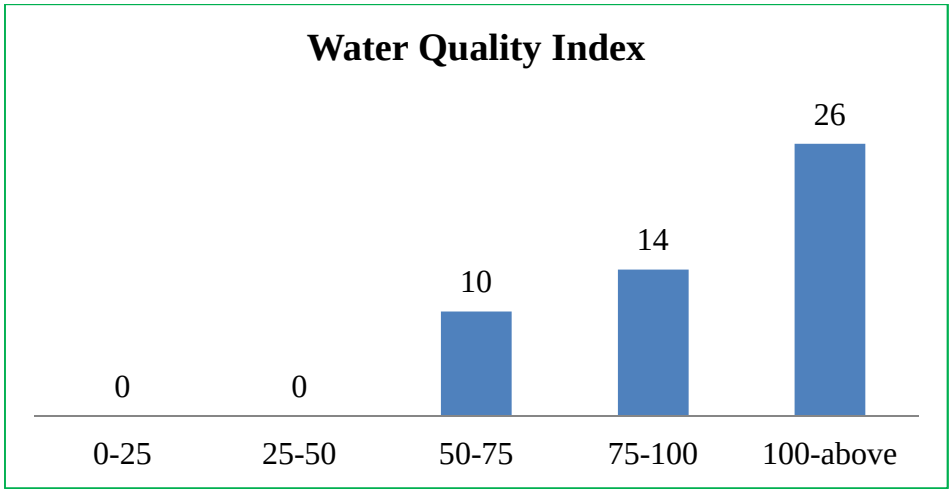

Figure 1: WQI of samples

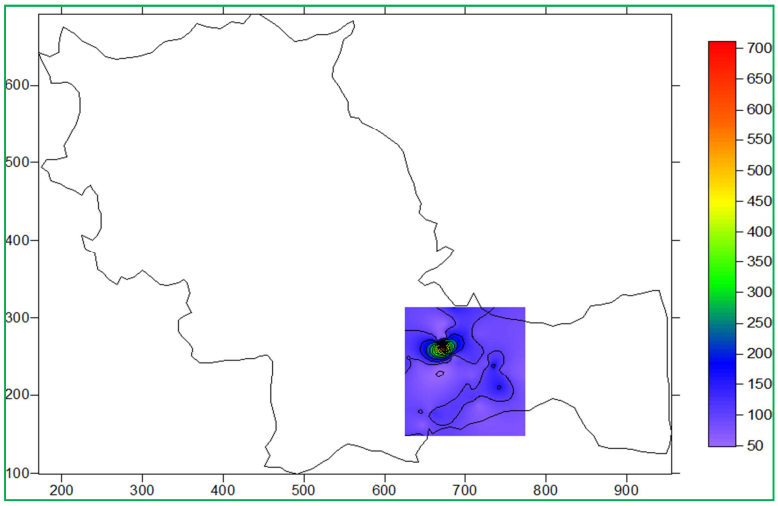

Figure 2: Water Quality Index map of Cauvery River Basin

About 26 villages show Water Quality Index above 100 and percentage of villages which fall under this category is 52%. From this, it is observed that the water in these regions is unsuitable for drinking due to its highly polluted condition. The high values of Water Quality Index are found to be mainly from the lower values of Nitrates, Calcium, Fluorides and Sulphates in ground water. The present study also reveals that pollution in ground water has increased considerably when compared to the previous years and proper measures have to be taken.

In the figure 2, the blue portion depicts that the value of Water Quality Index is low, from 50-100 and hence it can be said that water in these regions are moderately polluted. The Water Quality Index for the region which is green reads from 250-400, reveals that the water in these regions is very poor. The Water Quality Index for the region showed in red (550 - 700) confirms that the water in these regions has been contaminated with high pollutant level which is unsuitable for drinking.

4.0 Conclusion:

The WQI for ground water in 50 villages in Tiruchchirappalli district ranges from 34.47 to 730.96. Hence the result clearly shows that none of the villages have good quality of water. About 20% of the villages show that the water is moderately polluted. The high value of WQI at these stations has been found to be mainly from the lower values of Nitrates, Calcium, Fluorides and Sulphates in ground water. About 28% of the villages are poor in water quality. In this part, the groundwater quality may improve due to inflow of freshwater of good quality during rainy season. 52% of the villages contain water which is unsuitable for drinking. Hence it can be treated and used for aesthetic purpose. Thus the study reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination.

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