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ANALYTICAL STUDIES ON WATER QUALITY INDEX OF RIVER TAPTI

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ABSTRACT

River Tapti is of particular importance in the study of surface water pollution because municipal sewage, agricultural and urban run-off are discharged into it bringing about considerable change in the water quality. This study was aimed at using the application of Water Quality Index (WQI) in evaluating the quality of River Tapti for public usage. This was done by subjecting the 52 water samples to comprehensive physicochemical analysis using APHA standard methods of analysis. The WQI for the samples was 234.19. The high value of WQI has been found mainly from the higher values of total dissolved solid, phosphate and sulphate, COD and turbidity. The results of the analysis, when compared with World Health Organization (WHO) permissible limit indicated that the river was polluted and so the water is not safe for domestic use and would need further treatment. The present study demonstrated application of water quality index in estimating/understanding the quality of river water and appeared to be promising in the field of water quality management.

Key words: Physicochemical characteristic, Water quality index, Tapti river.

INTRODUCTION

Water is god's gift to all living creatures from unicellular to multicellular and from plants to animals on earth. The quality of water is of vital concern for humans beings, since it is directly linked with human health. Water plays an important role in various life processes in the human body. In our daily life, water is used for drinking, bathing, cooking and washing purposes. Water is the best solvent also (also called a universal solvent) and it is used in many industries like boiler industry for steam generation, textile, paper, pharmaceutical industry etc. Water is the most abundant component on earth's surface comprising about 70% of earth's surface in liquid, solid and gaseous state. The impact of rapid urbanization on the water front is of great concern. Millions of people all over the World, particularly in the developing countries are losing their lives every year from water

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borne diseases. Numbers of observations are reported on the pollution of water resources. The anthropogenic activities and population pressure is the major cause of the degradation of water quality. Tapti ponds are the origin centers for Tapti river.

Water is an essential requirement of human and industrial developments and it is one the most delicate part of the environment[1]. In the last few decades, there has been a tremendous increase in the demand for freshwater due to rapid growth of population and the accelerated pace of industrialization[2]. Human health is threatened by most of the agricultural development activities particularly in relation to excessive application of fertilizers and unsanitary conditions[3]. For instance, river Tapti in Multai is of particular importance in the study of surface water pollution because effluents from municipal sewage and agricultural and urban run-off are discharged into the river bringing about considerable change in the water quality. These anthropogenic activities on the river Tapti pose a serious threat not only to organisms in the river but also the downstream water users. In addition, once the surface water is contaminated, its quality cannot be restored by stopping the pollutants from the source[2]. It therefore becomes imperative to regularly monitor the quality of the water and to device ways and means to protect it.

Water quality index is one of the most effective tools to communicate information on the quality of water to the concerned citizens and policy makers. It thus, becomes an important parameter for the assessment and management of surface water. WQI is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of surface water for human consumption[4].

The objective of the present research is to provide information on the physico-chemical characteristics of river Tapti in order to appreciate the impacts of unregulated waste discharge on the quality of the river as well as to discuss its suitability for human consumption based on computed water quality index values.

EXPERIMENTAL

Materials and methods

Study area - Tapti river and its origin in Multai Distt., Betul, M. P. The history of Tapti river starts with its origin in the Betul District. Tapti river rises from Multai Distt., Betul of Madhya Pradesh and it flows between two spurs of the Satpura hills across the plateau of Khandesh and then, through the plain of Surat to the sea. It has a total length of around 724 Km and drainage area of 30,000 sq. Km for the last 32 Km. of its course, at its length. Multai is a Tehsil place and a small town. It was named on the name of Tapti pond;

actually Multai was derived from Multapi, which is origin place of Tapti river. Now-a-days, Tapti river and its ponds located in Multai have been polluted by immersion of idols, washing, cleaning of clothes and vehicles, domestic sewage and other recreational activities.

Fifty four sampling points have been selected in river Tapti. Its catchment area in the Multai is 8 sq. Km and population of the city is 35,000. The latitude and longitude are $21^{o}04'00"$ and $78^{o}21'00"$, respectively. The water of this river is supplied to the people of the city for drinking and irrigation purposes. The deterioration of water quality of this pond has posed a big problem for the living organism like human beings, animals and plants.

Laboratory analysis

Collected samples were subjected to filtration prior to chemical analysis while temperature, pH and dissolved oxygen were determined in the field. The water samples were then analyzed for 10 parameters: pH, turbidity, refractive index, total hardness, total acidity, and total dissolved solids, total solids, sulphates, phosphate, nitrate, dissolved oxygen and chemical oxygen demand using standard procedures of analysis (American Public Health Association, 1995)[5].

Calculation of WQI

The Water Quality Index (WQI) was calculated using the weighted arithmetic index method. The quality rating scale for each parameter q_i was calculated by using the expression -

$$q_i = (C_i / S_i) \text{ x } 100 \quad \ldots(1)$$

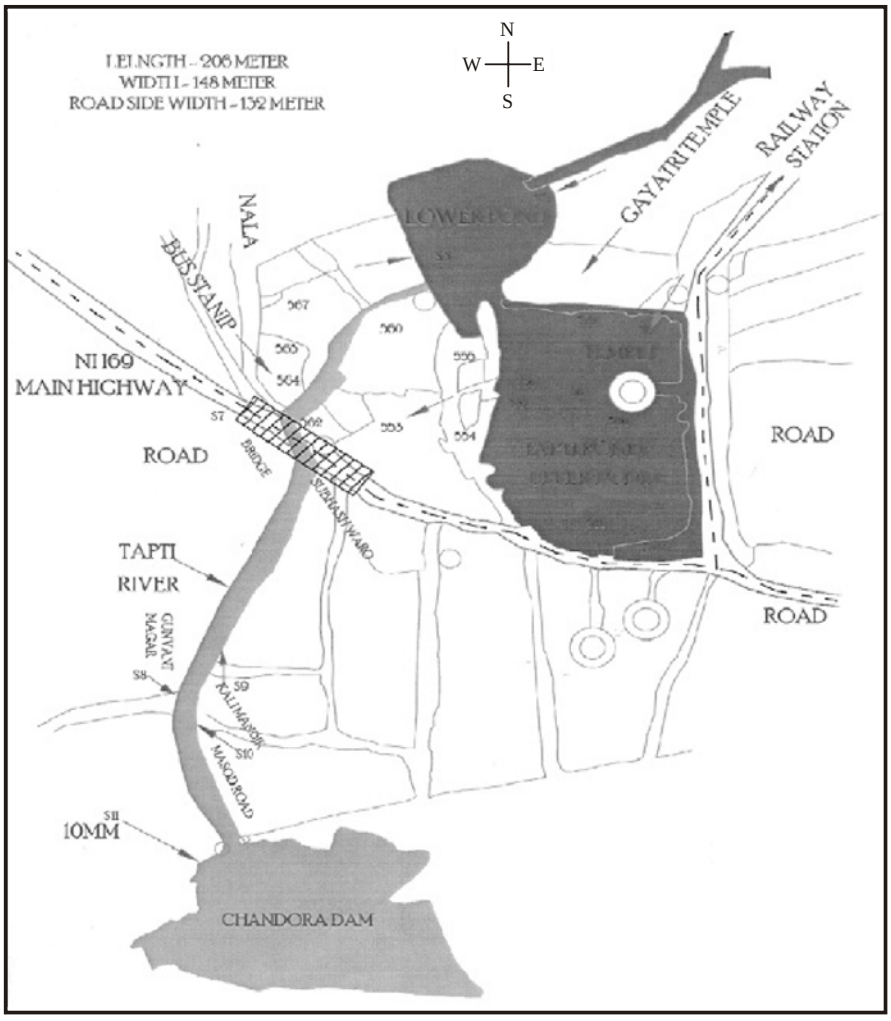
A quality rating scale (q_i) for each parameter is assigned by dividing its concentration (C_i) in each water sample by its respective standard (S_i) and the result is multiplied by 100.

Relative weight (W_i) was calculated by a value inversely proportional to the recommended standard (S_i) of the corresponding parameter -

$$W_i = 1 / S_i \quad \ldots(2)$$

The overall Water Quality Index (WQI) was calculated by aggregating the quality rating (Q_i) with unit weight (W_i) linearly -

$$WQI = \left(\sum_{I-1}^{i=n} W_i q_i \right) \quad \ldots(3)$$



Generally, WQI were discussed for a specific and intended use of water. In this study, the WQI for drinking purposes is considered and permissible WQI for the drinking water is taken as 100.

$$WQI = \frac{\sum q_i w_i}{\sum w_i} \qquad \ldots(4)$$

RESULTS AND DISCUSSION

The pH of the aquatic systems is an important indicator of the water quality and the extent of pollution in the watershed areas. Results obtained for pH varied between 6.90 and

7.50 as shown in the Table 1. The mean pH value was 7.20, Analytical observation of the pH values show that metals like cadmium and zinc are most likely to have increased detrimental environmental effect as a result of lower pH 6.90[6]. However, the pH concentration in the study area is within allowable limits for surface water (World Health Organization, 1998)[7]. The mean turbidity value obtained from the work carried out is 35.00 mg L^{-1} which is above the standard permissible limits of WHO. This could be attributed to presence of organic matter pollution, other effluents and run-off with a high suspended matter content and heavy rain fall (UNESCO/WHO/UNEP, 2001)[8].

Table 1: Physico-chemical properties and calculation of water quality index of tapti river

Parameter	Minimum	Maximum	Mean
pH	6.9	7.5	7.20
Turbidity	29	35	32
Total hardness	35	60	47.5
Total dissolved solids	260	680	470
Nitrate	1.1	1.6	1.35
DO	3.2	5.3	4.25
COD	69.3	110	89.65
Phosphate	3.6	5.7	4.65
Sulphate	6.7	13.4	10.05
Total acidity	17	210	113.5

All units are in mg L^{-1} except pH.

The mean total acidity value in the study area is above the permissible limits of 210 mg L^{-1}. This might be due to atmospheric deposition of acid-forming substances, industrial effluents whereas the total hardness value of the sample area is within the tolerable limits of (Nigerian Industrial Standards, 2003). Hardness of water causes chocking & clogging troubles of pipelines and formation of scales in boilers leading to wastage of fuel and the danger of overheating of boilers[9] (Egereonu, 2004). The hardness of natural water depends mainly on the presence of dissolved calcium and magnesium salts[10]. The total hardness varies from 35-60 mg L^{-1} and the values for the study area were found to be within the tolerable limit of WHO specification[7] i.e. 300 mg $L^{-1.}$

Water containing high solids may cause laxative or constipation effects[9]. The permissible total dissolved salts for drinking water is 680 mg L^{-1}. In the absence of potable water source, the permissible limit is 2000 mg L^{-1}. It is found from the analysis carried out that in all the samples the TDS ranged between 260-680 mg L^{-1}. The highest concentration of total dissolved solids was found to be 680 mg L^{-1} due to dense residential area and due to intensive irrigation in that area[11]. (Egereonu and Nwachukwu, 2005).

Total dissolved solids had concentration range between 260 and 680 mg L^{-1}. A mean maximum value is 470 mg L^{-1}. The observed high concentration of dissolved solid in the surface water is a pointer to the fact that there are intense anthropogenic activities along the course of the river and run-off with high suspends matter content[8].

The phosphate value obtained is within the tolerable limits. The minimum and maximum value are the same (3.60 mg L^{-1}). The mean concentration value is 4.65 mg L^{-1} which suggest that phosphorus is rarely found in high concentrations in waters as it is actively taken up by plants. High concentrations of phosphates can indicate the presence of pollution and are largely responsible for eutrophic conditions[7] in domestic waste-waters levels in surface waters.

Sulphates are naturally present in surface water as SO_4^{2-}. Urban discharges and atmospheric precipitation can also add significant amounts of sulphate to surface waters. The mean concentration of the sulphate value is 10.05 mg L^{-1}, which is within the tolerable limits of 500 mg L^{-1}. [9,10]

The mean DO values ranged from 3.20-5.30 mg L^{-1}. The average value obtained was 4.25 g L^{-1}, which indicated that the study area is highly deoxygenated. The low DO concentration could be ascribed to waste discharges high in organic matter and nutrient along the course of the river and probably as a result of the increased microbial activity (respiration) occurring during the degradation of the organic matter[12].

The mean concentration of chemical oxygen demand ranged from 69.30-110 mg L^{-1} The mean COD concentration in the samples analyzed was 89.65 mg L^{-1}, which indicated that the solids waste is highly polluted with both oxidizable organic and inorganic pollutants[13] (Otukune and Biukwu, 2005).

$$WQI = \frac{\sum q_i w_i}{\sum w_i} \qquad \ldots(5)$$

$$= 405.165/1.73$$

$$= 234.19$$

The WQI and overall WQI of all the samples taken, were calculated according to the procedure explained above and are presented in Table 2. The results obtained from this study revealed that WQI of Tapti river water is not within the permissible limits (100) from the entire sample taken. The computed overall WQI was 234.19 and can therefore be categorized into five types "excellent water' to "water unsuitable for drinking". Table 3 shows the percentage of water samples that falls under different quality. The high value of WQI has been found mainly from higher value of total dissolved solid, total acidity, COD and turbidity in the water sample.

Table 2: Computed WQI values for river Tapti (Multai)

Parameter	Standard permissible values (si)	W_i	q_i	q_iw_i
pH	6.5-8.5 (7.5)	0.13	192	24.96
Turbidity	1	1	3.2	3.2
Total hardness	200	0.01	23.75	23
Total dissolved solid	500	0	94	94
Nitrate	10	0.1	13.5	135
DO	5	0.2	85	17
COD	10	0.1	896.5	89.65
Phosphate	5.5	0.18	84.54	15.21
Sulphate	500	0	2.01	2.01
Total acidity	100	0.01	113.5	1.135

Table 3: Water quality classification based on WQI value

WQI value	Water quality	Water samples (%)
< 50	Excellent	20
50-100	Good water	36
100-200	Poor water	30
200-300	Very poor water	0
> 300	Water unsuitable for drinking	14

This could be attributed to improper disposal of wastes, large quantity of agricultural and urban run-off, sewage, over application of inorganic fertilizer, improper operation and maintenance of septic system[7,8].

CONCLUSION

At the outset, the study clearly indicates that the water of river Tapti can be used for public consumption without any treatment; however, the results obtained from the study reveals that river Tapti is polluted and this could be attributed to anthropogenic activities such as agricultural activities, The WQI of the samples was 234.19, which exceeded 100, the upper limit for drinking water. Application of Water Quality Index (WQI) in this study has been found useful in assessing the overall quality of water and to get rid of judgment on quality of the water. This method appears to be more systematic and gives comparative evaluation of the water quality of sampling stations. It is also helpful for public to understand the quality of water as well as it is being a useful tool in many ways in the field of water quality management.

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