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Physico-Chemical parameters and bacteriological study of vaigai River Water Madurai district, Tamilnadu, India

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Abstract

The water quality in the Vaigai River was studied by evaluating the physico-chemical parameters and bacterial population in the five areas during the period of July 2016 to September 2016. The analyzed physico-chemical parameters showed significant deviation from normal values indicating the presence of constant pollution load in the river. The physico-chemical and microbiological parameters are higher than the acceptable limits of APHA (2005), WHO (2004) and BIS (2012). The pH and temperature value of the water samples measured on the spot using digital pH meter and thermometer were observed with variations of 6.8 to 8.6 and 24 to 27 °C in five stations, respectively. The temperature of water sample is low due to dim sunlight during rainy season. The electrical conductivity (EC) was recorded with a minimum value of 970 $\mu\text{S}/\text{cm}$ at station 1 and maximum of 1825 $\mu\text{S}/\text{cm}$ at station 5. The dissolved oxygen (DO) in the water sample with high value of 9.57 mg/L in station 1 and a low value of 4.32 mg/L in station 5. The concentration of BOD in Vaigai river water samples were ranged from 4.5 to 22.6 mg/l respectively. The concentration of COD in Vaigai River samples were ranged from 7.2 to 240 mg/L. Total Alkalinity, total hardness, calcium, magnesium, Chloride were observed the ranges like 285- 870 mg/L, 242 -1750 mg/L, 65-220 mg/L, 42-165 mg/L and 185-385 mg/L respectively. The concentration of nitrate in Vaigai River water samples were ranged from 4.51 to 7.51 mg/L. The bacteriological investigation of Vaigai River water was greatly contaminated with total heterotrophic bacteria, fecal coliform and total coliform bacteria. The minimum value of 1.6×10^4 CFU/ml and maximum value of 3.2×10^4 CFU/ml were observed at Sholavandan and Kochadai respectively. In addition, the total coliform bacteria are present with the value of 3.2×10^4 and 14.3×10^4 CFU/ml respectively during the period of July 2016 to September 2016.

Keywords: Vaigai River, water quality, bacteriological analysis, physicochemical parameters

1. Introduction

Water pollution is not a new problem except in dimensions which we face today. Man has been using water around him for dumping wastes. In the early stages of human history, domestic discharges probably posed no problem as nature has the capacity to degrade waste and restore normal conditions. Nature still does, but with the advent of urbanization and industrialization we have been overloading the systems beyond their tolerance limit.

Consequently our water bodies such as rivers, streams and lakes are increasingly getting polluted, threatening the safety, welfare and the very existence of mankind. In recent years the newer environmental issues regarding hazardous waste, global climate change, stratospheric ozone depletion, groundwater contamination, disaster mitigation and removal of pollutant have become the focus of environmental attention. Though all the segments of environment are being polluted in various ways, the study of water pollution is preferred as it is not an ordinary liquid but is the elixir of life. Moreover, water is the most common liquid but it is also one of the most unusual because of its unique property ^[1].

In India, about 36% of urban and 65% of rural population is without access to safe drinking water ^[2]. Majority of the water bodies are polluted due to discharge of defective municipal sewerage system, effluent from septic tanks and sewage. Other sources that contaminate the water are domestic waste water, storm water runoff, cattle feedlots runoff etc ^[3]. These effluents contain human and animal faeces along with pathogenic microorganisms. In term of human health, the most dangerous water pollutants are pathogenic microorganism ^[4].

Consumption of water contaminated by these microorganisms poses the danger and risk of

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water borne diseases like cholera, typhoid fever, diarrhoea and dysentery and other diseases [5]. It is important to note that, two and a half billion people have no access to improved sanitation, and more than 1.5 million children die each year from diarrheal diseases [6]. These include *Salmonella* sp, *Shigella* sp, *Vibrio cholerae* and *E.coli* [7]. So, analysis for the presence of water borne pathogens become extremely important to further screen and treat the water to make it fit for human use. The utility of river water for various purposes is governed by physico-chemical and biological quality of the water [8] and therefore an analysis on river waters was made by many workers [9, 10].

The present study is aim to assess the physico-chemical properties like pH, Temperature, EC, TDS, Total alkalinity, Dissolved oxygen, biological oxygen demand, chemical oxygen demand, Total Hardness, Calcium hardness, Magnesium, Nitrate, Nitrite, Iron and bacteriological components of river Vaigai, Madurai, TamilNadu, India where many people living on its banks still uses it as a source of water for washing and bathing.

2. Materials and methods

2.1 Study area

The study area was included that five stations of Vaigai River in Madurai District. Water samples are collected from Sholavandan (S1), Thiruvudagam (S2), Thenur (S3), Thuvariman (S4) and Kochadai (S5) (Plate 1).

2.2 Collection of sample

The Vaigai River water samples were collected during July 2016 to September 2016 from Madurai District for the estimation of physical-chemical parameters and bacterial populations. Samples were collected during the fortnight of every month in sterile one litre polytene bottles and were analyzed. The bottles were immersed into the water and stoppers were removed underneath. Temperature and pH of the samples were measured at the site using digital pH meter and digital thermometer, respectively. After sample collection, the bottles were kept in ice box and transferred immediately to the laboratory for further analysis.

2.3 Analysis of water

The laboratory analysis of Vaigai River water samples were done by the standard procedure of the American Public Health Association [11] and World Health Organization [2]. Totally fifteen types of Physico-chemical parameters such as pH, Temperature, EC, TDS, Total alkalinity, Dissolved oxygen, biological oxygen demand, chemical oxygen demand, Total Hardness, Calcium hardness, Magnesium, Nitrate, Nitrite, Chloride, Iron were determined.

2.4 Bacteriological methods

Determination of the bacterial population from the Vaigai River water was analyzed by standard Microbiological methods of the World Health Organization (WHO) and Bureau of Indian Standard [12]. This bacteriological test was mainly performed to confirm the quality of water. The water samples were serially diluted from 10^{-1} to 10^{-6} dilutions. The enumerations and isolation of total heterotrophic bacterial colonies were done by pour plate method in nutrient agar medium, incubated at 37 °C for 24 h. After incubation, the bacterial colonies were recorded by Quebec colony counter and reported as colony forming units per milliliter (CFU/ml). The enumerations of total coliform were executed by standard

plate count method (SPC) and the faecal coliform bacteria were performed by fecal coliform membrane filter (m-FC) agar plate method.

3. Results and discussion

3.1 Physico-chemical parameters

The water quality in the Vaigai River was studied by evaluating the physico-chemical parameters and bacterial population in the five areas during the period of July 2016 to September 2016. The analyzed physico-chemical parameters showed significant deviation from normal values indicating the presence of constant pollution load in the river. The physico-chemical and microbiological parameters are higher than the acceptable limits of APHA (2005), WHO (2004) and BIS (2012).

The mean value of the physical and chemical parameters of Vaigai River water was summarized in Table 1. pH and temperature are the most important physical factors that affects the chemical and biological reaction in river water. The pH and temperature value of the water samples measured on the spot using digital pH meter and thermometer were observed with variations of 6.8 to 8.6 and 24 to 27 °C in five stations, respectively. The temperature of water in rainy season is low due to dim sunlight. The electrical conductivity (EC) was recorded with a minimum value of 970 $\mu\text{S}/\text{cm}$ at station 1 and maximum of 1825 $\mu\text{S}/\text{cm}$ at station 5.

Dissolved oxygen content is one of the most important factors in stream health. Its deficiency directly affects the ecosystem of a river due to bioaccumulation and biomagnifications. The oxygen content in water samples depends on a number of physical, chemical, biological and microbiological processes. Winkler's method measured the dissolved oxygen (DO) in the water sample with high value of 9.57 mg/L in station1 and a low value of 4.32 mg/L in station5. The water samples with more dumped sewage waste were observed to have low DO content. Which support the growth of pathogenic bacteria and this was due the presence of high concentration of organic matter [13].

Biological oxygen demand (BOD) is a measure of the oxygen in the water that is required by the aerobic organisms. The biodegradation of organic materials exerts oxygen tension in the water and increases the biochemical oxygen demand [14]. Rivers with low BOD have low nutrient levels; therefore, much of the oxygen remains in the water. Unpolluted, natural waters will have a BOD of 5 mg/l or less. BOD directly affects the amount of dissolved oxygen in rivers and streams. Sources of BOD include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots, and food processing plants; failing septic systems; and urban storm water runoff [9]. The BIS suggested the standard permissible limit in drinking water for BOD is 5 mg/l. The content of BOD is found that beyond the prescribed limit during the study period except station 1. The concentration of BOD in Vaigai river water samples were ranged from 4.5 to 22.6mg/l respectively.

Chemical oxygen demand (COD) is a measure of the oxidation of reduced chemicals in water. It is commonly used to indirectly measure the amount of organic compounds in water. The measure of COD determines the quantities of organic matter found in water. This makes COD useful as an indicator of organic pollution in surface water. In the conjunction with the BOD test, the COD test is helpful in indicating toxic conditions and the presence of biologically

resistant organic substances [12].

The concentration of COD in Vaigai River samples were ranged from 7.2 to 240mg/L. The water containing more than 10mg/L of COD is not advisable for drinking purpose. The highest values of COD indicates that most of the pollution in study area is caused by industrial effluents discharged by industrial units, other activities like bleaching and dyeing clothe along the river banks and inside the river also.

Alkalinity of natural water is due primarily to the salts of weak acids, although weak or strong bases may also contribute. Bicarbonate represents the major form of alkalinity, with that carbonate and hydroxide alkalinity also. Total Alkalinity (TA) values provide guidance in applying proper doses of chemicals in water and wastewater treatment processes particularly in coagulation, softening and operational control of anaerobic digestion. Water containing more than 200 mg/l of TA is not considered desirable for drinking purpose [12]. In the present study was observed the values ranged from 285 to 870 mg/L during the study period. Higher values can be attributed to the industrial effluents discharged into river and this may cause corrosion in water pipe lines.

Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water. Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. Water containing more than 300 mg/l of TH is not considered desirable for drinking purpose [15]. In the present study observed the values of Total hardness in Vaigai River water was ranged from 242 to 1750mg/L. The highest value was recorded in station 5.

Calcium is directly related to hardness. In order of abundance, calcium is the fifth element which is commonly present in all water bodies where it usually comes from the leaching of rocks. Calcium is very essential for nervous system and for formation of bones and teeth. Water containing more than 75 mg/l of calcium is not considered desirable for drinking purpose [16]. In the present study, the concentration of calcium in Vaigai River water samples was ranged from 65 to 220mg/L. The lowest value was recorded in station 3 and highest value recorded in station 5.

Magnesium is also directly related to hardness. Magnesium was acts as co-factor for various enzymatic transformations within the cell especially in the trans-phosphorylation in algal, fungal and bacterial cell [20]. Water containing more than 30 mg/l of magnesium is not considered desirable for drinking purpose. The values of magnesium were observed in Vaigai river water ranged from 42 mg/L to 165 mg/L. The minimum value recorded in station 3 and maximum value recorded in station 5.

Chlorides occur naturally in all types of water. This is the most common inorganic anion present in water. High concentration of chloride is considered to be the indicators of pollution due to organic wastes of animal or industrial origin. Chlorides are troublesome in irrigation water and also harmful to aquatic life [1, 20]. The BIS suggested the standard of chloride is 250 mg/l. The concentration of chloride in Vaigai River water samples were ranged from 185 to 355 mg/L. Station 1 and 5 were exceed the permissible limit during the study period.

Increasing concentration of nitrogen compounds in river and reservoirs lead to eutrophication and could be due to sewage water with agricultural wastes. Nitrate concentration also depends on the activity of nitrifying bacteria which in turn get influenced by presence of dissolved oxygen. Water containing

more than 45 mg/l of nitrate is not considered desirable for drinking purpose. The concentration of nitrate in Vaigai River water samples were ranged from 4.51 to 7.51mg/L. Decrease in nitrate content during monsoon and winter was probably due to its utilization as nutrient by the algal community [17].

Table 1: Physico-chemical parameters of Vaigai River water

| Parameters | S1 | S2 | S3 | S4 | S5 |
|---------------------------------|------|-------|-------|-------|------|
| pH | 6.8 | 6.9 | 7.2 | 7.9 | 8.6 |
| Temperature | 24 | 24.45 | 25.10 | 26.15 | 27 |
| Electrical Conductivity (µS/cm) | 970 | 1038 | 1090 | 1256 | 1825 |
| TDS (mg/L) | 1250 | 975 | 895 | 932 | 2275 |
| Dissolved oxygen (mg/L) | 9.57 | 8.02 | 7.13 | 6.21 | 4.32 |
| B.O.D (mg/L) | 4.5 | 7.0 | 13.6 | 18.0 | 22.6 |
| C.O.D (mg/L) | 7.2 | 18.5 | 45.2 | 85.7 | 240 |
| Total Alkalinity (mg/L) | 285 | 290 | 320 | 430 | 870 |
| Total Hardness (mg/L) | 242 | 276 | 372 | 610 | 1750 |
| Calcium hardness (mg/L) | 185 | 95 | 65 | 110 | 220 |
| Magnesium Hardness (mg/L) | 140 | 72 | 42 | 85 | 165 |
| Chloride (mg/L) | 285 | 195 | 185 | 175 | 355 |
| Nitrate (mg/L) | 4.51 | 4.92 | 5.75 | 6.25 | 7.15 |
| Nitrite (mg/L) | 0.50 | 0.52 | 0.40 | 0.42 | 0.52 |
| Iron (mg/L) | 6.05 | 3.20 | 1.05 | 0.55 | 5.75 |

Mean values of physical and chemical parameters of Vaigai River water in Madurai District, (S1- Sholavandan, S2- Thiruvudagam, S3- Thenur, S4- Thuvariman and S5- Kochadai).

3.2 Bacteriological Parameters

Bacterial parameters are one of the most important parameters to confirm the river quality. The bacteriological investigation of Vaigai River water was greatly contaminated with total heterotrophic bacteria, fecal coliform and total coliform bacteria. On the basis of bacterial studies in Vaigai River water from Sholavandan to Kochadai, the presence of higher concentration of heterotrophic bacterial colonies were found in all five stations of the river. The mean values of the total heterotrophic and total coliform bacterial colonies of Vaigai River water were summarized in Table 2. The minimum value of 1.6×10^4 CFU/ml and maximum value of 3.2×10^4 CFU/ml were observed at Sholavandan and Kochadai respectively. In addition, the total coliform bacteria are present with the value of 3.2×10^4 and 14.3×10^4 CFU/ml respectively during the period of July 2016 to September 2016. The polluted water contains a large amount of organic matter that provides an excellent source of nutrition for the growth and multiplication of microbes [18].

The total coliform bacteria were identified in MacConkey agar, in which the appearance of small pink colonies (*E.coli*), large pink mucoid colonies (*Klebsiella sp.*) was found. Similarly, in EMB Agar plates, *E. coli* and *Klebsiella* species produced green metallic sheen colonies. *Enterobacter sp.* Produced only pink colour colonies without metallic sheen identified. The faecal coliform bacteria were enumerated by mFC agar plates, with the appearance of colonies in dark blue colour. The high concentrations of *E.coli* forms in the river water was mainly due to municipal sewage disposal and septic tank discharges, which was found to be unhealthy for human consumption [19]. The presences of *Streptococci* were identified in blood agar by the appearance of a small pin point haemolytic colonies.

Table 2: Results of Total heterotrophic and total coliform bacterial analysis from different sampling stations of Vaigai River water, Madurai District.

| Sampling sites | Total heterotrophic bacteria (total colony count x 10 ⁴ CFU/ml) | | | Total coliform bacteria (total colony count x 10 ⁴ CFU/ml) | | |
|----------------|--|-------------|----------------|---|-------------|----------------|
| | July 2016 | August 2016 | September 2016 | July 2016 | August 2016 | September 2016 |
| S1 | 1.6 | 1.8 | 1.7 | 3.2 | 3.2 | 4.0 |
| S2 | 1.7 | 2.2 | 2.0 | 5.5 | 5.7 | 5.8 |
| S3 | 1.9 | 2.4 | 2.3 | 6.7 | 8.3 | 7.0 |
| S4 | 2.1 | 2.8 | 2.9 | 8.5 | 10.5 | 9.3 |
| S5 | 2.5 | 3.1 | 3.2 | 14.3 | 13.8 | 13.5 |

Mean values of total heterotrophic and total coliform bacterial population colony counting in Vaigai River water from Madurai District.

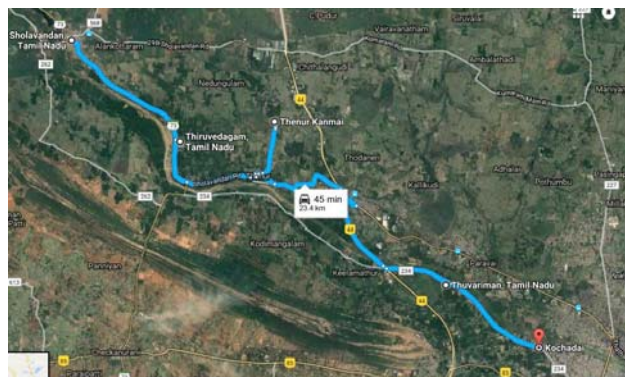


Plate 1: Study area of the sampling stations of Vaigai River, Madurai District.

4. Conclusion

The People of Madurai District strictly depend upon the source of water from the Vaigai River for their agricultural and household activities in their day to day life. Nevertheless, the physico-chemical parameters of the water were found to be below the standards of the WHO. The scenario has been alarmed by the continuous particle of improper sanitation, drainage system and septic tank discharge in the river. In addition, the presence of highly contagious pathogens in the river water warrants the attention of the sanitary department in the district in addition to the public education in practice hygiene and sanitation.

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