

# Occurrence of pollution indicators in tropical perennial river of Periyar, Southern India

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## Abstract

The Periyar river water samples were collected from nine different places during summer 2015 for physiochemical and bacteriological analysis. The mean concentrations of DO (mg/L) and BOD (mg/L) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 were 6.7 and 7.8, 5.8 and 8.1, 4.9 and 5.8, 5.6 and 6.3, 4.3 and 7.4, 8.0 and 9.1, 4.4 and 5.1, 3.4 and 6.8, and 5.1 and 3.8, respectively. The level of Pollution Index (PI) (Fecal coliforms / Fecal *Streptococci*) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 was 1.8, 1.3, 2.1, 1.75, 2.4, 1.8, 2.3, 1.4 and 1.5, respectively. The higher PI ratio (>1) indicated that the sampling sites were contaminated by human fecal matters which is major contribution for river pollution and which require immediate attention. The study further raises points for the need of action for a sustainable utilization of precious resources. The study also recommends the necessity of proper sanitation and waste disposal to sustain the surface water quality.

**Keywords:** Periyar River, Pollution indicators, Physiochemical parameters, Pollution index.

## 1. Introduction

India Environmental surveys are necessary for understanding and documenting the occurrence and distribution of pollution indicator and human pathogenic bacteria. In order to quantify and understand their relationship with relevant environmental factors, several investigators have examined distribution of these groups of bacteria and certain viruses in coastal waters [1][2][3]. Availability of water is a critical factor for the socio-economic development in many countries and hence in most parts of the world freshwater supplies are put to heavy use [4]. At present, the annual freshwater consumption is around 4000 km<sup>3</sup> worldwide with the Indian consumption being 10 % of this value [5]. But the quantity of freshwater demands does not reflect the problems associated with water quality parameters such as toxic metal, pesticide, and bacterial contamination. Rivers have also been used for cleaning and disposal of waste and may become polluted by indiscriminate disposal of sewage, industrial waste, agricultural practices and human activities, which all affect their microbiological quality [6].

Land drainages, domestic sewage outfalls, and other discharges alter the abundance and type of both autochthonous and allochthonous microbial populations in the near shore environments [7]. An understanding of incidence and distribution of bacterial species, their physiological characteristics including pathogenicity to both plants and animals is important for gaining insights on the presence of harmful microbial communities. Safe drinking water would prevent around 2.5 million deaths caused by diarrheal diseases, 150 million cases of schistosomiasis and 75 million cases of trachoma every year [8]. Prevention of river pollution, therefore, also requires effective monitoring of microbiological parameters [1]. Detection and enumeration of indicator organisms are of primary importance for the monitoring of sanitary and microbiological quality of water [9]. The aim of this study was to determine the level of pollution indicators and physiochemical parameters from tropical perennial river water samples and also find their sources of pollutions.

## 2. Materials and methods

### 2.1 Study area

Periyar River is the longest river and the river with the largest discharge potential in the Indian state of Kerala. It is one of the few perennial rivers in the region and provides drinking water for several major towns. The Periyar is of utmost significance to the economy of Kerala. The Periyar basin spreads over an area of 5,398 square kilometers (2,084 sq mi), most of it in central Kerala. It lies between latitudes 9°15'30"N and 10°21'00"N and longitudes 76°08'38"E

and 77°24'32"E. The lower reaches of the Periyar are heavily polluted. Industries in the Eloor industrial zone discharge waste into the river. Greenpeace India describes the lower Periyar as "a cesspool of toxins, which have alarming levels of deadly poisons like DDT, endosulfan, hexa and trivalent chromium, lead, cyanide, BHC". Several studies have pointed out that the riverbed has deposits of heavy metals like lead, cadmium, mercury, chromium, nickel, cobalt and zinc and the ecosystem of the river has many dead zones. Some of the major recommendations are ensuring zero effluent discharge from the industrial units in the Eloor-Edayar stretch and zero emission from companies. Pollution of the river and surrounding wetlands has almost wiped out traditional occupations, including fishing and farming. Illegal sand mining from the Periyar is another major environmental issue. Studies have pointed out that the quantity of sand being mined from the Periyar is at least 30 times the actual quantity that can be taken out without causing damage to the river's environmental system. In the Periyar river basin, land sand mining is widespread in the plateau region in the highlands. Mining of sands from these areas impose severe environmental problems to the river basin environment.

## 2.2 Sampling

The water samples were collected from nine different places within the river during summer 2015 for physiochemical and bacteriological analysis. The sampling sites were Kuttampuzha (S1), Boothathankettu (S2), Kodanad (S3), Kalady (S4), Marampally (S5), Aluva (S6), Pathalam (S7), Varapuzha (S8) and Pizhala (S9). The sampling sites were chosen based on the massive discharges of pollutants into river. The river water samples were collected from 0 to 20 cm below the surface [11][12]. The 2000 mL of water samples were collected with a 2500 mL sterile container in each location and stored in ice box at 4 °C. The samples were transported into laboratory and processed within 12 hrs.

## 2.3 Physiochemical analysis

The physiochemical parameters, i.e., pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured using field kit (Thermo Orion 5-Star pH Multi-Meter) on the site and, the dissolved oxygen (DO) and biological oxygen demand (BOD) were determined according to the method described by APHA and Vignesh *et al* [9][10].

## 2.4 Bacteriological analysis

All the selective media (Table 1) were prepared with the addition of distilled water and autoclaved properly. The bacterial populations in different water samples were estimated by pure culture technique on selective medium plates with 100 µL of suitable dilutions [13]. All the media plates were incubated at 37°C ± 1°C for 24–48 h, except M-FC agar plates. The M-FC agar plates were incubated at 44.5°C ± 1°C for 24–48 h. After incubation, the final counts of colonies were noted and all trials were performed in triplicate. The specific biochemical tests were performed for identification (Rapid Microbial Limit Test kits used) of bacterial [1][14].

## 3. Result and discussion

Monitoring of physicochemical characteristics is not only decided the quality of water but the microbiological studies are also an important analysis for assessment of water quality [10]. In this study, the mean concentration of pH in S1, S2, S3, S4, S5, S6, S7, S8 and S9 were 8.14, 8.74, 7.84, 7.66, 8.08, 8.6, 7.76, 8.13 and 7.66, respectively (Figure 1). The mean concentrations of EC (µm/cm) and TDS (mg/L) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 were 2516 and 1585, 1845 and 1162, 1465 and 923, 1765 and 1112, 2490 and 1569, 2500 and 1575, 1964 and 1237, 2230 and 1405, and 2841 and 1790, respectively (Figure 2). The mean concentrations of DO (mg/L) and BOD (mg/L) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 were 6.7 and 7.8, 5.8 and 8.1, 4.9 and 5.8, 5.6 and 6.3, 4.3 and 7.4, 8.0 and 9.1, 4.4 and 5.1, 3.4 and 6.8, and 5.1 and 3.8, respectively.

The range of TVC (CFU/mL) and TC (CFU/mL) concentrations were in the range of 4.3 – 9.9 [x 10<sup>4</sup>] and 1.43 – 2.6 [x 10<sup>3</sup>] respectively (Figure 3). In the present study, most of the sites were found to have high TVC in most of the water samples. Most of the samples were found to have TVC higher than suggested by the Bureau of Indian Standard limits [15]. The water of the Periyar River is used for drinking and domestic purposes in most places but high total viable pathogen levels suggest not using the water for such purposes at certain localities. The high TVC values may be attributable to the presence of large microbial populations residing in the water. Sewage contamination of aquatic habitats is detected by enumerating the coliform groups of bacteria [16]. As is universally accepted, higher sewage contamination would lead to increased numbers of coliforms in natural water bodies. Indiscriminate, deliberate, accidental or regular/routine disposals of sewage in most developing countries lead to higher abundance of coliform groups. Kistemann *et al* [17] in 2003 observed that during rainfall, the microbial loads of running water may suddenly increase and reach reservoir.

The mean concentration of TS (CFU/mL) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 were 210, 180, 310, 380, 170, 150, 190, 200 and 460, respectively. Ecological surveillance for microbiological analysis is therefore necessary on a continuous basis for realizing the impacts of effluent discharges. The aquatic environment is able to recover from the inorganic/organic/trace metal pollution stress only after the diffusion and probably through their self-purification system

[9]. Further, as innumerable pathogenic bacteria will constitute the microflora of effluents discharged from domestic, urban, agricultural and certain manufacturing practices, quantifying different groups of pathogenic prokaryotes ought to be part of such surveys. For instance, information on occurrence, abundance and distribution of potent human pathogens, *Vibrio cholerae* (causing cholera in humans), *Vibrio parahaemolyticus* (gastroenteritis), *Salmonella* and *Shigella* spp (typhoid fever; food poisoning), *Streptococcus* spp (meningitis and skin infections) and *Aeromonads* (septicaemic conditions) in aquatic ecosystems may prove useful in public health management [2].

The mean concentrations of FC (CFU/mL) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 were 180, 250, 310, 210, 240, 170, 190, 140 and 200, respectively. But, the mean concentrations of FS (CFU/mL) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 were 100, 180, 150, 120, 100, 90, 80, 100 and 130, respectively (Figure 4). In comparison to the Mondovi and Zuari river system [2] and Tamirabarani river system [13] and Cauvery river system [1][9] microbial pollution indicator counts were generally lower in the Periyar river system. Heterotrophic bacteria commonly respond to pollution of this type by decomposing organic matter and releasing nutrients and energy [18]. Frequent visits to surface water systems by the public and by livestock are common in developing countries. Particularly, poor rural communities lack access to potable clean water and they largely reside near river banks [19]. As a result, they often utilize surface waters for their daily washings and defecation which leads to contamination of the respective water bodies. These activities particularly deteriorate microbial water quality as fecal matter is disposed and the surrounding area is littered with feces [20].

The level of PI (FC/FS) in S1, S2, S3, S4, S5, S6, S7, S8 and S9 was 1.8, 1.3, 2.1, 1.75, 2.4, 1.8, 2.3, 1.4 and 1.5, respectively. The higher pollution index (PI) ratio (>1) were observed in all sampling sites which indicated the human fecal matters were responsible for river water pollution. In addition to pathogens, urine and feces contain organic matter as well as eutrophying macronutrients such as phosphorus and nitrogen compounds [21]. The presence of such indicator organisms may provide an indication of waterborne problems and is a direct threat to human and animal health. The river is mainly passing through several rural areas that have many small animal farms, and huge amounts of fecal excreta are dropped into the river system daily. Their abundance in the Periyar river system suggests that they might provide suitable bio-indicators of enteric contamination.

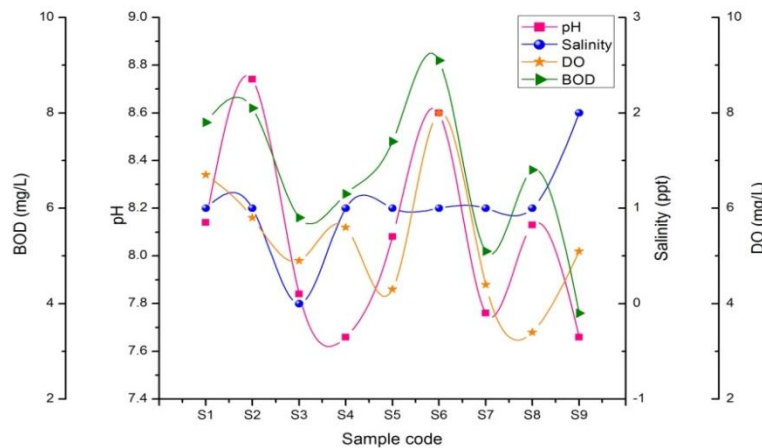


Figure 1: Concentrations of pH, Salinity, DO and BOD levels in Periyar river water

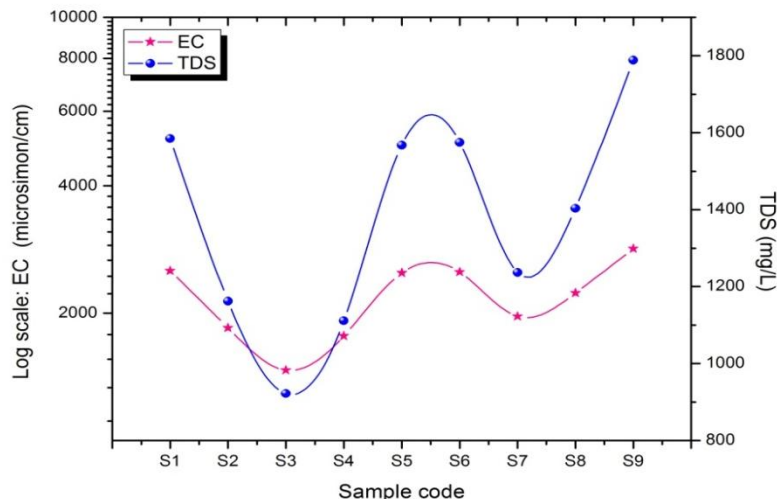


Figure 2: Concentrations of EC and TDS levels in Periyar river water

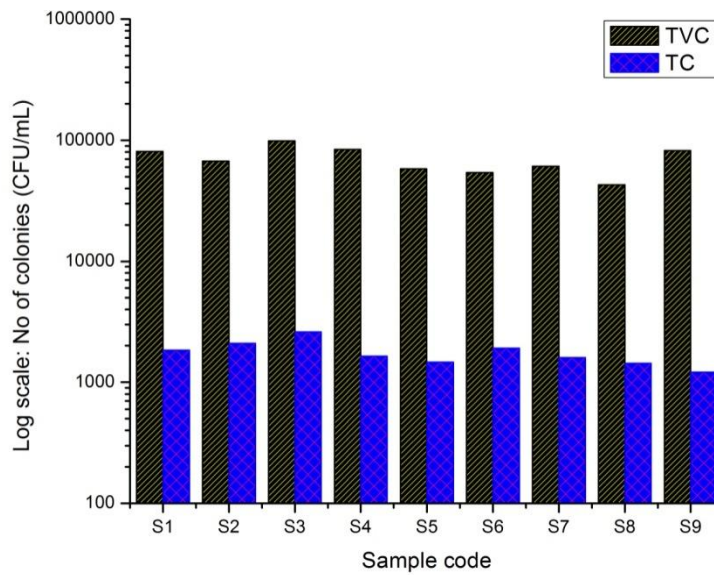


Figure 3: Counts of TVC and TC levels in Periyar river water

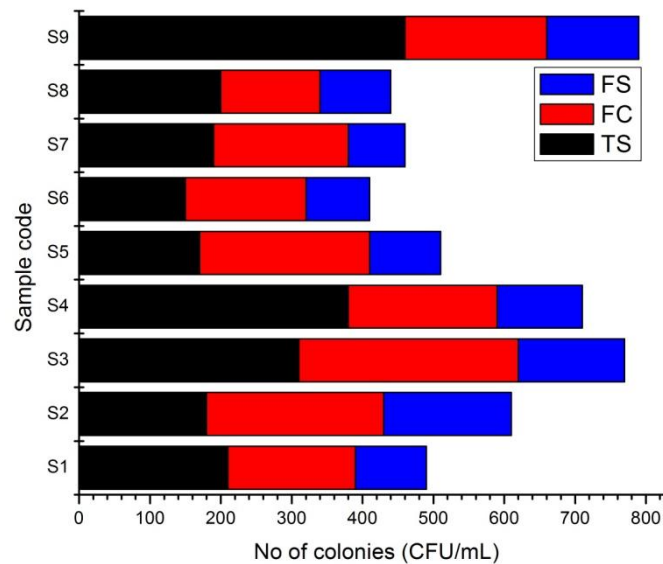


Figure 4: Counts of TS, FC and FS levels in Periyar river water

Table 1: Details of specific culture media used for quantitative bacterial analysis

S. No	Bacterial Indicators	Culture medium	Positive Colonies	References
1.	Total Viable Count (TVC) <sup>a</sup>	Nutrient Agar	All colonies counted	Nagvenkar and Ramaiah [2]
2.	Total Coliforms (TC) <sup>a</sup>	MacConkey Agar	All colonies counted	Vignesh <i>et al</i> [3]
3.	Total <i>Streptococci</i> (TS) <sup>a</sup>	M <i>Enterococcus</i> Agar	All colonies counted	Kumarasamy <i>et al</i> [1]
4.	Fecal Coliforms (FC) <sup>b</sup>	M FC Agar	Blue colonies counted	Vignesh <i>et al</i> [12]
5.	Fecal <i>Streptococci</i> (FS) <sup>a</sup>	KF <i>Streptococcus</i> Agar	Red colonies counted	Vignesh <i>et al</i> [13]

<sup>a</sup> Media plates were incubated at 37°C ± 1°C for 24–48 h; <sup>b</sup> Media plates were incubated 44.5°C ± 1°C for 24–48 h

#### 4. Conclusion

Our study gives an indication of the extent of microbial pollution; any further addition of wastes may deteriorate the existing hygienic quality in the area. It is recommended that regular microbiological studies including supplemental bacterial indicators should form an integral part of coastal pollution monitoring programs. Thus as far as sample waters are concerned the potential risk of getting infected by water borne diseases is always there if used without proper disinfections. The water can be definitely used after practicing suitable disinfections system.

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