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Assessment of Physiochemical, Heavy Metal and Microbiological Parameters in Periyar River Basin, Kerala

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Abstract

The present study, the water samples were collected from 15 different places within the Periyar river during monsoon 2015 for physiochemical, heavy metal and bacteriological analysis. In monsoon 2015, the mean values of pH, TDS, EC, DO, BOD, COD, TA, TH, Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, N-NO_2 and O-PO_4 were 7.82, 551.35, 871.56 (µS/cm), 4.35, 6.85, 13.51, 119.83, 85.37, 39.70, 28.06, 51.31, 20.81, 105.93, 125.45, 77.28, 5.67 and 8.28 mg/L, respectively. In heavy metal studies, the mean values of Cd, Cr, Cu, Fe, Ni, Pb and Zn were 0.24, 0.12, 0.35, 1.36, 0.14, 0.3 and 1.12 mg/L, respectively. The range of TVC, TC, TS, FC, FS, VC, SAC, SHC and PC were 7200 – 263000, 230 – 13900, 30 – 1020, 0 – 2800, 0 – 1600, 0 – 1000, 0 – 170, 0 – 220 and 0 – 1800 CFU/mL, respectively. The level of PI (FC/FS) in S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14 and S15 was 0, 0, 1.3, 3.8, 5.0, 6.7, 5.0, 12.7, 6.8, 12.4, 13.6, 13.6, 10.8, 2.0 and 1.8, respectively. Most of the sites included in this study are not suitable for bathing/other purpose with respect to the maximum permissible limits of FC and FS counts as per the standards laid by BIS (2009) and WHO (2003). Based on the detailed investigation, S8, S13, S14 and S15 are identified as highly vulnerable zones because of receiving large quantities of municipal/industrial wastes, human/animal excretions and other of Periyar river basin.

Keywords: Periyar river basin, Pollution index, Heavy metals, *Pseudomonas* sp.

Introduction

Water can be obtained from a number of sources, among which are streams, lakes, rivers, ponds, rain, springs, wells and oceans (Kolade, 1982). Potable water is defined as water that is free from diseases producing microorganisms and chemical substances deleterious to health (Ihekoronye and Ngoddy, 1985). Unfortunately, clean, pure and safe water only exists briefly in nature and is immediately polluted by prevailing environmental factors and human activities. About 95% of rural population living in India depends on surface/ground water for domestic use (Moharir et al., 2002). According to WHO, it is estimated about 80% of water pollution in developing country, like India is carried by domestic waste. Water from most sources is therefore unfit for immediate consumption without some sort of treatment (Raymond, 1992). Water quality problems stemming from contamination by sewage and runoff containing pathogenic organisms increase the incidence of illnesses among swimmers (Haile et al., 1999) potentially leading to extensive river closures. The runoff from sewage /industrial /shipping activities /agricultural /storm drains are significant source of trace of trace metals, indicator organisms and associated pathogens in Tamilnadu coastal zones. A wide range of pathogenic microorganisms can be transmitted to humans *via* water contaminated with faecal material. These include enteropathogenic agents such as Salmonellas, Shigellas, enteroviruses, and multicellular parasites as well as opportunistic pathogens like Pseudomonas aeroginosa, Klebsiella, Vibrio parahaemolyticus and Aeromonas hydrophila (Hodegkiss, 1988).

Pollution of the natural environment by heavy metals is a worldwide problem as these metals are indestructible and have toxic effects on living organisms when they exceed a certain concentration limit (MacFarlane and Burchett, 2000). High levels of heavy metals (e.g., cadmium, cobalt, mercury, copper lead, vanadium, and zinc) in aquatic ecosystems are regarded as serious pollutants, because they can be toxic and incorporated into the food chain (Kishe and Machiwa, 2003). Water quality guidelines provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values to protect specific water uses. Important physical and chemical parameters influencing the aquatic environment are temperature, rainfall, pH, salinity, dissolved oxygen and carbon dioxide. Others are total suspended and dissolved solids, total alkalinity and acidity, heavy metals, microbiological and other contaminants (Vignesh

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et al., 2015). Therefore, the accurate determinations of physiochemical, heavy metals and microbiological parameters in aquatic environment are of ultimate important for controlling their pollution, this study aims at providing additional information to existing data on aquatic quality assessments of this important water body.

Materials and methods

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 town. The Periyar is of utmost significance to the economy of Kerala. The Periyar basin spreads over an area of 5,398 square kilometres (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. But in middle stretches, industries are surrounded in these regions especially in Eloor, which discharge massive waste into the river.

Sampling

The water samples were collected from 15 different places within the Periyar river during monsoon 2015 for physiochemical, heavy metal and bacteriological analysis. The sampling sites were Idamalayar (S1), Kuttampuzha (S2), Boothathankettu (S3), Thodakayam (S4), Kodanad (S5), Kalady (S6), Marampally (S7), Aluva (S8), Kayantikkara (S9), Pathalam-Eloor (S10), Udyogamandal (S11), Adichilikkadavu (S12), Varapuzha (S13), Pizhala (S14) and Kochi estuary (S15). The river water samples were collected from 0 to 20 cm below the surface (Vignesh et al., 2012b, 2014). 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. One liter of water sample was acidified immediately with concentrated nitric acid to maintain the stable pH. The samples were transported into laboratory and processed within 12 hrs.

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 other parameters were determined according to the method described by APHA (1998) and Vignesh et al., (2015).

Heavy metal analysis

One liter of water sample was filtered through whatman No 1 filter paper and adjusted to acidic pH with HNO_3 taken in a separatory funnel. From a freshly prepared solution of amino-pyrolidine dithiocarbamate (APDC) 10 ml (3% w/v) were added into the funnel, and the mixture was shaken by a mechanical shaker for 10 min. Furthermore, 25 ml of methyl-isobutyl-ketone (MIBK) was added to this mixture and shaken for 15 minutes. The phases were allowed to separate and the top organic phase was collected. The bottom aqueous phase was again shaken with 25 ml of MIBK, and the organic phase was obtained and pooled with the previous phase. The pooled organic phase was mixed with 2 ml of 50% HNO_3, and shaken vigorously for 10 min to separate the bottom acid layer (Muthukumar et al., 2015).

Bacteriological analysis

All the selective media (Table 1) were prepared with the addition of Milli Q water and autoclaved properly. The bacterial populations in water samples were estimated by pure culture technique on selective medium plates with 100 µL of suitable dilutions (Vignesh et al., 2015). 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 (Kumarasamy et al., 2009; Vignesh et al., 2014).

Result and discussion

In the recent past, expanding human population, industrialization, intensive agricultural practices and discharges of massive amount of wastewater into the aquatic environment have resulted in deterioration of water quality. Indicator bacteria are certain species of bacteria used by health authorities to detect contaminated water. Each gram of human feces contains approximately 12 billion bacteria, among them may include pathogenic bacteria, such as *Salmonella*, *Shigella*, *E. coli* associated with gastroenteritis. Indicator bacteria are not themselves dangerous to the health but are used to indicate the presence of a health risk (Ramaiah and De, 2003). The most popularized known indicator bacteria are fecal coliforms, which are found in the intestinal tracts of warm blooded animals. The determination of trace metal contents in aquatic environment is one of the important indicators for the assessment of environmental pollution (Soylak et al., 1999). Runoff from different sources typically has elevated levels of enteric organisms and metals.

In monsoon 2015, the mean values of pH, TDS, EC, DO, BOD, COD, TA, TH, Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, N-NO_2 and O-PO_4 were 7.82, 551.35, 871.56 (µS/cm), 4.35, 6.85, 13.51, 119.83, 85.37, 39.70, 28.06, 51.31, 20.81, 105.93, 125.45, 77.28, 5.67 and 8.28 mg/L, respectively. The range of pH, TDS, EC, DO, BOD, COD, TA, TH, Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, N-NO_2 and O-PO_4 in monsoon season were 7.2 – 8.5, 108.2 – 1883.7, 171.7 – 2990 (µS/cm), 2.6 – 5.9, 4.6 – 12.2, 7.9 – 18.6, 22.4 – 251.6, 10.6 – 284.6, 2 – 134.6, 1.2 – 80.6, 3.8 – 136.2, 1.2 – 57.6, 18.3 – 224.6, 8.9 – 689.4, 17.4 – 150.8, 0.5 – 14.8 and 2.1 – 14.2 mg/L, respectively (Figure 1). The main anthropogenic impact caused by the seasonal population rise in aquatic regions during monsoon is the elevated organic load discharged into the water bodies, which are used as sewers (Sato et al., 2005).

In heavy metal studies, the mean values of Cd, Cr, Cu, Fe, Ni, Pb and Zn were 0.24, 0.12, 0.35, 1.36, 0.14, 0.3 and 1.12 mg/L, respectively. The range of Cd, Cr, Cu, Fe, Ni, Pb and Zn were BDL – 0.24, BDL – 0.12, 0.06 – 0.35, 0.18 – 1.36, BDL – 0.14, BDL – 0.3 and 0.08 – 1.12 mg/L, respectively (Figure II). High levels of heavy metals (e.g., cadmium, cobalt, mercury, copper lead, vanadium, and zinc) in aquatic ecosystems are regarded as serious pollutants, because they can be toxic and incorporated into the food chain (Kishe and Machiwa, 2003).

The mean concentration of microbiological parameters such as TVC, TC, TS, FC, FS, VC, SAC, SHC and PC were 81700, 6487, 545, 1304, 274, 179, 75, 93 and 233 CFU/mL, respectively. The range of TVC, TC, TS, FC, FS, VC, SAC, SHC and PC were 7200 – 263000, 230 – 13900, 30 – 1020, 0 – 2800, 0 – 1600, 0 – 1000, 0 – 170, 0 – 220 and 0 – 1800 CFU/mL, respectively (Figure 3). The level of PI (FC/FS) in S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14 and S15 was 0, 0, 1.3, 3.8, 5.0, 6.7, 5.0, 12.7, 6.8, 12.4, 13.6, 13.6, 10.8, 2.0 and 1.8, respectively. Environmental quality indicators and indices are a powerful tool for processing, analyzing and conveying raw environmental information to decision makers, managers, technicians or the public (Ramos et al., 2002). 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 comparison to the Mondovi and Zuari river system (Nagvenkar and Ramaiah 2009) and Tamirabarani river system (Vignesh et al., 2015) and Cauvery river system (Vignesh et al., 2013; Kumarasamy et al., 2009) microbial pollution indicator counts were generally lower in the Periyar river system. The results of this study in Periyar river basin indicated that it might need throughout impoundment and routine monitoring is needed to prevent the source and pathways of pollutions.

Results

Table I. Details of specific culture media used for quantitative bacterial analysis

S.No	Bacterial Indicators	Culture medium	Positive Colonies	References
1.	Total Viable Count **(TVC)**[a]	Nutrient Agar	All colonies counted	Nagvenkar and Ramaiah (2009)
2.	Total Coliforms **(TC)**[a]	MacConkey Agar	All colonies counted	Vignesh et al. (2012)
3.	Total *Streptococci* **(TS)**[a]	M *Enterococcus* Agar	All colonies counted	Kumarasamy et al. (2009)
4.	Fecal Coliforms **(FC)**[b]	M FC Agar	Blue colonies counted	Vignesh et al. (2014)
5.	Fecal *Streptococci* **(FS)**[a]	KF *Streptococcus* Agar	Red colonies counted	Vignesh et al. (2015)
6.	Vibrio Cholerae **(VC)** [a]	TCBS Agar	Yellow colonies counted	Muthukumar et al., (2015)
7.	*Salmonella* sp. **(SAC)** [a]	XLD Agar	Black colonies counted	Vignesh et al. (2013)
8.	*Shigella* sp. **(SHC)** [a]	XLD Agar	Pink colonies counted	Nagvenkar and Ramaiah (2009)
9.	*Pseudomonas* sp. **(PC)** [a]	Cetrimide Agar	All colonies counted	Muthukumar et al., (2015)

[a] Media plates were incubated at 37°C ± 1°C for 24–48 h; [b] Media plates were incubated 44.5°C ± 1°C for 24–48 h

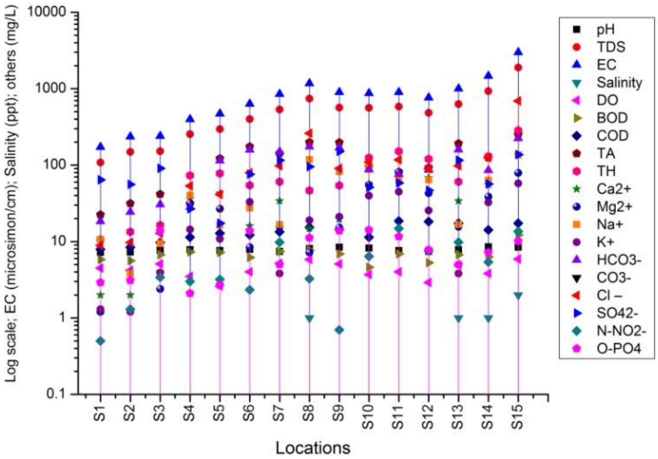

Figure 1. Concentration of physiochemical parameters in Periyar river

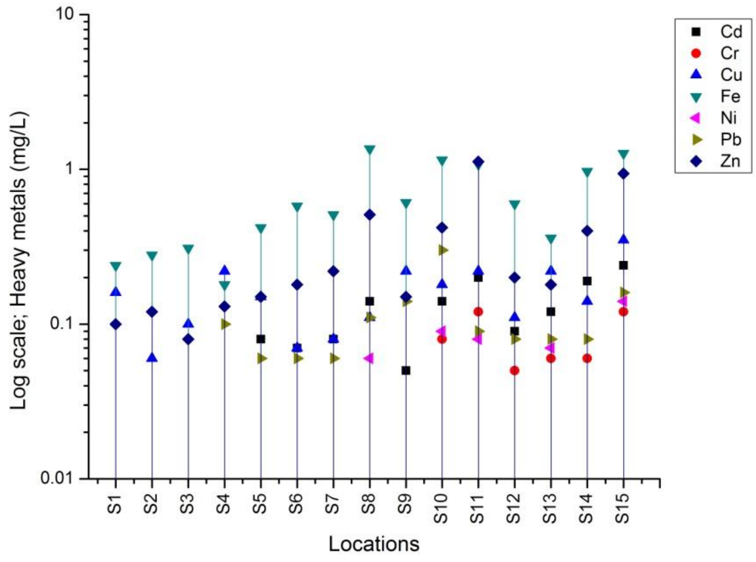

Figure II. Concentration of heavy metal parameters in Periyar river

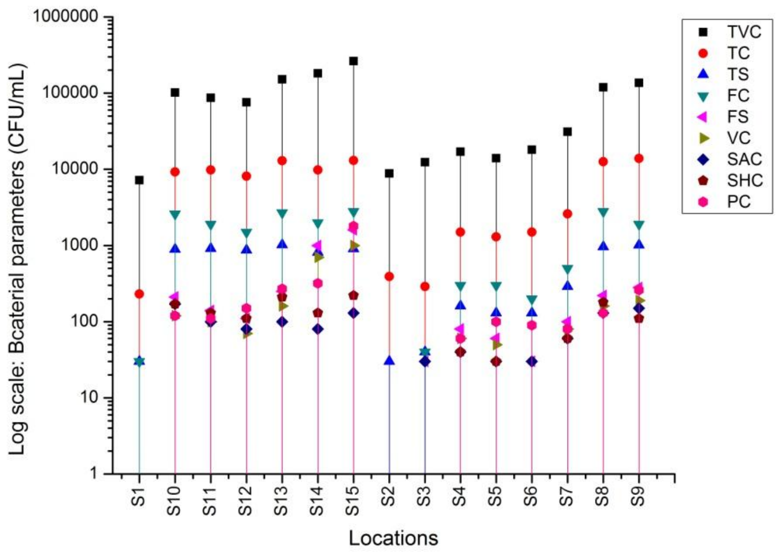

Figure III. Counts of bacterial parameters in Periyar river

Conclusion

The presence of indicator organisms and heavy metals may provide indication of water-borne problems and is a direct threat to human and animal health. This study in relation to pollution, have clearly revealed that there is significant presence of bacterial indicators of faecal pollution in most of the sites and the situation is not good for recreational purpose. 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. Most of the parameters in some locations are crossing the standard level which indicated that these are highly vulnerable regions. The base line data is much useful for all scientists, policy makers and resource managers working with environmental planning and management of such areas.

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