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An integrated approach on evaluation of hydrochemical parameters of riverine systems in Trivandrum urban area along with phosphate removal studies

Karthika V. S[1,2], Harsha Mahadevan[1,3], V. Viswadas[1,3], Vinu V. Dev [1,3], K. Anoop Krishnan[1,*]

Author Affiliations
[1]Hydrological Processes (HyP) Group, National Centre for Earth Science Studies (NCESS), Akkulam, Trivandrum-695011, India
[2]Department of Chemistry, Government Arts College, Thycaud, Trivandrum-695001, India
[3]Research Scholar, University of Kerala, Trivandrum, India

Corresponding Author
***K. Anoop Krishnan.** Hydrological Processes (HyP) Group, National Centre for Earth Science Studies (NCESS), Akkulam, Trivandrum-695011, India

E-mail: sreeanoop@rediffmail.com

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Abstract

The present work focuses on the quality aspects of riverinesystems in Trivandrum urban area during premonsoon season of 2017along with phosphate removal studies. Altogether, 11 water samples collected from Karamanariver, Killiyar and Parvathy Puthanar canal, andsubsequently analysed for various physic-chemical parameters. *In situ* measurements made for finding out the parameters such as pH, electrical conductivity, total dissolved solids and dissolved oxygen, which was in the range of 6.6–6.9, 265.6–6317.0 µS/cm, 4.7–65.5 mg/L and BDL–4.9 mg/L, respectively. The biochemical oxygen demand and alkalinity were found to be in the range of BDL–3.8 mg/L and 19.5–53.7 mg/L, respectively. Other parameters such as chloride (1.4–28.1 mg/L), sulphate (177.6–585.0 mg/L), nitrite (BDL–1.95 mg/L), silicate (7.1–27.3 mg/L) and phosphate (BDL–5.5 mg/L) were also determined. The results showed that most of the hydrochemical parameters were found to be within the standard limit prescribed by BIS(2012) except hardness, conductivity, TDS and Phosphate. In general, the study was helpful in evaluating the level of pollution in Trivandrum urban area during pre monsoon season. In the application side, the phosphate removal studies from Parvathy Puthanar were carried out using a novel zirconium impregnated bentonite clay.

Keywords: Physic-chemical parameters, Trivandrum urban area, bentonite clay, phosphate adsorption

1. INTRODUCTION

Freshwater resources are deteriorating day-by-day and now become a global problem. Therefore, the continuous monitoring of these precious resources are highly warranted to know the extent of pollution levels. The physic-chemical and biological characteristics of water bodies showed the health of a particular environmental system. Any of these parameters beyond the limit of maximum permissible level may cause serious threat to flora and fauna. Most of the rural communities depends upon rivers, streams, water reservoirs, ponds, lakes, etc for their domestic as well as agricultural needs, whereas urban people depends on these water sources for domestic and industrial purposes. The domestic, agricultural and industrial wastes have been discharged back to these water sources, from which these water resources get polluted and ultimately lead to different types of diseases and toxic effects. The human activities includeurbanization and conversion of agricultural land to impervious building and road increase the rate of urban runoff, the highly contaminated water streams enriched with nutrients deteriorates the water resources instantaneously leading to eutrophication of water bodies. Higher pollutant concentration leads to the degradation of water to a very large extend. Therefore monitoring of physic-chemical and microbiological quality of water required for the safe and sustainable life on earth.

Nutrient pollution monitoring studies give an input about their dynamics in the riverine systems. These studies are highly helpful in developing viable treatment techniques to reduce the concentration of nutrients such as phosphate, below the permissible limits. Among the various techniques, adsorption is found to be an efficient and ecofriendly technique in removing phosphate from aqueous phase. In this context, we designed our work by integrating the nutrient monitoring studies in the riverine systems along with its removal studies for maintaining a sustainable ecosystem in the river basins.

2. MATERIALS AND METHODS

Thiruvananthapuram district is the capital city of Kerala, situated between north latitudes 8º 17' and 8º 54' and east longitudes 76º 41' and 77º 17'., Karamana river, Killiyar river and Parvathy Puthanar are the three major rivers flowing through the urban part of the district, which is being mainly polluted by municipal wastes and sewerages. To monitor the nutrient flux, the fieldwork was conducted in these rivers during the pre monsoon season of 2017 and the study area is as shown in Figure 1.

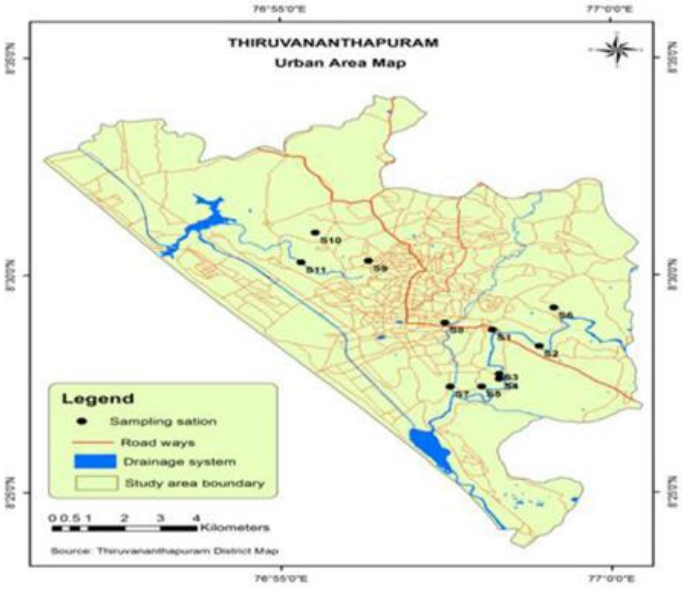

Fig. 1: Study Area

The laboratory analysis of samples was carried out using standard procedures [1]. The titrimetric methods were used for the determination of total alkalinity and acidity. The amount of DO and BOD was determined by EDTA titrimetric method. The colorimetric methods of analysis include the estimations of nitrite, sulphate, silicate and inorganic phosphate. All the chemicals used were of GR grade.The Mohr's argentometric titration method was used for chloride determination. At the same time calcium, magnesium and total hardness was determined by EDTA titrimetric method. The adsorption experiments were carried out using the riverine water collected from different riverine streams of Trivandrum urban area using the zirconium pillared bentonite clay.

3. RESULTS AND DISCUSSIONS

3.1. Hydrochemical parameters

The permissible limit for pH prescribed by WHO is 6.5–8.5. The pH below 4.8 and above 9.2 is deleterious for aquatic organisms especially for fish [2]. The selected samples shows a range of 6.6–6.9, implies slightly acidic nature of water.Conductivity defines the water quality and it indicates the level of dissolved solids in water. Collected water samples show conductivity values varies from 265.6 –6317µS/cm. Conductivity was found to be high at station 4 and low at station 7. The TDS values are ranged from 4.73– 645.50 mg/L. The variation of nitrite in all three riverine systems is presented in Figure 2.

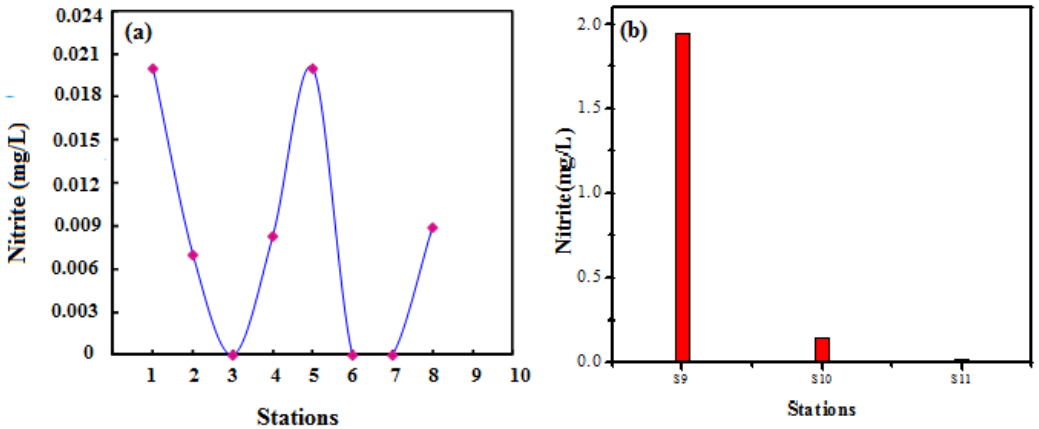

Fig. 2: Variation of Nitrite (mg/L) (a) Karamana (S2-S7), Killi River (S1, S6- S8) Bar diagram showing Variation of Nitrite (mg/L) (b) Parvathy Puthanar

The DO concentration more than 5 mg/ L favours good growth of flora and fauna. In the present study, DO was varied between BDL–4.48 mg/L.In the present study, BOD ranges between BDL–3.84 mg/L. Water sample collected from Karamana river Basin (station 3) having high value of BOD.

Alkalinity is usually imparted by the carbonate or bicarbonate ions of natural water. The collected samples have alkalinity in the range of 19.52– 53.68 mg/L. In natural freshwater, high concentration of chlorides may be treated as an indicator of sewer pollution. In the present study, chloride ranges between 1.4–28.1 mg/L. A maximum value of 28.1 mg/Lwas found at S11, while a minimum value of 1.4 mg/L was found in S1.Domestic sewage and industrial effluents, besides biological oxidation of reduced species may add Sulphate to natural water. In our study area, Sulphate concentration varies from 5.85–177.6 mg/L. Station 5 show higher value of Sulphate concentration.Nitrite concentration in the present study varies from BDL–1.95 mg/L. Water sample from Parvathy Puthanar exhibit maximum nitrate (1.95 mg/L).Phosphate determination may help to judge if the pollution is due to domestic sewage or not [3]. Under normal condition, the concentration of phosphate should not exceed 5mg/L. In the selected samples phosphate present in the range 0.014–5.47 mg/L, which indicates high degree of phosphate pollution.In our study area, silicate values range from 7.07–27.33 mg/L. Overload of silicate may influence the composition of other nutrients especially phosphate and nitrite. Enrichment of silicate reduced the nutrient concentration. This also

implies serious environmental issues and deterioration.Hardness of water is caused by polyvalent ions like Ca^{2+}, Mg^{2+}, iron etc, which is dissolved in water. Water containing calcium and magnesium are said to be hard.In the present study, most of the stations exhibit higher hardness.

3.2 Application of zirconium pillared bentonite clay for cleaning Parvathy Puthanar

Adsorption is not only an economical technique, but also simple in operation as the variables are rather flexible and the separation is almost complete with in a short time.In order to study phosphate adsorption,water samples collected from Parvathy Puthanar (man–made canal) is used. The concentrations of phosphate in Parvathy Puthanar at different stations are shown in Table 1.

Table 1: The phosphate concentration at different stations, Parvathy Puthanar

Stations (Parvathy Puthanar)	Amount of Phosphate (mg/L)
Station 1	5.47
Station 2	3.71
Station 3	2.23

Batch adsorption studies were performed at normal experimental conditions for the removal of phosphate from the samples collected from Parvathy Puthanar using the zirconium pillared bentonite clay. In our experiments, phosphate concentration of 15mg/L showed a maximum adsorption of 91.0 %, when the real samples are spiked with 10 mg/L of phosphate solution. The % of adsorption and spiking details are given in Table 2.

Table 2: The adsorption percentage of phosphate at various spiking events

Station	Phosphate Concentration (mg/L)	Adsorption (%)
Station 1	5.47 mg/L (phosphate present in real system) + 10 mg/L (Spiking)	91%
Station 2	3.71 mg/L (phosphate present in real system) + 12 mg/L (Spiking)	79%
Station 3	2.23 mg/L (phosphate present in real system) + 13 mg/L (Spiking)	87%

4. CONCLUSIONS

A detailed hydrochemical profiling of three major riverine systems in the urban area of Trivandrum district carried out. Among the parameters, conductivity, hardness, total dissolved solids and Phosphatewere found to be above the maximum permissible levels. Considering the nutrient profile, sulphate shows maximum concentration (5.85–177.66 mg/L) compared to other nutrients such as nitrite (BDL–1.95 mg/L), silicates (7.07–27.33 mg/L) and phosphate (BDL–5.47 mg/L). The water samples collected from Parvathy Puthanar exhibit maximum concentration of nitrates and phosphates shows the high degree of pollution among other rivers.The result of the study concluded that the present status of the river water system in Trivandrum Urban area is almost suitable for all aquatic lives, domestic and agricultural uses.Necessary initiatives, therefore, should be taken against river bank erosion, use of excessive fertilizers and pesticides to improve the overall quality of the water for sustainable management. Moreover, further research and periodic monitoring of river water quality is of importance for the improvement or maintenance of the river waters. Also, the newly developed adsorbent was found to be highly efficient for phosphate removal.

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