

Chapter 34

Assessment of Water Pollution Using GIS: A Case Study in Periyar River at Eloor Region



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34.1 Introduction

Water is one of the most essential elements for the survival of human life and health of the environment. Water quality testing is an important part of environmental monitoring. BOD, DO, pH, Conductivity, Turbidity, Acidity, Alkalinity, TDS etc. are some of the major Water Quality Parameters which needs to be assessed to determine the extent of pollution in a water body. GIS is found to be an effective tool which helped in providing solutions for water sources problems such as to assess water quality and to understand the natural environment. Water Quality Assessment can be done using Spatial Variation Map of Water Quality Parameters using GIS.

The river Periyar, originates from Sivagiri Peaks of Sundaramala in Tamil Nadu. Total length of the river is about 300 km with a catchment area of 5.396 km². During its journey to Arabian Sea, it provides drinking water for several towns including Cochin. Periyar has been performing an important role in shaping the economic prospects of Kerala, as it help in power generation, domestic water supply, irrigation, tourism, industrial activities and fisheries. Due to these reasons the river has been named as “Lifeline of Kerala”. However in recent days due to excess contamination, lower reaches of the river are referred as “a cesspool of toxins”. Many times the Periyar River was found to flow in red colour. This might have occurred because of the ejection of effluents from industries.

Eloor region, about 20 km from where the river Periyar meets the Arabian Sea, is the industrial hub of Kochi, the commercial capital of Kerala and is home to Kerala’s largest industrial cluster. Among 282 industries in Eloor, around 110 are chemical industries. These industries discharge their effluents into the river on

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several instances without treatment. Eloor is the 35th toxic hotspot in the world identified by Green Peace in 1999.

34.2 Study Area

Eloor is the industrial hub of Ernakulam, Kerala, belonging to the Alangad Block in Paravur Taluk which is located in between 76° 16' and 76° 20' Eastern Longitude and 10° 05'–10° 02' North Latitude having a population of about 30,092 (according to 2011 census). It is an island of 14.21 km² formed between two distributaries of River Periyar. Location map of study area is shown in Fig. 34.1.

34.3 Methodology

Water quality data collection, spatial variation map creation and analysis were done.

34.3.1 Data Collection

A preliminary questionnaire survey was conducted at Eloor to gather details regarding extend of pollution in the area. The conclusions drawn from the questionnaire survey was that Periyar River water which was the major source of water for domestic purposes in earlier days is currently not depended for any purpose. So, the water is supplied from the Aluva Water Supply which is free of cost. Also, fishing can be seen to be declining due to pollution. Water samples were collected from 12 different locations in Eloor as shown in Fig. 34.2. The sample collection was done in accordance with IS 3025 (Part 1), 1987. Water quality data was



Fig. 34.1 Location map of the study area

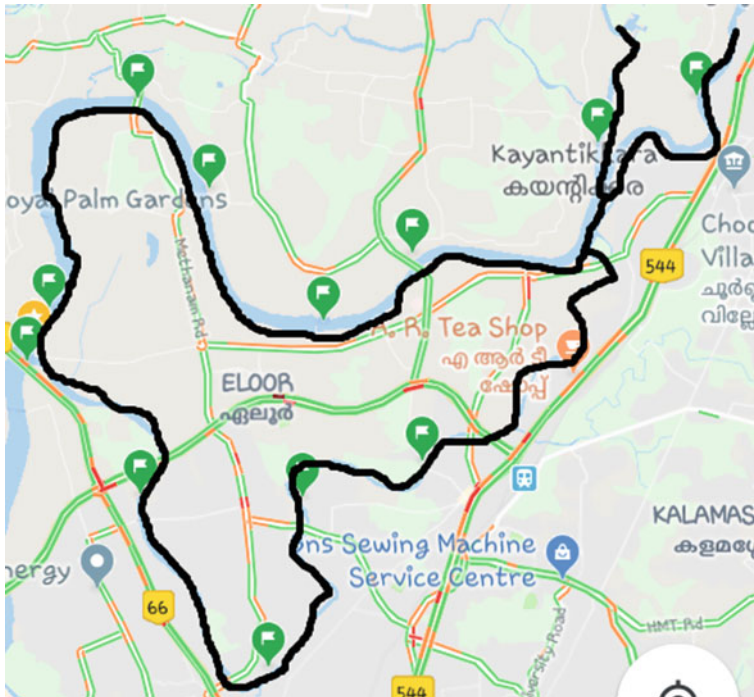


Fig. 34.2 Sampling points

obtained from Laboratory testing and compared with data obtained from Kerala State Pollution Control Board (KSPCB, Gandhi Nagar). Map of the required study area was extracted from Google Earth.

34.3.2 Spatial Variation Map

Spatial variation map of various water quality parameters were prepared in ArcGIS 10.3. The variability of different water quality parameters like BOD, DO, pH, Conductivity, Turbidity, Acidity, Alkalinity, TDS were plotted in the ArcGIS using IDW (Inverse Distance Weighted) interpolation method.

34.4 Results and Discussion

In order to determine the quality of water in Periyar River flowing around Eloor region, spatial variation map of BOD, DO, pH, Conductivity, Turbidity, Acidity, Alkalinity, TDS were generated.

34.4.1 *Spatial Variation Map*

The spatial variation map for different water quality parameter such as BOD, DO, pH, Conductivity, Turbidity, Acidity, Alkalinity, TDS were generated using IDW (Inverse Distance Weighted) interpolation method.

Bio-chemical Oxygen Demand (BOD). BOD is the amount of dissolved oxygen needed by aerobic biological organisms to breakdown organic material present at a specific time and temperature. As per IS 10500:2012, the acceptable limit of BOD for drinking water ranges between 0 and 5 mg/l. High concentration of BOD indicates poor water quality. The spatial variation map for BOD was prepared and is shown in Fig. 34.3a. The minimum and maximum BOD values were obtained as 1.21 mg/l and 70.56 mg/l respectively. It was observed that in the north-eastern side of Eloor, there was a trend of increase in BOD, where the clustering of large number of industries in the north eastern region gave an explanation for the same. Also the BOD level was found to be higher in Northern side which is densely populated area.

Dissolved Oxygen (DO). It is defined as the amount of oxygen essential for aquatic life. According to IS 10500:2012, the acceptable limit of dissolved oxygen for drinking water is 5 mg/l or more. The spatial variation map for Dissolved Oxygen (DO) was prepared and is shown in Fig. 34.3b. The maximum and minimum value for DO was obtained as 11.19 mg/l and 6.70 mg/l respectively.

pH. pH is the logarithm of reciprocal of hydrogen ion concentration and hence becomes an indicator of acidity and alkalinity. According to IS 10500:2012, the acceptable limit of pH for drinking water is between 6.5 and 8.5. The spatial variation map for pH was prepared and is shown in Fig. 34.3c. The maximum and minimum value for pH was observed to be 6.71 and 3.80 respectively. The major portion of Periyar River in Eloor region was found to have a pH ranging from 3.80 to 4.12 which was highly acidic and was not suitable for drinking purposes.

Conductivity. It is the ability to conduct or transmit heat, electricity or sound. It is measured using conductivity meter. According to IS 10500:2012, the acceptable limit of conductivity is 150 $\mu\text{S}/\text{cm}$ and permissible limit is 500 $\mu\text{S}/\text{cm}$ for drinking water. The spatial variation map for conductivity was prepared and is shown in Fig. 34.3d. The maximum and minimum value for conductivity was observed to be 160.37 $\mu\text{S}/\text{cm}$ and 54.56 $\mu\text{S}/\text{cm}$ respectively. The river in north western regions of Eloor had highest conductivity which exhibits a trend of increasing to reach the maximum towards west and then decreasing towards south and south eastern parts of Eloor.

Turbidity. It is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. It is measured by using turbidity meters which works on the principle of measuring the interference caused by the water sample to the passage of light rays. The measurement of turbidity is a key test of water quality. According to IS 10500:2012, the acceptable limit of turbidity is 1 NTU and permissible limit is 5 NTU for drinking water. The spatial variation map for turbidity was prepared and is

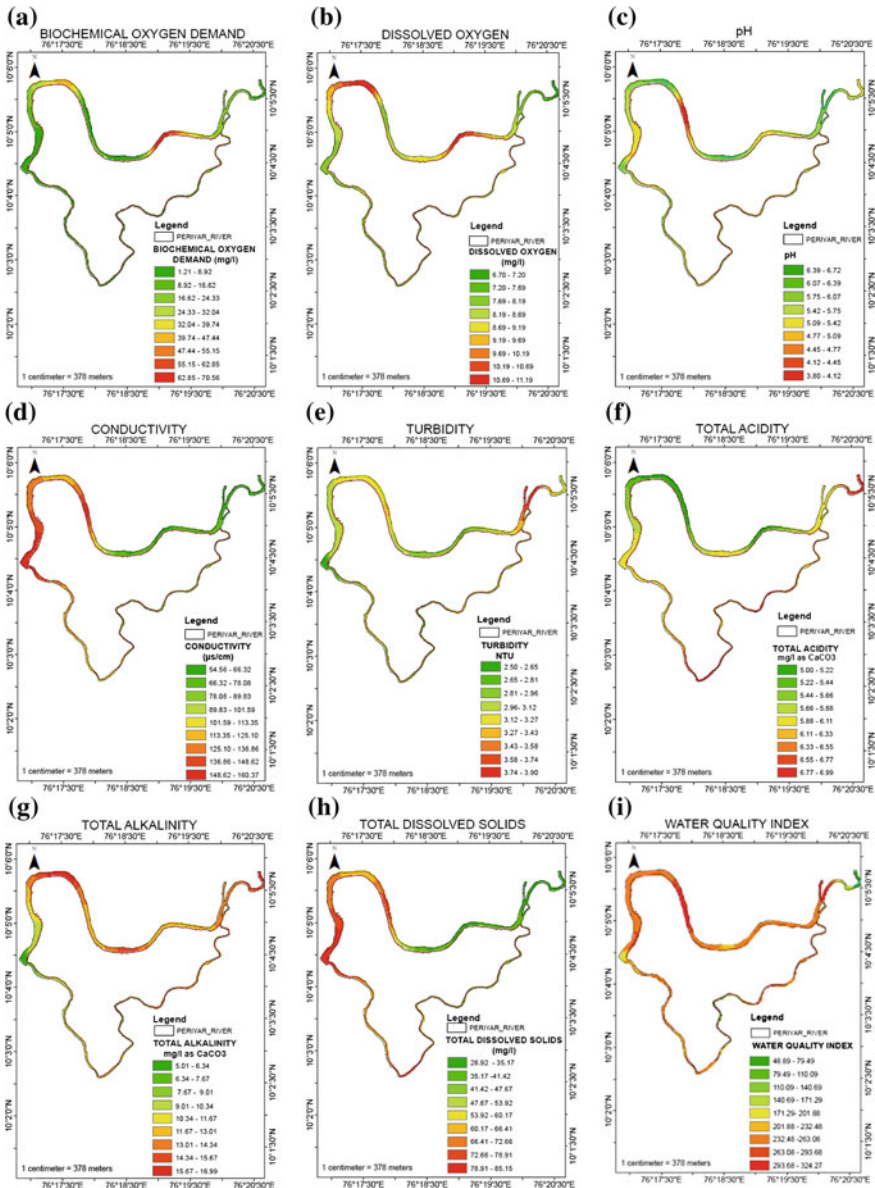


Fig. 34.3 Spatial variation map of a BOD, b DO, c pH, d conductivity, e turbidity, f total acidity, g total alkalinity, h TDS, i WQI

shown in Fig. 34.3e. The maximum and minimum value for turbidity was obtained as 3.89 NTU and 2.50 NTU respectively. The river water in north eastern regions of Eloor had highest turbidity which was the upstream portion which goes on decreasing to the minimum towards west.

Acidity. Acidity is the quantitative expression of water's capacity to neutralize a strong base to a designated pH and an indicator of how corrosive water is. Results of the acidity tests are reported in mg/L CaCO₃. According to IS 10500:2012, there is no specific range for acidity and the maximum value and minimum value observed from the spatial variation map was 6.99 mg/L CaCO₃ and 5 mg/L CaCO₃ respectively. The spatial variation map for acidity was prepared and is shown in Fig. 34.3f. The south eastern regions and upstream portion of Eloor had highest acidity and the northern parts had lowest value.

Alkalinity. Alkalinity is a measure of the capacity of water to neutralize acids. Results of the acidity tests are reported in mg/L CaCO₃. According to IS 10500:2012, the acceptable limit and permissible limit are 200 mg/L CaCO₃ and 600 mg/L CaCO₃ respectively. The maximum value and minimum value observed from the spatial variation map was 16.99 mg/L CaCO₃ and 5.01 mg/L CaCO₃ respectively. The spatial variation map for alkalinity was prepared and is shown in Fig. 34.3g. It was observed that alkalinity was increasing from upstream to downstream and a decrease was observed in the western region of Eloor.

Total Dissolved Solids. The total amount of dissolved solids is measured using conductivity meter in mg/L. The electrical conductivity (μS/cm) of a water sample is converted into approximate concentration of total dissolved solids (ppm), the unit i.e., μS/cm is multiplied by a conversion factor called conductivity factor whose value usually ranges between 0.54 and 0.96. According to IS 10500:2012, the acceptable limit and permissible limit are 500 mg/L and 2000 mg/L respectively. The maximum value and minimum value observed from the spatial variation map was 85.16 mg/L and 28.92 mg/L respectively. The spatial variation map for total dissolved solids was prepared and is shown in Fig. 34.3h. It was observed that total dissolved solids increases from upstream to downstream and reached its maximum at the western region of Eloor region.

Water Quality Index (WQI). Water Quality Index was determined by weighted arithmetic water quality index method.

$$WQI = \frac{\sum Q_i W_i}{\sum W_i} \quad (34.1)$$

$$Q_i = \frac{100(V_i - V_o)}{(S_i - V_o)} \quad (34.2)$$

$$W_i = \frac{K}{S_i} \quad (34.3)$$

Table 34.1 Water quality rating as per weighted arithmetic water quality index method

| WQI value | Rating of water quality |
|-----------|----------------------------------|
| 0–25 | Excellent |
| 26–50 | Good |
| 51–75 | Poor |
| 76–100 | Very poor |
| >100 | Unsuitable for drinking purposes |

$$K = \frac{1}{\sum \frac{1}{S_i}} \quad (34.4)$$

where, WQI = Water Quality Index, W_i is Weight for each water quality parameter, V_i is Estimated concentration of i th parameter in the analyzed water, V_o is Ideal value of this parameter in pure water, S_i is Recommended standard value of i th parameter and K is Proportionality constant.

Rating of Water Quality as per weighted arithmetic WQI method is shown in the Table 34.1. The maximum value and minimum value observed from the spatial variation map was 302.05 and 48.25 respectively. The spatial variation map for WQI was prepared and is shown in Fig. 34.3i. It is observed that that river flowing around the Eloor region was completely polluted as the WQI was more than 50 in that region, even exceeding up to 300 which indicated the unsuitability for drinking purposes. While the upper reaches of Eloor region had a water quality index of 48.25 which was good water quality for drinking purposes. From the above statements it is clear that the water entering the Eloor region was pure but as it flows around this region it gets polluted due to the high emission of industrial wastes and the rapid growth of urbanization.

34.5 Conclusion

In this paper, the GIS technology have been thoroughly and successfully utilized in order to assess the water pollution in Periyar River at Eloor Region. Laboratory tests of the water samples from that region gave the necessary data for the preparation of spatial variation map. BOD, DO, pH, Conductivity, Turbidity, Acidity, Alkalinity and TDS were the parameters selected in order to represent the water pollution in the Periyar River and they were used as input criteria in GIS by IDW (Inverse Distance Weighted) interpolation method so as to generate spatial variation map. The results and relevant studies conducted have confirmed that the river flowing around the Eloor region is completely polluted as the water quality index was found to be more than 50 in that region even exceeding up to 300 which indicated the water was inappropriate and unfit for drinking purposes even though the upper reaches of Eloor region has a water quality index of 48.25 which is good water quality for drinking purposes. From the above statements it is evident that the

water entering the Eloor region is pure and harmless but as it flows around this region it gets polluted due to the presence of industries and the rapid growth of urbanization. It could be inferred that application of GIS technologies related with water quality studies, plays an important role in the environmental management and assessment studies of Rivers which are found to be easier and economical than conventional methods. The maps shows the extent of pollution and the vulnerability of water at a particular area which indicates the risk of water contamination. The discussed maps can be used by land use planners, hydrogeologists, water managers or various environmentalists which helps them to identify the rate and extent of pollution of the area.