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Study of Trace Metals in Different Sites of Neyyar River Basin, Kerala, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Rivers are one of the most important waterbodies depended on by the whole environment for their daily lives. But now a days, water-related incidents are increasing much more because of the improper lifestyle of human beings. Trace metals are one of the main causes of the contamination of water. The present study deals with the analysis of five trace metals using Atomic Absorption Spectrophotometer at five selected sites in Neyyar River. The study period is from March 2022 to February 2023. According to rainfall the study period was portioned into three main seasons, monsoon (March 2022 to June 2022), post monsoon (July 2022 to October 2022) and pre monsoon (November 2022 to February 2023). Trace metals such as nickel, zinc, copper, iron, and manganese were selected for this study. Statistical analysis was done by the help of Two-way analysis of variance (ANOVA). It shows variation in some parameters. The water in the Neyyar River is in good condition.

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1. INTRODUCTION

Rivers are getting polluted day by day, mainly due to urbanisation, the environment, and human-induced pollution habits. Heavy metals are one of the major pollutants affecting aquatic organisms. The term heavy metal refers to a group of metalloids with densities greater than 4 g/cm^3 and greater than water [1]. Currently, environmental pollution caused by metals is one of the major problems facing the world. An increase in the number of heavy metals directly affects the entire environment. In order to reduce pollution occurring in the environment and control the degradation of water resources, it is important to detect the concentration of metals in water. Contamination of river water with heavy metals is hazardous to human health. Heavy metals are also called trace metals because they are found in small concentrations in the universe. Heavy metals such as mercury, lead, and aluminium are the most common toxic metals that can accumulate in living organisms through water bodies. Metals including chromium, zinc, cadmium, lead, copper, and nickel are highly toxic in rivers [2]. Many researchers have already studied trace metals in freshwater around the world. A study on trace metals in the Neyyar River was conducted by Ancy Mol et al. [3]; Change in dissolved zinc concentration during the COVID-19 lockdown phase in a coastal area of West Bengal by Agarwal et al. [4]; Seasonal analysis of heavy metals in the Muvattupuzha and Periyar Rivers was conducted by Anju et al. [5]; a study on the physico-chemical and heavy metal characteristics of the Noel River, Tamil Nadu, India, was done by Babunath et al. [6]; contamination of surface water in the Neyyar River by heavy metals was analysed by Badusha and Santhosh [7]; pollution in soil water vegetation irrigated with ground water by heavy metals was analysed by Bharose et al. [8]; human and environmental risk assessment of toxic metals in water and sediment of the Kaveri River was studied by Bhuvaneshwari et al. [9]; a study on heavy metals in Narmada River water was done by Hussain et al. [10]; distribution of heavy metals in the Godavari River basin was done by Jakir et al. [11]; the presence of heavy metals in aquatic environments raises critical worries with respect to their immediate effect on biota and their backhanded ramifications for human wellbeing, done by Khan et al. [12]; a study on water in the Kor River, Iran, was done by Mokarram et al. [13]; Heavy Metal Contamination in Surface Water of Harike Wetland, India: Source and Health Risk Assessment conducted by Naqash et al. [14]; A time-series record during the COVID-19 lockdown shows high concentrations of dissolved heavy metals in the Ganges River was done by Shukla et al. [15]; a study on heavy metal contamination in the Ganga River was done by Singh et al. [16] and Integrated assessment of trace element contamination in sediments of a typical aquaculture bay in China was studied by Wang et al. [17].

2. MATERIALS AND METHODS

2.1 Study Area

Neyyar is the southernmost river in Kerala, located in the Thiruvananthapuram district of Kerala, India. It originates from Agasthyarkoodam in the Western Ghats and flows through Neyyattinkara taluk to reach the Arabian Sea. It is 56 km long and is located between 8° 36' 56.2428'' N and 77° 14' 45.5604'' E to 8° 18' 20.0124'' N and 77° 4' 47.0064'' E (Fig 1). Five sites of the river Neyyar, including Arattu Kadavu (S1), Arakkunnu (S2), Vadakkekotta (S3), Alatharackal (S4), and Panchikattu Kadavu (S5), were selected for the present study. There is a distance of more than 2 km between each site.

2.2 Sampling Methods

Monthly samples were collected from each site early in the morning from March 2022 to February 2023. Two-litres of fresh polyethylene-sterilized bottles, previously soaked with 10% nitric acid and rinsed with double-distilled water, were used to collect the sample. Immediately after collection, the samples were acidified with 4 mL of pure nitric acid to maintain a constant pH of 2 over the normal pH range of 6–7 with the help of a pH meter. Usually, 2 ml of HNO_3 is used per litre of water sample. Then it is stored in sampling kits in order to maintain a temperature of 4 °C. The collected samples are immediately transferred to the laboratory for metal analysis. The analysis of metals from water samples was done by following the standard methods of APHA [19] and the FSSAI manual of methods of analysis of foods and water [18]. According to the rainfall, the whole study period is divided into 3 seasons, i.e., monsoon (March 2022 to June 2022), post monsoon (July 2022 to October 2022), and pre monsoon (November 2022 to February 2023).

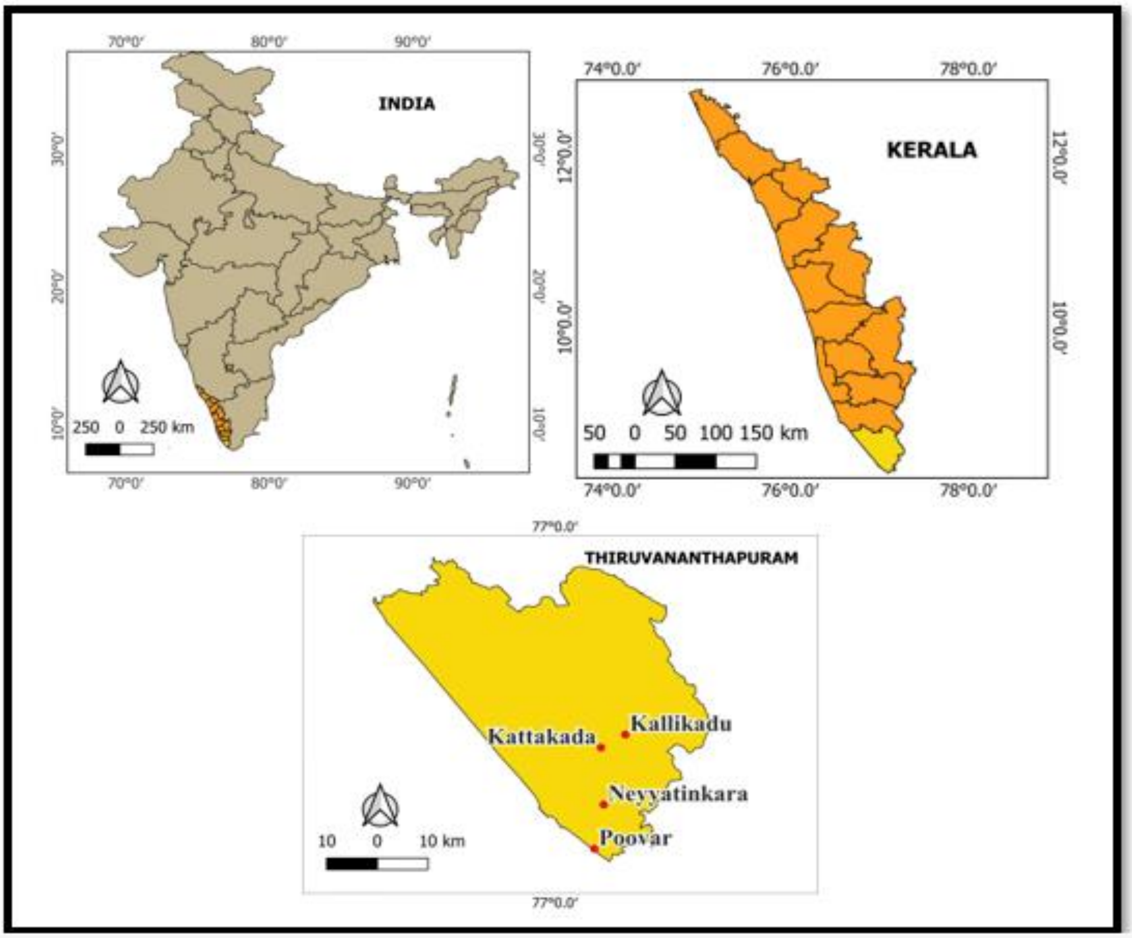

Fig. 1. Map showing the study area

2.3 Metal Analysis

Analysis of metals such as nickel (Ni), zinc (Zn), copper (Cu), iron (Fe), and manganese (Mn) from water samples was carried out using basic methods (APHA, FSSAI Manual of Water Analysis). The collected water samples were acidified with concentrated nitric acid before being transferred to the lab. An atomic absorption spectrophotometer (AAS) is a technique used to determine the concentration of metal elements in a sample. In this method, light of a specific wavelength is passed through atomic vapor element, and the resulting absorption is measured by the intensity of the light. Flame atomic absorption spectroscopy (flame AAS) and electrothermal atomic absorption spectroscopy (graphite furnace) are the two techniques involved in atomic absorption spectrophotometer (AAS) for metal determination in water. Analysis of zinc in water samples was performed using the flame AAS method and analysis of nickel, copper, iron, and manganese in water samples was performed using the electrothermal AAS-graphite furnace method [19]. A two-way analysis of variance (ANOVA) was used here for each heavy metal between seasons and between sites.

3. RESULTS AND DISCUSSION

Trace metals are of great importance in environmental and health problems due to their high toxicity. Major sources of trace metals are weathering, mining, agricultural runoff from fields, the burning of fuels, smelting, electroplating, incineration, and industrial effluents entering water bodies. Annual averages of all trace metals during the study period were compared with standard drinking water quality standards, including WHO [22], USEPA [20], and BIS [21] (Table 1). The annual variation of metals such as nickel, zinc, copper, iron, and manganese are illustrated in Table 1. Two-way ANOVA for selected trace metals is depicted in Table2.

Table 1. The comparison of trace metals in water in Neyyar River with national and international drinking water quality standards

Metals	Annual Average (In mg/L)					BIS (IS 105000) (In mg/L)		WHO guideline (In mg/L)		USEPA (In mg/L)	
	S1	S2	S3	S4	S5	A	B	A	B	A	B
Nickel	0.112	0.084	0.097	0.092	0.143	-	0.2	-	0.1	-	-
Zinc	1.747	1.562	2.325	2.116	1.875	-	5	-	5	-	5
Copper	0.349	0.307	0.291	0.328	0.368	0.05	0.3	1	2	1	-
Iron	0.274	0.500	0.692	0.674	0.923	0.3	1	0.3	-	-	-
Manganese	0.032	0.021	0.025	0.028	0.030	0.05	0.3	0.05	0.5	-	0.05

Table 2. Two-way analysis of variance (ANOVA) of trace metals in water between sites and stations

Trace Metals	Comparison	F	p-value	F-crit
Nickel (mg/L)	Between Sites	1.641	0.255	3.838
	Between Season	4.744	0.044	4.459
Zinc (mg/L)	Between Sites	0.622	0.660	3.838
	Between Season	0.362	0.707	4.459
Copper (mg/L)	Between Sites	0.386	0.814	3.838
	Between Season	1.554	0.269	4.459
Iron (mg/L)	Between Sites	19.809	0.003	3.838
	Between Season	4.376	0.052	4.459
Manganese (mg/L)	Between Sites	1.141	0.403	3.838
	Between Season	1.470	0.286	4.459

Nickel is a ferromagnetic, hard metal that is white in colour. The primary source of nickel in drinking water is the leaching process that occurs when water meets pipes and fittings. Fertilisers, detergents, metal plating, fuel combustion, and coins are the main sources of nickel in water. The monthly variation of nickel at five different sampling sites in the present study area is shown in Fig 2. The levels of nickel during monsoon, post monsoon, and pre monsoon are 0.068 mg/L at S2 to 0.123 mg/L at S3, 0.083 mg/L at S2 to 0.195 mg/L at S5, and 0.030 mg/L at S3 to 0.133 mg/L at S5. The monthly variation of the amount of nickel in selected sites of the Neyyar River is shown in Fig 1. Two-way ANOVA shows no significant difference in nickel between sites hence, hypothesis is accepted and there is significant difference between seasons hence, hypothesis is rejected (Table 2). In the present study, analytical data of nickel is within the permissible limit of BIS [21], WHO [22] and USEPA [20] except sites S1 and S2 (Table 1).

Zinc is a naturally occurring metallic element. The main sources of zinc are chemical industries, domestic waste, and soil, which are mixed with rainwater and discharged into rivers. The levels of zinc at each site during monsoon, post monsoon, and pre monsoon include 1.072 mg/L at S2 to 2.581 mg/L at S3, 1.522 mg/L at S3 to 2.792 mg/L at S5, and 1.095 mg/L at S1 to 2.874 mg/L at S3. The monthly variation of the amount of zinc in selected sites of the Neyyar River is shown in Fig 3. Two-way ANOVA shows no significant difference in zinc between sites hence hypothesis is accepted and there is no significant difference between seasons hence, hypothesis is accepted (Table 2). In the present study, analytical data of zinc is within the permissible limit of BIS [21], WHO [22] and USEPA [20] (Table 1).

Normally, a small amount of copper is found in water, which is because of anthropogenic and natural sources. Naturally by weathering, from rocks and soils. The levels of copper at each site during monsoon, post monsoon, and pre monsoon include 0.180 mg/L at S3 to 0.384 mg/L at S4, 0.258 mg/L at S4 to 0.379 mg/L at S2, and 0.232 mg/L at S2 to 0.497 mg/L at S5. The monthly variation of the amount of copper in selected sites of the Neyyar River is shown in Fig 4. Two-way ANOVA shows no significant difference in copper between sites hence, hypothesis is accepted and there is no significant difference between seasons hence, hypothesis is

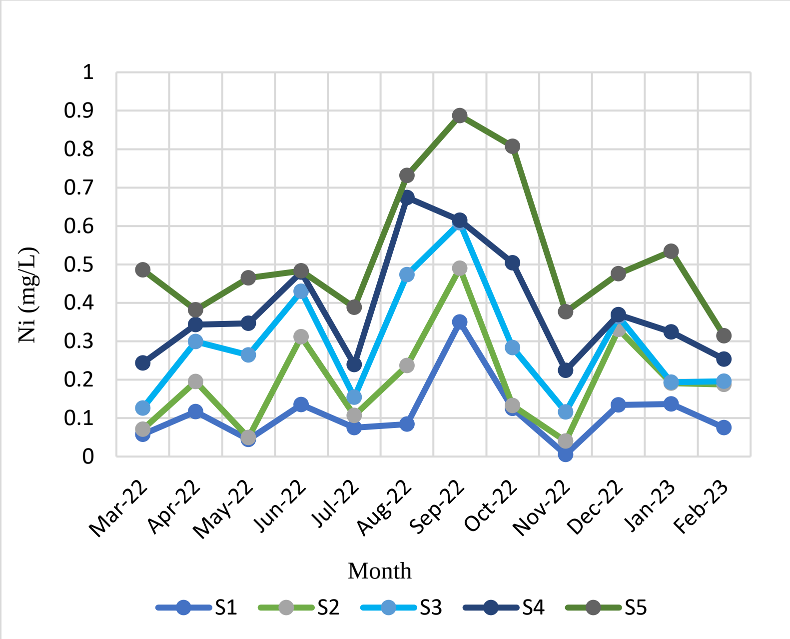

Fig. 2. Monthly variation of amount of nickel in selected sites of the Neyyar River

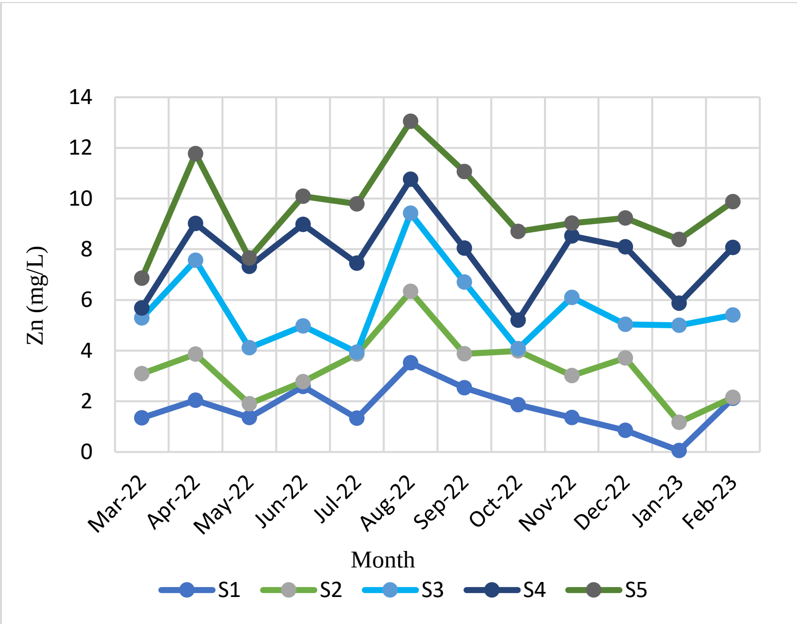

Fig. 3. Monthly variation of amount of zinc in selected sites of the Neyyar River

accepted (Table 2). In the present study, analytical data of copper is within the permissible limit of BIS [21], WHO [22] and USEPA [20] (Table 1).

Iron is included in the trace metals. It is found in earth's crust as 5% level. The levels of iron at each site during monsoon, post monsoon, and pre monsoon include 0.256 mg/L at S1 to 0.927 mg/L at S5, 0.259 mg/L at S1 to 0.771 mg/L at S5, and 0.304 mg/L at S1 to 1.099 mg/L at S5. The monthly variation of the amount of iron in selected sites of the Neyyar River is shown in Fig 5. Two-way ANOVA shows significant difference in iron between sites hence, hypothesis is rejected and there is no significant difference between seasons hence hypothesis is accepted (Table 2). In the present study, analytical data of iron is within the permissible limit of BIS [21], WHO [22] and USEPA [20] (Table 1).

The levels of manganese at each site during monsoon, post monsoon, and pre monsoon include 0.019 mg/L at S2 to 0.030 mg/L at S5, 0.025 mg/L at S3 to 0.048 mg/L at S1, and 0.013 mg/L at S2 to 0.036 mg/L at S4. The monthly variation of the amount of manganese in selected sites of the Neyyar River is shown in Fig 6. Two-way ANOVA shows no significant difference in manganese between sites hence hypothesis is accepted and there is significant difference between seasons hence, hypothesis is rejected (Table 2). In the present study, analytical data of zinc is within the permissible limit of BIS [21], WHO [22] and USEPA [20] (Table 1).

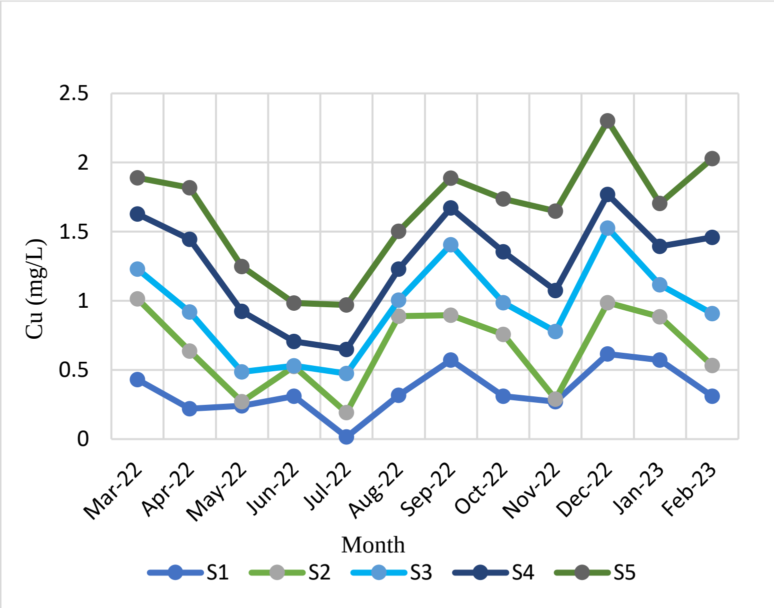

Fig. 4. Monthly variation of amount of copper in selected sites of the Neyyar River

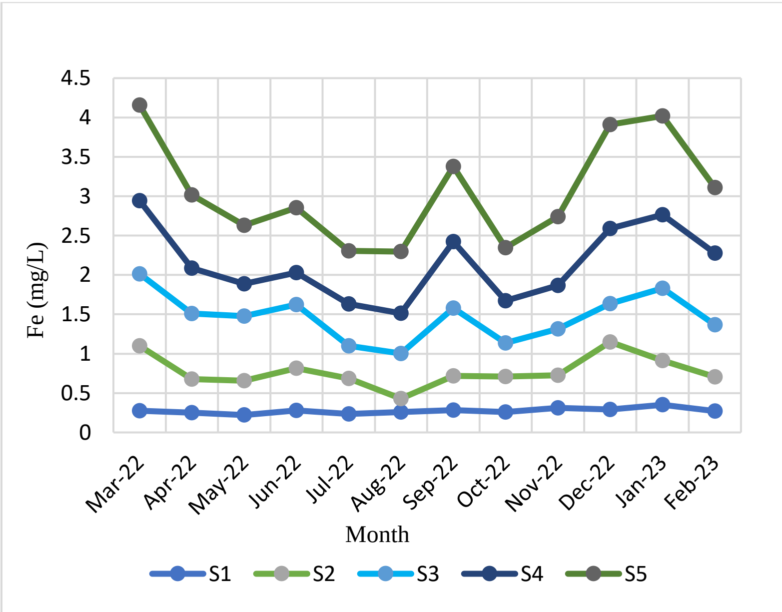

Fig. 5. Monthly variation of amount of iron in selected sites of the Neyyar River

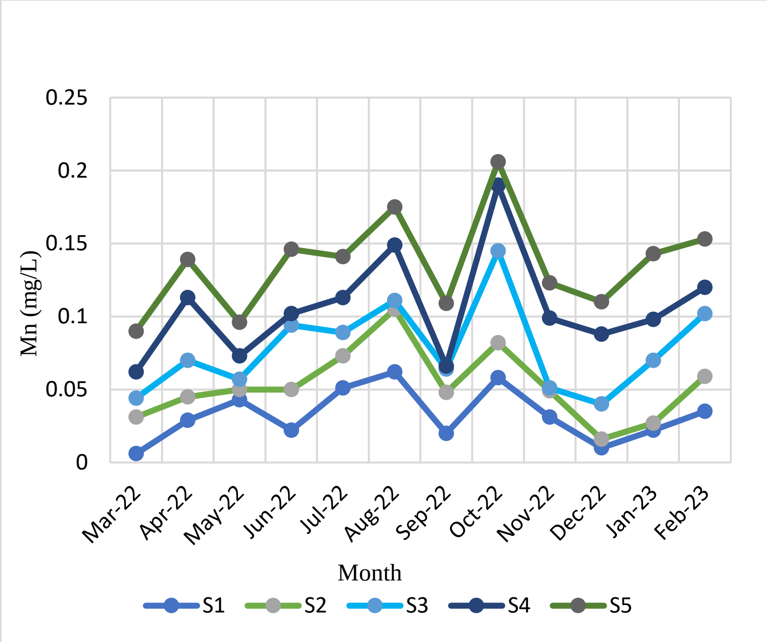

Fig. 6. Monthly variation of amount of manganese in selected sites of the Neyyar River

4. CONCLUSION

In the Neyyar River, all trace metals except nickel were found within permissible limits as compared to WHO [22], BIS [21] and USEPA [20] drinking water standards. The concentration of metals was low in S1 and increased when it reached S5. The increase in the concentration of trace metals in the downstream area was due to the presence of anthropogenic pollutants. Overall, the quality of Neyyar river water is good and can be used for further purposes such as drinking, agriculture, industrial uses, domestic purposes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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