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A Correlation Study of the Major and Trace Metals Present in the Riverine Sediments of the River Kortalaiyar in Tamilnadu, India

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Abstract The objective of the present study is to assess the contamination level in Kortalaiyar River which plays an inevitable role in the water supply, food security and economic development of the Chennai city. The growing competition in the quantitative and qualitative demand of water from domestic, industrial and economic sector seek the approach to water resource management. Rivers are the carriers of the contaminants due to the flocculation of metals in the sediments. Sediment samples were collected from 30 locations starting from Poondi Lake to Ennore creek to analyze the geochemistry of the river. The geochemical analysis was carried out for Pre Monsoon and Post Monsoon seasons for two consecutive years. The trace metals and the major metals analyzed are considered for the ecotoxicolgy by evaluating their availability and interrelationships using Pearson's correlation matrix .The river is found to be contaminated with heavy metals from various anthropogenic inputs. Hence, measures are to be taken to conserve this fluvial system.
Key Words: Kortalaiyar River, Geochemistry, Pearson's Correlation matrix, Trace metals, Heavy metals, Ecotoxicology.

Introduction

Rivers are water ways of strategic importance across the world, which provides main water resources for domestic, industrial and agricultural purposes[1]. Rivers take the major role of integrating and organizing the landscape and moulding the ecological setting of a basin. They are the prime factors that controls global water cycle .In the hydrologic cycle, they are the most dynamic agents of transportation[2] **.**

It has long been known that, in the right concentrations, many metals are essential to life and ecosystems[3]. Chronic low exposures to metals can lead to severe environmental and health effects. Similarly, in excess, these same metals can be poisonous[4]. The main metal threats are associated with heavy metals such as lead, arsenic, cadmium, and mercury. Unlike many organic pollutants, which eventually degrade to carbon dioxide and water, heavy metals will tend to accumulate in the environment, especially in lake, rivers or other aquatic sediments[5]. Heavy metals are closely connected with environmental deterioration and the quality of human life, and thus have stimulated concern all over the world. More and more countries have signed treaties to monitor and reduce heavy-metal pollution[6]. Moreover, this field of research has been receiving increasing scientific attention due to its negative effects on life[7].The metals in water and biota indicates the presences of natural or anthropogenic contamination. The problem is not restricted to soils with high metal levels alone, such as those of mining areas, but includes those with moderate to low metal contamination also[8].Metal contamination in aquatic environments has received much concern due to its toxicity, large quantity and persistence in the environment, and consequent accumulation in aquatic habitats. Heavy metal residues in contaminated habitats may accumulate in microorganisms like aquatic flora and fauna, which may enter into the human through food chain transfer and result in health problems[9]. The change in environmental conditions such as pH, redox potential, naturally organic matters and sediment texture may affect their mobilization of metals from sediments[10]. The trace metals associated with coarse particles may deposit on the upstream area, while dissolved trace metals and those associated with fine particles could be transported to downstream to the surrounding aquatic area by physical transportation[11].The metal contamination is a real threat and heavy metal pollution is a serious worldwide problem for wildlife conservation due to the metals toxic effect on the biota[12].Hence, it is vital to detect the metal contamination in the water bodies.

Experimental

Study Area

Kortalaiyar River is one of the three rivers that flow in the Chennai metropolitan area. It is also known as Kosasthalaiyar. The river has a length of 136 Km and it originates near Kaveripakkam in Vellore district and finally drains into the Bay of Bengal. It has a catchment area in North Arcot District with a branch near Kesavaram Anicut.The main Kosasthalaiyar River flows into Poondi reservoir.The water flows through Thiruvallur district from the Poondi reservoir, enters into the Chennai metropolitan area, and joins the sea at Ennore creek. There are two check dams across the river, one at Tamaraipakkam and the other at Vallur. Whenever the flood gates of Poondi reservoir are opened .a considerable volume of water drains into the sea through Kortalaiyar River near the Ennore Creek. The area for present study is 30 sampling points starting from Poondi reservoir to Ennore creek. The geographical representation of the River is Shown in fig-1

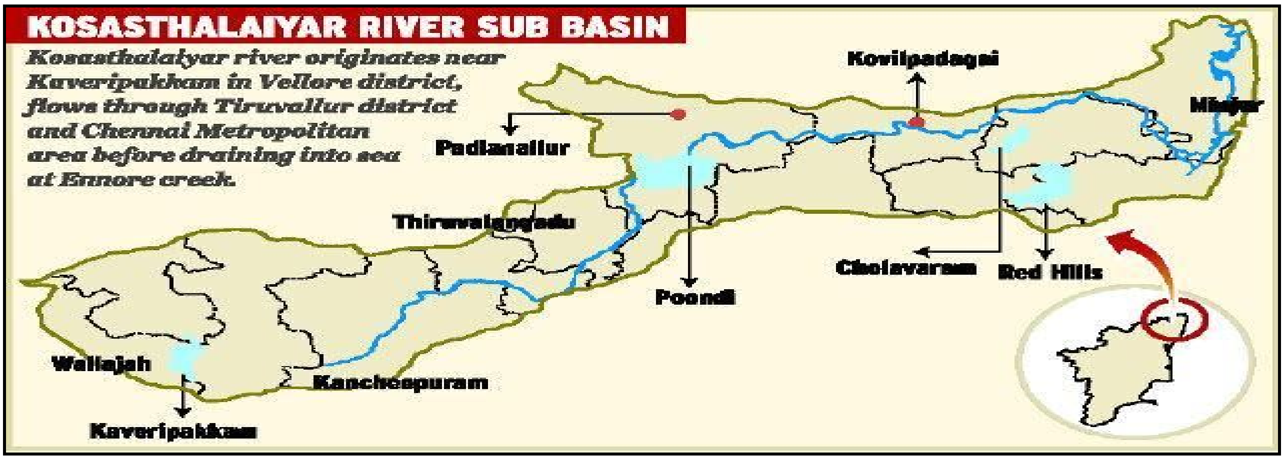

Fig-1

Sediment Sampling And Analysis

Thirty samples of surface sediments were collected in a air dried Zip Lock covers for each season, Pre-Monsoon (PRM) and Post-Monsoon (POM) for two consecutive years from August 2011 to August 2013. The geographical locations of the sampling stations were marked using a Garmin eTrex hand-held GPS. The samples were collected from the surface of the river. The collected samples were tightly sealed in a zip lock cover and labeled before adopting laboratory geochemical analysis. The samples were dried in air and then powdered using an agate mortar. The powdered samples were sieved for further analysis[13].

Results and Discussion

The Pearson Correlation Coefficient (*r*) measures the strength and direction of linear relationships between two or more random variables and ranges from −1 to 1[14]. In the present study *r* is used to describe the interrelationships between the elements analyzed at a significance level (p) of < 0.01. Although there is no direct implication of the cause and effect relations depicted by the intermetallic correlation associations, they indicate that these elements travel in the same pathways through the aquatic system[15]. The positive correlation between metals shows an association or interaction between the metals in a particular study area, but that on the other hand, these metals might have similar sources of input[16].

The correlation between the various metals is studied using Pearson's Correlation coefficient Matrix. The results indicate that in PRM and POM, there is close correlation between N, P and K among themselves and also with other metals. There is similarity in the correlation of these metals with heavy metals too. Nitrogen correlates strongly with heavy metals like Ni, Cu, Zn, Co, Pb and Cd. Potassium follows Nitrogen in the correlation pattern. Phosphorous shows strong correlation with Ni, Cu, Co and Pb. Since N, P and K have strong association with all other metals in the sediment, their existence as major metals have been justified. The variation of major metals in PRM is shown in Fig-2 and the variation of major metals in POM is shown in Fig-3.It is inferred from the graph that the concentration of metals on an average is high in PRM than in POM The concentration of Nitrogen varies between 179 mg/kg and 953 mg/kg, Phosphorous between 165 mg/kg and 437 mg/kg and Potassium between 265 mg/kg and 507mg/kg. Barium, Calcium and Magnesium varies between 201 mg/kg to 412 mg/kg, 543.9 mg/kg to1024.3 mg/kg and 302.7 mg/kg to 881 mg/kg respectively. The variation of these metals in the PRM and POM is shown in Figure-1 and Figure-2 respectively. Although Ca, Mg and Ba do not have any significant correlation between them or with any other major element, if the significance level is changed to $p<0.05$ instead of $p<0.01$ some positive relations among them and the rest of the major elements are revealed, explaining the same pattern followed by them as the rest of the elements, but not with the same degree of similarity.

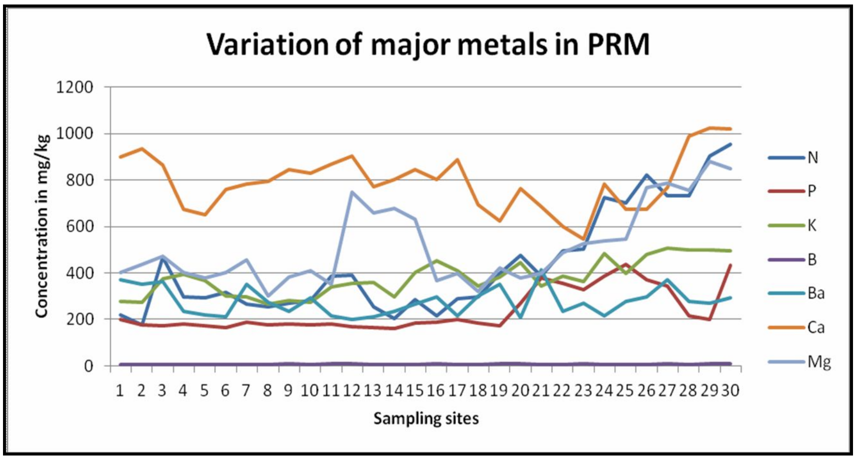

Fig-1

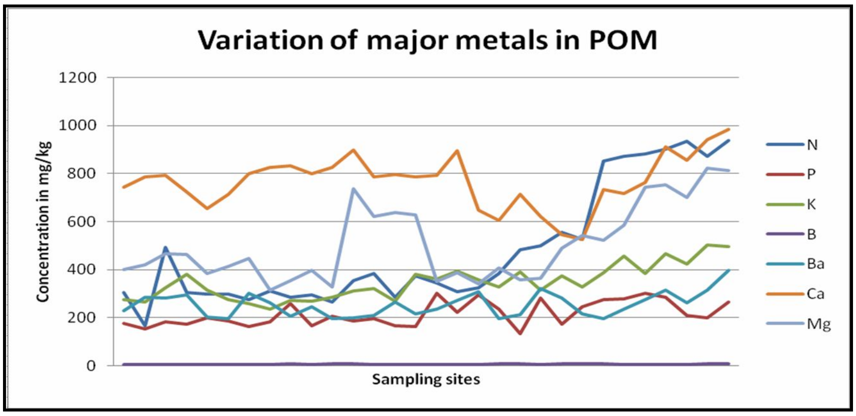

Fig-2

Considering Iron, most of the heavy metals like Cr, Ni, Cu, Co, Pb, Cd etc tend to show close associations with it. This shows the distribution pattern with the local redox conditions[17]. Along the heavy metals, Fe is fairly correlated to N, K and Mg. Chromium shows strong correlation with Ni and Pb in PRM and POM. It also has significant association with N, P, K, Mg, Cu, Mn, Fe, Co, Cd. There is a very strong correlation between Cd, Zn, Cu, Pb, Co, Cr and Ni . Associations between metals are important, as they determine the bioavailability and potential toxicity to fish in an aquatic system[18, 19].The correlation between Cr, Ni, Cu, Fe, Zn, Co, Pb and Cd in PRM and POM is tabulated in Table-1and Table-2 respectively.

Table-1

	Cr	**Ni**	**Cu**	**Fe**	**Zn**	**Co**	**Pb**	**Cd**
Cr	1							
Ni	0.917801	1						
Cu	0.589729	0.601509	1					
Fe	0.562264	0.510001	0.58735	1				
Zn	0.482912	0.598728	0.737999	0.601567	1			
Co	0.580286	0.667128	0.83711	0.644827	0.830499	1		
Pb	0.71575	0.882375	0.655849	0.406082	0.698781	0.755646	1	
Cd	0.587567	0.650264	0.8452	0.683404	0.865303	0.919428	0.731282	1

Table-2

	Cr	**Ni**	**Cu**	**Fe**	**Zn**	**Co**	**Pb**	**Cd**
Cr	1							
Ni	0.888091	1						
Cu	0.607862	0.618604	1					
Fe	0.593601	0.515367	0.600627	1				
Zn	0.408673	0.532496	0.705217	0.457458	1			
Co	0.572198	0.632986	0.882466	0.671461	0.765027	1		
Pb	0.743031	0.876631	0.720348	0.537072	0.680284	0.757168	1	
Cd	0.597853	0.661992	0.917495	0.649492	0.802439	0.950816	0.772077	1

A strong correlation between two heavy metals may be an occurrence of strong dependence of both the metals on the same causal factor[20]. The significant seasonal differences in intermetallic relations indicate that metal mobility and association in both the water and sediment interface also depends on the limnochemistry, hydrodynamics (especially water volume) and particularly the temperature of the water phase[21]. It is evident from the correlation matrix that there exists a close proximity between the major metals and the heavy metals. The metals show synergistic and ameliorative effects in the sediment phase, more so for the water-sediment interface.

Conclusion

The present study reveals the correlation between the various metals present in the River Kortalaiyar. The relationship between the metals predicts the possible source of contamination. The strong correlation between the major metals and the trace metals indicate the enrichment of these metals in due course of time. As the majority of the of the elements show high positive correlations, the distribution of the metals is expected to be similar throughout the river course. Overall, the data also signifies the need for a regular approach towards monitoring on enrichment of trace metals and the present study is part of a larger regular monitoring program in the aquatic environments of south India. This type of development plans and remedial measures can serve as an example and will help to reduce the level of enrichment in the aquatic environment especially in major populated industrialized cities.

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