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SEASONAL VARIATION IN SELECTED HEAVY METAL CONCENTRATIONS IN THE NANDALAR ESTUARY EAST COAST OF TAMIL NADU-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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ABSTRACT

Estuaries are dynamic environments with respect to metal speciation, as many of the physicochemical parameters that affect metal equilibria are subject to change as fresh and marine waters mix. pH, hardness, dissolved organic matter concentration, and ionic strength will all significantly affect the partitioning of copper within and between solid and solution phases. Heavy metals have been present in nature for many years, but their toxicity is increasing as a result of anthropogenic activities. There is an increase in heavy metal contamination in many inland waters as well as estuarine ecosystems nowadays. The aim of the present study is to evaluate seasonal variation in some selected heavy metal concentrations in the Nandalar estuary on the east coast of Tamil Nadu, India, during the 2020 to 2021 period. The monsoon season saw the highest appearance of followed the order of Cu (0.043mg/L) > Cr (0.027mg/L) > Zn (0.024mg/L) > Pb (0.023mg/L) > Ni (0.012mg/L) > Cd (0.007mg/L) > Hg (>0.00001mg/L) metals compared with the pre and post monsoon seasons, while present metals were higher than the Fisheries and aquatic life standard reference value. Overall, the metal of Cu (0.032 to 0.043 mg/L) was the higher concentration found to be in the Nandalar estuary. The seasonal variation analysis showed to higher content of copper was observed in Nandalar estuary, Tamil Nadu.

Keywords: Nandalar estuary; heavy metals; copper metal; estuarine ecosystems.

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1. INTRODUCTION

"Estuarine sediments constitute a fundamental step in the pathway of contaminants to the ocean as estuaries filter the fluvially fluxed metals derived from both natural and anthropogenic sources" [1]. Sediment, a complex and dynamic matrix derived from weathering of crustal rocks, can be considered as a data-source of environmental information, because chemical constituents of sediments reflect time integrated information of local respectability [2] "Trace metals are significantly hazardous pollutants in aquatic environments, even at very low concentrations" [3]. "In this sense, study of the occurrences, fate and distribution of trace metals in estuarine environments has received major attention, mainly because of the persistent toxic effects of heavy metals as well as their ability to be accumulated within compartments of these environments" [4].

Water contamination with heavy metals has become the topic of headache now-a-days as it possesses the status of being poisonous, abundant and persistent [5]. "Hazardous chemicals especially heavy metals is being released into aquatic systems worldwide as by product of man made activities. There's an increase in heavy metal contamination in many inland waters as well as estuarine ecosystems nowadays. Estuaries are important because they have enormous habitats like open water, reefs, sediments, sand and mud flats, seagrasses, salt marshes, and mangroves. An estuary also supports various species of marine plants and animals. The estuaries are also important for the environment because they filter pollutants like pesticides, herbicides, and heavy metals" [6,7]. "Estuaries are important pathways for the transport of dissolved and particulate materials from continents into the oceans. The wastes of anthropogenic and industrial origin are of complex character and have a considerable percentage of heavy metals. The heavy metals in the brackish water phase generally deposit on the sediment bed or remain in a dissolved state in the water column, depending on the nature of chemical species, which are influenced by factors like the aquatic environment" [8]. The aim of the present study is to analysis the selected heavy metal in pre-monsoon, monsoon and post-monsoon in the Nandalar estuary on the east coast of Tamil Nadu, India, during the 2020 to 2021 period.

2. MATERIALS AND METHODS

2.1 Location of Sample Collection

The Nandalar estuary (Fig. 1) water sample was collected from the River - Kaveri (Cauvery) branch; Place Tharangambadi, Nagapattinam District, Tamil Nadu [9]. During the study period (2020-2021), samples of water were collected fortnightly; the data were pooled seasonally to understand the seasonal effect. The three distinct seasons were pre-monsoon (March to May), monsoon (June to Sept.) and post-monsoon (Oct. to Dec.) periods. The sea water samples were collected from five different points of each site and were mixed together to prepare an integrated sample.

2.2 Heavy Metal Analysis in Water Samples

Bio concentration of heavy metals (Cd, Cu, Cr, Pb, Ni, Hg, Zn) in water samples collected in different seasons were measured by pre concentration methodology described by Abdullah *et al.* [10]. "The Standard Solution of different micronutrient cation are prepared preferably by using their foil or wire (AR Grade). Dissolve 0.1g of the foil in dilute HCl (1+1) and make the volume to one liter with deionized water to obtain 100 mg/mL (i.e. mg/L or ppm) solution of every micronutrient cation. Alternatively, analytical grade salts can be used to prepare Stock Standard Solution of different micronutrients. 100 ppm stock solution of the Zinc, Copper, Iron, Manganese, Boron and Molybdenum were formed by mixing required quantity of salts in distilled water for elemental analysis of soil. Diethylene triamine penta acetic acid method was used for elemental analysis. Weight 10 g of soil sample and add 20 mL of the extractant DTPA solution added to it. The flask was shake continuously for 2 hours preferably on a horizontal shaker, and filter through Whatman filter paper No. 42. The filtrate was then analysed for vatious metals with Solar-AAS2-(UK made) atomic absorption spectrophotometer". Lindsay and Norvell [11] gave "the method commonly used for determined on an Atomic Absorption spectrophotometer (AAS)".

3. RESULTS AND DISCUSSION

"Heavy metals can be subdivided into two main groups: essential and non-essential metals. One group includes iron (Fe), manganese (Mn), magnesium (Mg), cobalt (Co), zinc (Zn), copper (Cu) which are essential elements for the growth and life cycle of organisms, but are toxic at high concentrations. Heavy metals of second group consist of lead (Pb), cadmium (Cd), mercury (Hg), arsenic (As) which are toxic even at low concentrations, have no biological functions in the metabolisms of aquatic organisms" [12]. "Heavy metals have been present in nature for many years [7], but their toxicity is increasing as a result of anthropogenic activities such as mining, urbanization, oil extraction, and sea reclamation. Soil gets polluted by heavy metals after the use of sewage and waste

water for irrigation. These heavy metals are absorbed by the plants and consumed by the animals or humans, and that is how they enter into the food chain. An increased amount of heavy metals in soil and water systems due to human actions leads to a high risk to the environment".

"Estuaries are dynamic environments with respect to metal speciation, as many of the physicochemical parameters that affect metal equilibria are subject to change as fresh and marine waters mix. pH, hardness, dissolved organic matter concentration, and ionic strength will all significantly affect the partitioning of copper within and between solid and solution phases" [13]. This in turn can strongly influence the uptake of the metals by aquatic organisms. The present study carried out seasonal variation in some selected heavy metal concentrations in the Nandalar estuary on the east coast of Tamil Nadu, India (2020 to 2021). The monsoon season saw the highest appearance of followed the order of Cu > Cr > Zn > Pb > Ni > Cd > Hg metals compared with the pre and post monsoon seasons, while present metals were higher than the fisheries and aquatic life standard reference value and with the exception of lead, represented in table 1 and Fig. 2. Among the various season, monsoon has a higher concentration of copper than pre and post monsoon. Open oceans have very low concentrations of copper, typically 0.12–0.38 µg/L [14]. "The concentration of copper in estuaries is usually higher than open ocean, due to the contribution of terrestrial sources (eg runoff), inputs from rivers, domestic effluents and urban storm water" [13].

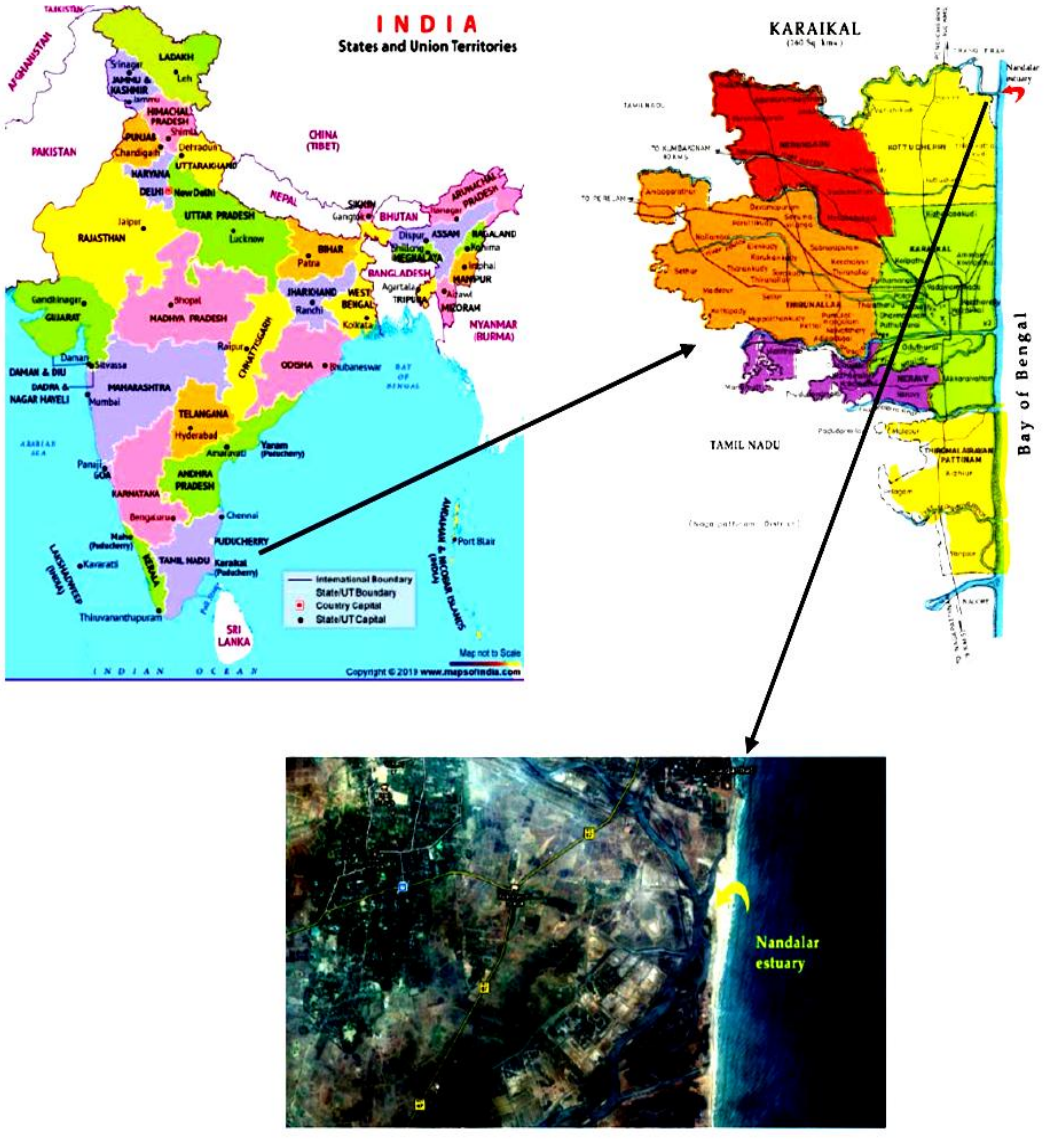

Fig. 1 Location of Nandalar estuary (http://www.casmbenvis.nic.in/Database)

Table 1. Heavy metals analysis of Nandalar estuary water of east coast of Tamil Nadu (2020-2021)

Parameters	Season			Mean ± SD	* Fisheries and aquatic life Std.
	Pre-monsoon	Monsoon	Post-monsoon		
Cadmium (mg/L)	0.006	0.007	0.006	0.006±0.0005	0.005
Chromium (mg/L)	0.026	0.027	0.031	0.028±0.002	0.02-0.005
Copper (mg/L)	0.032	0.043	0.041	0.038±0.005	0.001
Lead (mg/L)	0.017	0.023	0.020	0.02±0.003	0.1
Mercury (mg/L)	>0.00001	>0.00001	>0.00001	0.00001	0.00001
Nickel (mg/L)	0.013	0.012	0.011	0.012±0.001	0.01
Zinc (mg/L)	0.017	0.024	0.021	0.020±0.003	0.01

** Maximum allowable concentrations of selected water quality variables for Fisheries and aquatic life uses (Water Quality Assessments, 1996).*

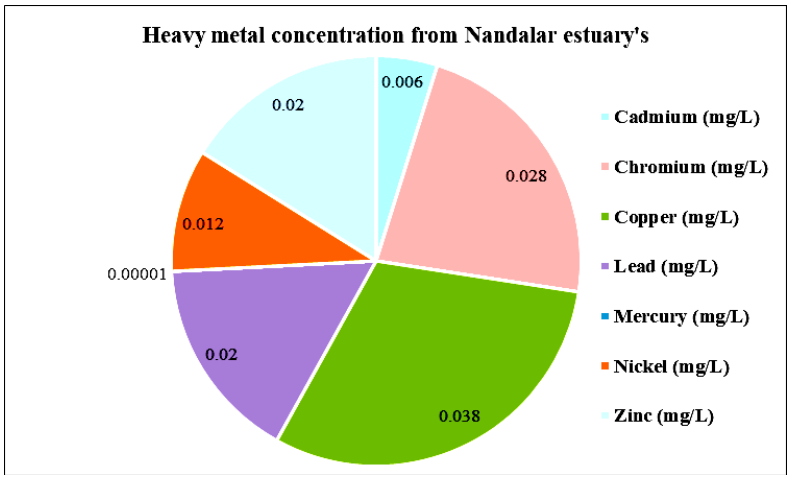

Fig. 2. Graphical representation of some heavy metals analysis of Nandalar estuary water of east coast of Tamil Nadu

Overall, the heavy metal concentration from Nandalar estuary's water is copper content was high, compared with other metals in all seasons, represented in Table 1. In this study, the concentrations of Cu (0.032 to 0.043 mg/L) was the maximum abnormal concentrations of selected water quality variables for fisheries and aquatic life uses [15] references. Similarly, as Abdullah *et al.* [10] agreed, heavy metal concentrations in estuary water were low, with the exception of Cu in the Likas and Kota Belud estuaries in Sabah, where concentrations were 0.042±0.001 mg/L. "The distribution of dissolved heavy metals followed the order Cu > Cr > Zn > Pb > Ni > Cd > Hg all the three season and exhibited a unique seasonal pattern with highest values during monsoon and lowest during pre-monsoon. This variation may be attributed to huge run-off from the adjacent land masses during the monsoon" [16,8]. "The wastes containing appreciable concentration of heavy metals find their way into the coastal water and adjacent estuaries. It also consists the impact of relevant physico-chemical parameters on the metal levels of the ambient media as these variables have considerable effect on the process of compartmentation of heavy metals in the estuarine system" [17]. Hypothesis of the work was higher copper content in the estuary due to industrial effluent discharge in the area.

"Copper is an essential heavy metal plays an important role in various biological processes including oxidative phosphorylation, gene regulation and free radical homeostasis as essential cofactor. However, when its concentration exceeds metabolic requirements, it becomes harmful and play a major role among pollutants. Aquatic pollution undoubtedly has direct effects on fish health and survival. Heavy metals are regarded as serious pollutants of the aquatic environment because of their persistence and tendency to be concentrated in aquatic organisms. Most heavy metals released into the environment find their way into the aquatic phase as a direct input by various anthropogenic processes, atmospheric deposition and erosion due to rainwater" [18]. Copper plays a protective role against oxidative damage caused by variety of xenobiotic. The antioxidant

effects of ceruloplasmin and metallothionein seems to be the mechanism by which copper protects under these conditions. Ceruloplasmin serves as a transport protein of copper in plasma. Parvez *et al*., [19] and Zhang *et al*. [20] reported that "copper pre-exposure increases the activity of ceruloplasmin in fish serum. Ceruloplasmin, through ferroxidase activity, is involved in iron homeostasis and acts as an antioxidant in plasma. Copper is able to induce the biosynthesis of metallothionein. The metallothionein induction plays a role in the oxidative defence against chronic copper exposure in the liver of a freshwater fish. Elevated levels of copper may become acutely or chronically toxic to aquatic lives. Chronic effects include reduced growth, shorter lifespan, reproductive problems, reduced fertility and behavioral changes. Copper deficiency leads to physiological disturbances, symptoms which include depression of growth, anemia, bowing of legs, spontaneous fractures, ataxia of new born, cardiac and vascular disorders, depigmentation, decrease in some organs weight, depressed reproductive performance including egg production and tissue accumulation"

4. CONCLUSION

The findings of this study showed that water from the Nandalar estuary contained a higher concentration of copper metal in all seasons. Overall, this study concluded that the Nandalar estuary's has significant accumulation of copper content. More attention should be paid to the Cu pollution, considering its great values of potential ecological risk index. Our findings provided better understanding of heavy metal pollution in estuarine environments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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