Heavy Metal Analysis In The Kali Estuary: A Cause For Concern

Sujal K. Revankar[1*] And J.L. Rathod[1]

[1*]Department of studies in Marine Biology, Karnatak University Post Graduate Centre, Karwar, Karnataka

***Corresponding Author:** Sujal K. Revankar
Email:sujalrevankar97@gmail.com

Abstract
The Kali Estuary (14^0 80'58"N & 74^0 14'26.2"E) , located on the southwestern coast of India, is an important ecological system facing the threat of heavy metal contamination. The present study investigates the levels and sources of heavy metals in the estuary, focusing on water, sediment, and commercially important edible bivalve *Meretrix meretrix*. The analysis of heavy metals like Cadmium, Chromium, Nickel, Zinc and Arsenic reveals that elevated concentrations of metals are present in sediment and bivalve when compared with water. The heavy metals were observed in the following order Sediment Cr>Zn>Ni>As>Cd, *Meretrix meretrix* Zn> Ni> Cr>As>Cd and water Zn>Cd>Cr>Ni>As was observed. The geo accumulation of metals in sediment was negative and the bioaccumulation of Zinc and Nickel was observed in the *Meretrix meretrix.* Industrial activities, agricultural runoff, and natural weathering are identified as the primary contributors to this pollution in the Kali Estuary.

Keywords: Heavy metals, Sediment, *Meretrix meretrix,* Kali estuary, Bioaccumulation, Marine Biology

Introduction

Estuaries, the transitional zones where freshwater rivers meet the saline ocean, are vital ecosystems teeming with biodiversity (Martinetto et al., 2019). They serve as crucial nurseries for fish populations and act as natural filters, removing pollutants before they reach the open ocean (Lillebø et al., 2004). However, their role as collection points for land-based contaminants makes them vulnerable to pollution, particularly by persistent environmental toxins like heavy metals (Kennish, 2016).

Heavy metals are a growing concern due to their toxicity and ability to accumulate in the environment over time (Alloway, 2013). These pollutants can disrupt ecological balance, impacting the intricate web of life within estuaries (Wang & Wang, 2018). This vital ecosystem faces challenges from heavy metal contamination, potentially jeopardizing its ecological health and the well-being of the communities that depend on it.

This study investigates the distribution and potential ecological and human health risks associated with heavy metal contamination in the Kali Estuary. By analyzing water, sediment, and biota samples, we aim to assess the current state of heavy metal pollution and its potential consequences. Understanding these issues is critical for developing effective strategies to protect the Kali Estuary and ensure its long-term sustainability. Estuarine ecosystems are crucial for marine biodiversity and productivity. However, they are also vulnerable to pollution due to their role as collection points for land-based contaminants. Heavy metals, a class of persistent environmental toxins, pose a significant threat to estuarine health. This study aimed to assess the levels and potential impacts of heavy metal contamination in the Kali Estuary

Materials and Methods

Water, Sediment and *Meretrix meretrix* samples were collected from Kali estuary (14^0 80'58"N & 74^0 14'26.2"E) during low tide.

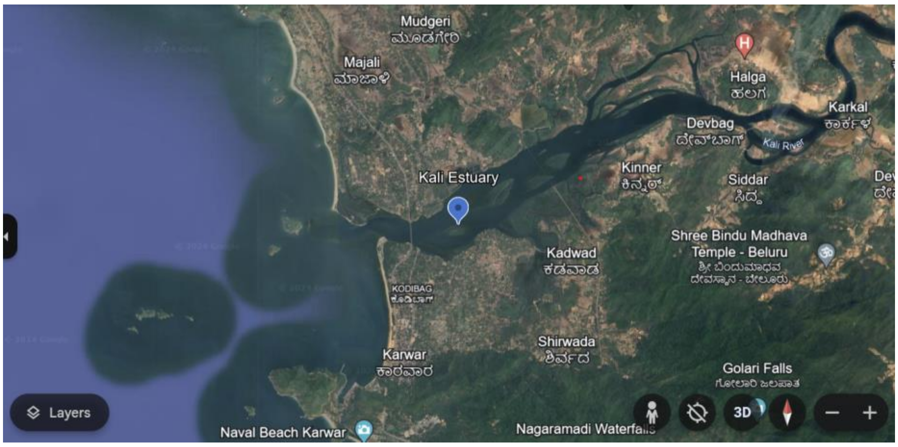


Figure 1: Image Showing Kali Estuary

The *M.meretrix samples* were dissected and dried whereas sediment samples were dried for heavy metal analysis. The dries samples were powdered and then digested based on EPA Method 3051A (U.S. EPA.,2007) and analyzed using Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) using ICP-OES OPTIMA 8000 (Pekin Elmer). The collected water samples were analysed for heavymetals (APDC-MIBK extraction) based on Brooks et.al.,1967. The Calculation of the quantity in mg/kg of the element in the sample by multiplying this value by Dilution factor.

$$\textbf{Concentration, ppm} = \frac{\textbf{C x Dilution Factor}}{\textbf{1000}}$$

Where, C = concentration of metal in sample (ppb)

$$\textbf{Dilution Factor (D)} = \frac{\textbf{Final volume after digestion(ml)}}{\textbf{Weight of sample(g)}}$$

Geo Accumulation Index

Igeo is used to measure the degree of metal contamination in aquatic sediments by comparing current concentration with industrial levels and calculated by the following formula introduced by Muller (1969) to measure the degree of metal pollution in aquatic sediments Wedepohl, K. H. (1971)

$$\boldsymbol{Igeo = \log_2[Cn \div 1.5 \times Bn]}$$

Biota Sediment Accumulation Factor

Biota Sediment Accumulation Factor (BSAF) is defined as the ratio of the metal concentration in an organism to that of concentration in sediment. The efficiency of metal accumulation in marine organisms was evaluated using formula (Karthikeyan et al. 2020).

$$\boldsymbol{BSAF} = \frac{\textbf{Concentration of metal in an organism}}{\textbf{Concentration of metal in sediment}}$$

Result

The study revealed significant differences in heavy metal concentrations across water, sediment, and *Meretrix meretrix*. Sediments consistently showed the highest levels, followed by *M.meretrix* and then water. The study found that the water column of the Kali Estuary had low concentrations of heavy metals, with zinc being the most prevalent (Table.1, Figure.2-6). In contrast, the sediment showed higher accumulations, particularly of chromium. The bivalve M. meretrix exhibited bioaccumulation of heavy metals, with zinc having the highest concentration within the organism. The metals analysed from water, sediment and bivalve were within the permissible limit (Table.2). The elevated levels of heavy metals in the sediment and *M. meretrix* are indicative of the estuary's pollution status. The high concentration of chromium in the sediment may be attributed to weathering of metal bearing rocks and agricultural runoff. The bioaccumulation of zinc in *M. meretrix* suggests that this metal is readily taken up by the bivalve, potentially affecting its physiology and reproductive success. Bioaccumulation was evident in *M. meretrix*, with considerably higher concentrations of Zn and Ni compared to water and sediment levels. This indicates that these metals are being taken up by organisms at lower trophic levels and concentrated as they move up the food chain. Elevated levels of metals in biota pose a potential threat to the health of higher-order predators and ultimately human consumers. The findings underscore the need for sustainable management practices to mitigate heavy metal pollution in the Kali Estuary and protect its ecological integrity.

Table.1.Heavy Metal Concentration(ppm) in Kali Estuary

Heavy Metals	Water	Sediment	M.meretrix
Cd	0.141	0.3	1.26
Cr	0.028	29.33	4.36
Ni	0	8.63	11.43
Zn	0.671	10.59	74.85
As	0	1.11	3.97

Table.2.Permissible Limits of Heavy Metals

Metals	***Meretrix meretrix***		**Sediment**	
Cadmium	2 ppm	Indian Standards	4.9 ppm	NOAA 2009/ WHO2003
Chromium	12-13 ppm	USFDA 1993b	26 ppm	NOAA 2009/ WHO2003
Nickel	70-80 ppm	Indian Standards FAO/WHO, 1984; FAO/WHO, 2011	20ppm	WHO 2003
Zinc	40 ppm	USFDA 1993b	120 ppm	NOAA 2009/ WHO2003
Arsenic	86 ppm	Indian Standards & USFDA	--	--
(Laly et al. 2020,) Indian standards				

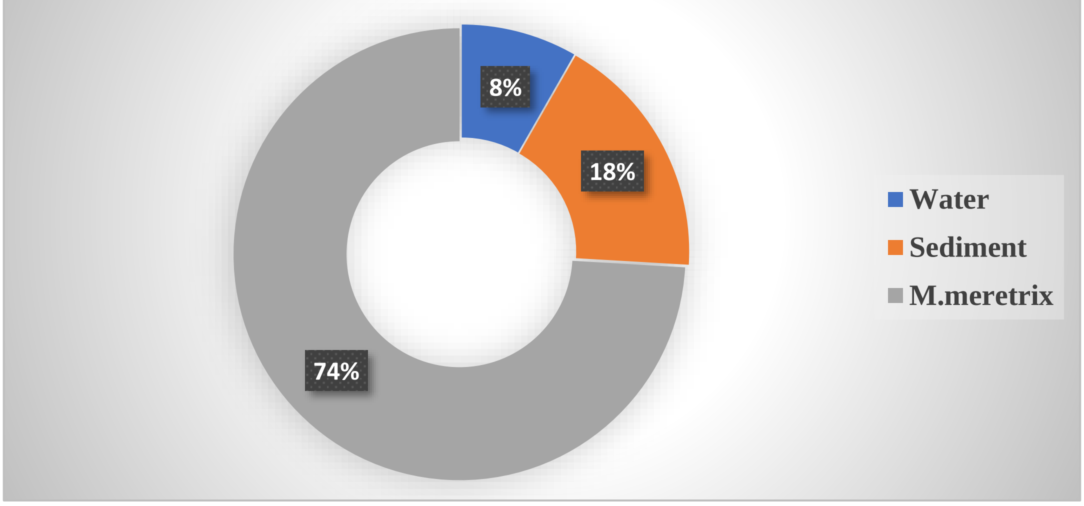


Figure.2.Average Percentage of Cadmium in Kali Estuary

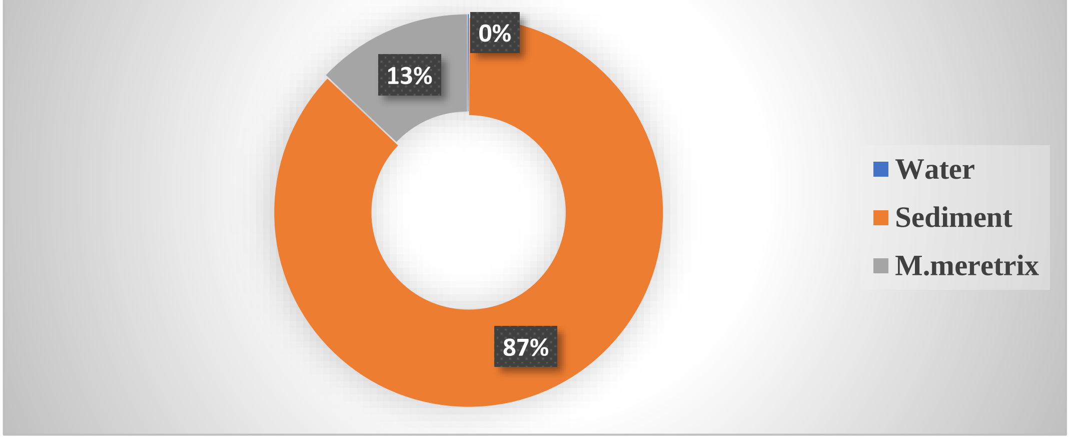


Figure.3.Average Percentage of Chromium in Kali Estuary

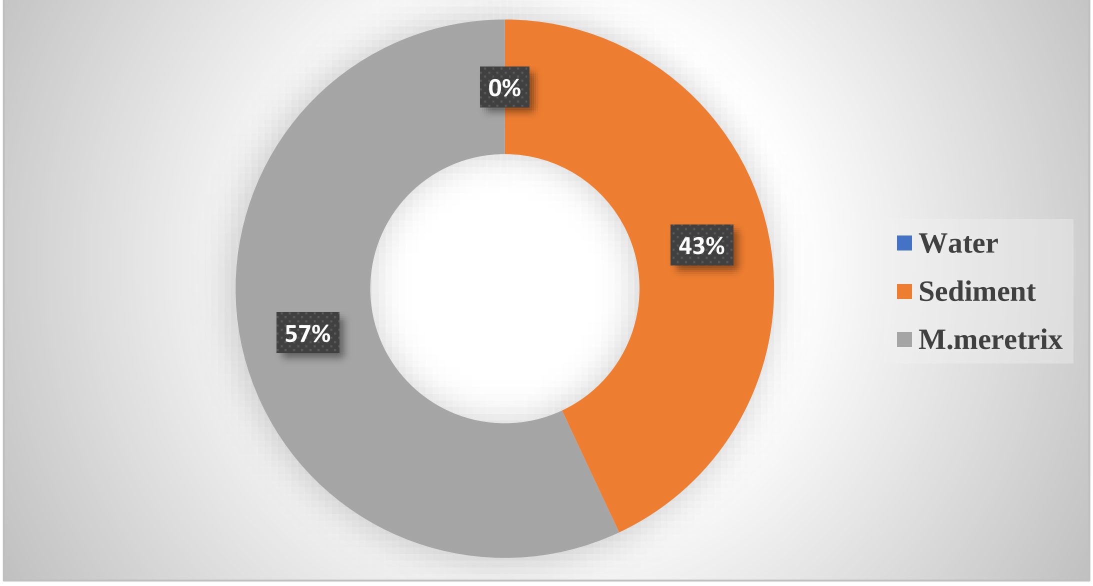
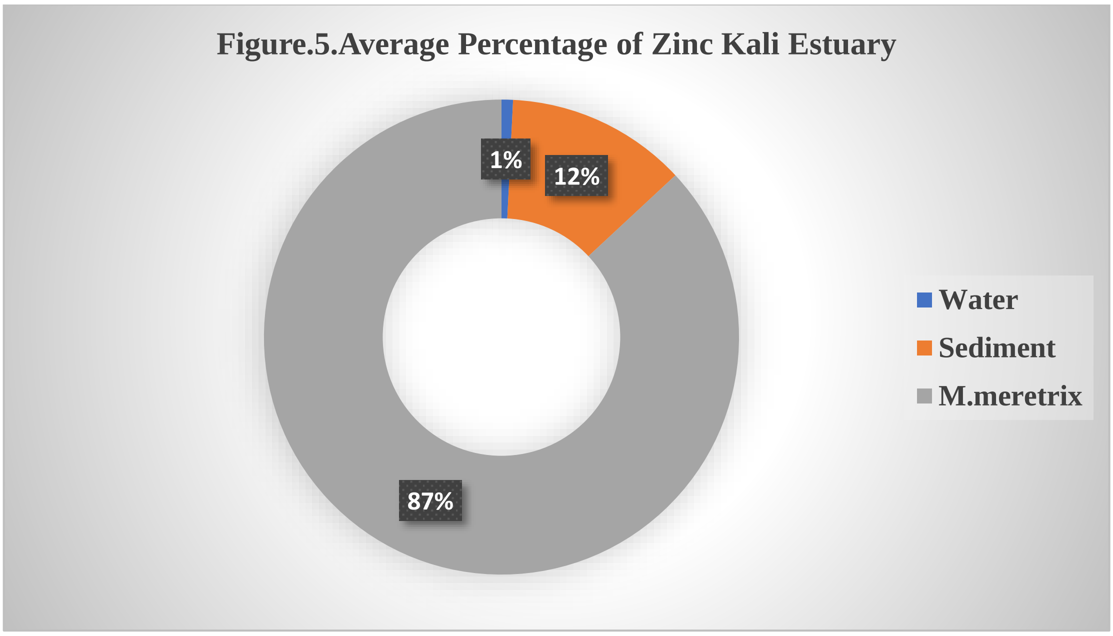
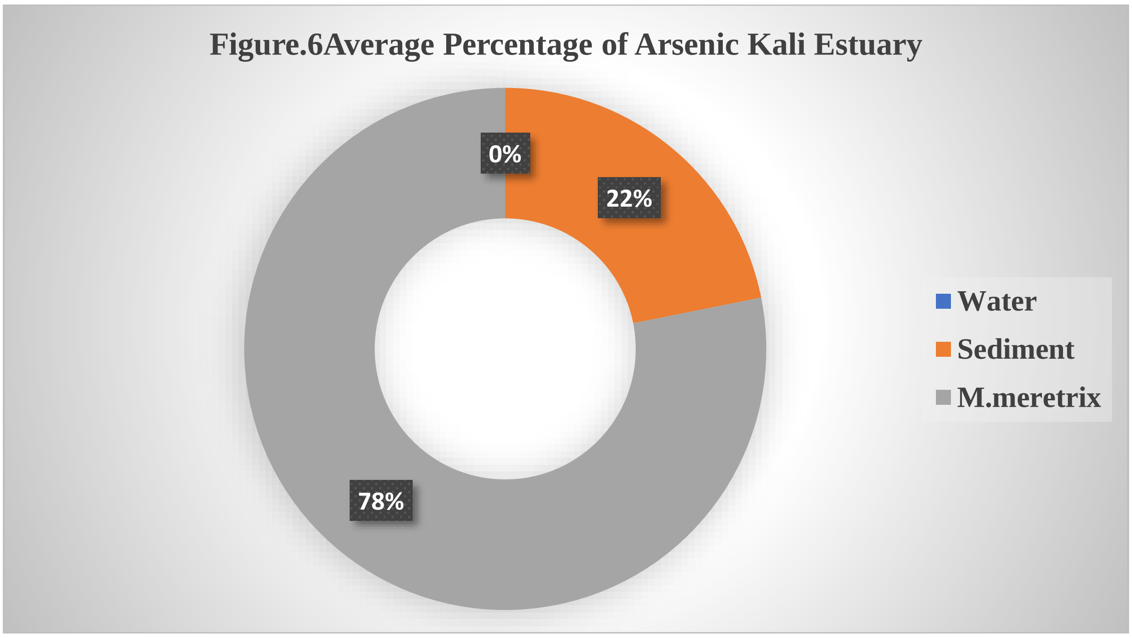


Figure.4.Average Percentage of Nickel Kali Estuary





Conclusion

The present research provides evidence of heavy metal contamination in the Kali Estuary, with varying degrees of pollution in different environmental compartments. The high levels of heavy metals in sediment and biota are a cause for concern, as they may impact the estuary's biodiversity and the health of local populations. Future studies should focus on identifying the specific sources of heavy metal pollution and implementing effective remediation strategies to preserve the Kali Estuary's ecological health.

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