

HEAVY METAL ACCUMULATION IN THE MUSCLE OF SELECTED AQUATIC SPECIES: A SEASONAL AND STATION-WISE ANALYSIS

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Abstract

Heavy metal contamination in aquatic environments is a growing concern due to its potential risks to human health and ecological balance. This study investigates the seasonal variation of Zn, Cu, and Pb in the muscle tissues of *Liza parsia*, *Liza tade*, and *Penaeus monodon* across three monitoring stations in and around the World Heritage Site of Indian Sundarbans during 2021 and 2022. The results indicate a higher concentration of these metals during the monsoon season, followed by postmonsoon and premonsoon periods. Zn exhibited the highest accumulation among the metals analyzed, whereas Pb concentrations remained lowest, but still significant. The findings provide insights into environmental contamination and potential food safety concerns for consumers of these aquatic species.

Keywords: Heavy metal, *Liza parsia*, *Liza tade*, *Penaeus monodon*, Bioaccumulation

1. Introduction

Heavy metal contamination in aquatic ecosystems has been a significant environmental issue due to industrial discharge, agricultural run-off, and anthropogenic activities (Fig. 1).

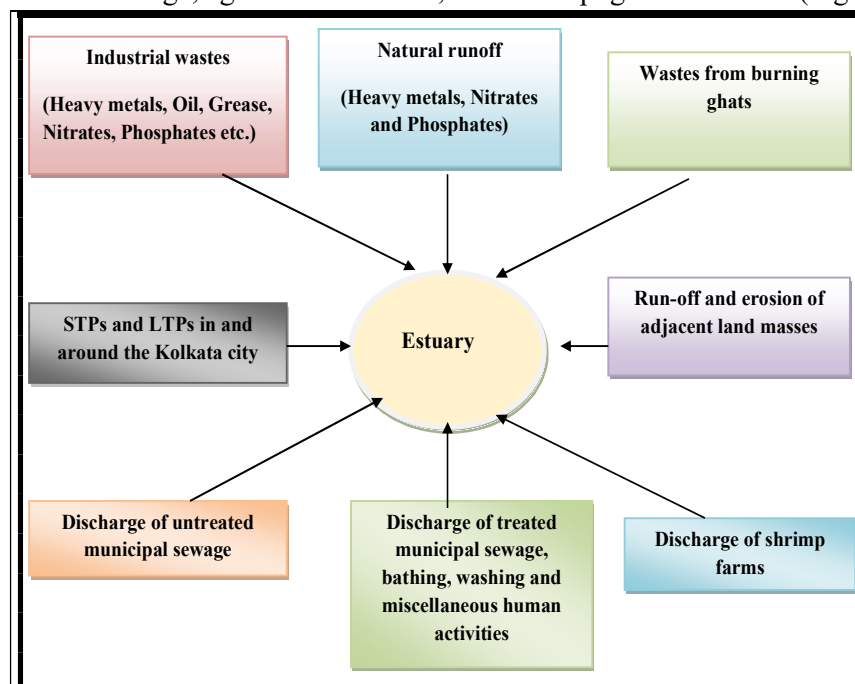


Fig. 1 Sources of heavy metals in the estuary

The heavy metals bioaccumulate in aquatic organisms and may pose health hazards to humans through consumption. *Liza parsia*, *Liza tade*, and *Penaeus monodon* are economically important species in coastal and estuarine fisheries, making them suitable bioindicators for assessing metal contamination (Mitra et al., 2009; Mitra et al., 2010a, b; Mitra et al., 2011; Mitra et al., 2012a;). This study aims to analyze the seasonal and spatial variations in Zn, Cu, and Pb concentrations in the muscle tissues of these species, highlighting possible ecological and health implications.

2. Methodology

2.1. Study Area and Sample Collection

Fish samples were collected from three sites in and around the World Heritage Site of Indian Sundarbans namely Diamond Harbour (Stn. 1) (22°11'4.2"N; 88°11'22.2"E), Kakdwip (Stn. 2) (21°52'35.7"N; 88°11'55.0"E) and Namkhana (Stn. 3) (21°45'53.7"N and 88°13'51.5"E) during premonsoon, monsoon, and postmonsoon seasons in 2021 and 2022. The species studied included *Liza parsia*, *Liza tade*, and *Penaeus monodon*. Muscle tissue was extracted and analyzed for metal concentration.

2.2. Metal Analysis

Samples were digested using nitric acid and analyzed through atomic absorption spectrophotometry (AAS) to quantify Zn, Cu, and Pb concentrations. Data were compiled for each species, season, and station to assess trends and potential environmental risks.

3. Results

3.1. Zinc Concentration

Liza parsia: Zn ranged from 90.56 ppm to 310.05 ppm, with the highest levels recorded in the monsoon season (Table 1).

Liza tade: Zn ranged from 93.16 ppm to 321.92 ppm, showing a similar seasonal trend as *Liza parsia* (Table 2).

Penaeus monodon: Zn concentrations varied from 150.19 ppm to 228.70 ppm, peaking in monsoon months (Table 3).

Table 1: Station-wise seasonal variation of Zn in *Liza parsia* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	90.56	112.05	96.54	115.11	117.37	185.36
Monsoon	182.55	210.17	195.22	222.41	204.59	310.05
Postmonsoon	113.15	143.14	150.07	156.19	173.82	196.33

Table 2: Station-wise seasonal variation of Zn in *Liza tade* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	93.16	120.35	102.14	127.10	142.05	155.05
Monsoon	191.30	217.88	173.51	236.00	215.36	321.92
Postmonsoon	127.45	150.43	166.39	167.99	185.04	204.65

Table 3: Station-wise seasonal variation of Zn in *Penaeus monodon* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	150.19	155.73	156.99	160.02	167.14	172.56
Monsoon	200.28	212.58	215.83	223.44	221.30	228.70
Postmonsoon	176.33	182.35	181.92	205.71	190.41	212.35

3.2. Copper Concentration

Liza parsia: Cu levels ranged between 65.29 ppm and 151.19 ppm, highest in the monsoon season (Table 4).

Liza tade: Cu concentrations ranged from 71.05 ppm to 166.50 ppm, following the same trend (Table 5).

Penaeus monodon: Cu accumulation varied from 45.66 ppm to 101.48 ppm, again with monsoon showing the highest levels (Table 6).

Table 4: Station -wise seasonal variation of Cu in *Liza parsia* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	65.29	69.04	74.20	79.54	83.66	89.72
Monsoon	108.23	117.59	126.31	131.02	140.49	151.19
Postmonsoon	79.54	83.06	85.28	91.41	101.36	111.00

Table 5: Station -wise seasonal variation of Cu in *Liza tade* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	71.05	75.08	80.17	84.55	91.47	105.12
Monsoon	113.99	122.44	131.44	146.72	151.38	166.50
Postmonsoon	88.65	91.85	97.21	101.57	117.43	130.71

Table 6: Station 6-wise seasonal variation of Cu in *Penaeus monodon* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	45.66	52.39	51.44	54.75	60.24	62.20
Monsoon	75.21	80.43	81.31	83.04	93.42	101.48
Postmonsoon	68.30	70.20	72.49	81.91	79.33	86.73

3.3. Lead Concentration

Liza parsia: Pb levels ranged between 17.85 ppm and 59.75 ppm, highest in the monsoon season (Table 7).

Liza tade: Pb ranged from 19.44 ppm to 67.96 ppm, with similar trends as observed in Zn and Cu (Table 8).

Penaeus monodon: Pb concentrations were the lowest among the metals, ranging from 6.15 ppm to 18.97 ppm (Table 9).

Table 7: Station-wise seasonal variation of Pb in *Liza parsia* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	17.85	23.68	26.52	31.49	35.43	40.08
Monsoon	27.07	39.15	41.82	50.77	57.29	59.75
Postmonsoon	21.44	31.02	37.10	42.35	46.34	51.09

Table 8: Station-wise seasonal variation of Pb in *Liza tade* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	19.44	28.50	29.32	36.74	38.03	43.25
Monsoon	31.82	49.11	46.55	53.95	61.90	67.96
Postmonsoon	26.50	36.75	39.95	46.88	50.21	58.39

Table 9: Station-wise seasonal variation of Pb in *Penaeus monodon* muscle (ppm) during 2021 and 2022

Season	Stn. 1		Stn. 2		Stn. 3	
	2021	2022	2021	2022	2021	2022
Premonsoon	6.15	8.10	8.55	11.03	10.44	12.78
Monsoon	11.26	14.59	13.48	15.99	16.32	18.97
Postmonsoon	9.05	12.28	10.85	13.08	13.44	15.64

4. Discussion

The results indicate that the monsoon season exhibits the highest accumulation of heavy metals in fish and prawn species, which can be attributed to increased surface run-off and industrial

discharge into aquatic bodies. Zn was the most prevalent heavy metal, while Pb levels remained relatively low but still concerning. The station-wise variation suggests localized sources of contamination, requiring targeted mitigation strategies. Several studies have been undertaken to study the growth of fishes in relation to environmental parameters (Emerson *et al.*, 1975; Bolorunduro and Abba, 1996; Boyd, 1998; Bhatnagar and Garg, 2000; Machena and Moehl, 2001; Imsland and Jonassen, 2003; Bhatnagar *et al.*, 2004; Ma *et al.*, 2006; Imsland *et al.*, 2007; Bhatnagar and Singh, 2010; Ekubo and Abowei, 2011). This study considers the heavy metals as important parameters.

From a public health perspective, these findings highlight the importance of monitoring metal levels in commercially important fish species. The consumption of contaminated aquatic products could pose health risks, necessitating stringent regulatory measures to limit industrial discharge and promote sustainable aquaculture practices. Future research should focus on bioaccumulation trends over extended periods and assess the potential health risks posed by the consumption of these species.

5. Conclusion

This study highlights the significant seasonal variation in the accumulation of Zn, Cu, and Pb in the muscle tissues of *Liza parsia*, *Liza tade*, and *Penaeus monodon*, with the highest concentrations observed during the monsoon season. The increased levels during this period can be attributed to intensified surface runoff and industrial discharge, leading to higher metal bioaccumulation. Among the metals analyzed, Zn exhibited the highest accumulation, while Pb, though present in lower concentrations, remains a concern for food safety. The station-wise variations indicate localized sources of contamination, emphasizing the need for targeted pollution control strategies. These findings underscore the necessity of continuous monitoring of heavy metal concentrations in commercially important aquatic species to ensure consumer safety. Given the potential health risks associated with the consumption of contaminated seafood, stringent regulatory interventions are required to limit industrial discharge and promote sustainable aquaculture practices. Future research should focus on long-term bioaccumulation trends and assess the health implications for consumers. Implementing effective waste management policies and raising public awareness are crucial steps toward safeguarding aquatic food resources and maintaining ecological balance.

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