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ASSESSMENT OF PATH WAY FOR ACCUMULATION OF HEAVY METAL IN FISH SPECIES APPEALING IN MRIGI RIVER, SHERPUR, BANGLADESH

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ABSTRACT

This study aimed to evaluate heavy metal concentrations in five fish species (Tengra, Puti, Bele, Chingri, and Bain) from the Mrigi River in Sherpur, a major river in northeastern Bangladesh. Concentrations of five heavy metals, namely lead (Pb), cadmium (Cd), chromium (Cr), zinc (Zn), and copper (Cu) were analyzed in fish samples collected from three distinct sites during January and February 2023, using Atomic Absorption Spectroscopy (AAS). The mean concentrations of Pb, Cd, Cr, Zn, and Cu were 0.79, 0.02, 0.41, 6.25, and 0.69 mg/kg, respectively, with metal levels following the order Zn (6.25) > Pb (0.79) > Cu (0.69) > Cr (0.41) > Cd (0.02). Anthropogenic sources were identified as primary contributors to metal presence. Notably, Pb concentrations exceeded FAO safety standards across all fish species, particularly in Chingri, while Tengra exhibited the lowest Pb levels. Significant positive correlations of Pb with Cr ($r = 0.535$) and Cu ($r = 0.493$) indicate a shared source pathway. Cd levels were highest in Chingri, though they remained below FAO limits with a mean of 0.02 ± 0.01 mg/kg. Cr and Zn presented the most severe pollution risks, with Bain exhibiting the highest Cr levels and Puti the highest Zn levels. Mean concentrations of Cr (0.41 ± 0.12 mg/kg) and Zn (6.25 ± 1.08 mg/kg) both exceeded FAO standards, highlighting considerable contamination. These findings indicate significant Cr and Zn pollution in Mrigi River fish, raising potential health risks for local consumers.

Key words: Heavy metals, bioaccumulation, Mrigi river, cadmium pollution

Introduction

Heavy metals enter aquatic systems from natural sources as well as various human activities, including industrial and domestic wastewater discharge, pesticide and fertilizer use, stormwater runoff, landfill leaching, and atmospheric deposition (Bem *et al.*, 2003; Yilmaz, 2009). Once in the water, heavy metals accumulate in aquatic organisms through bio-concentration and bioaccumulation in the food chain, becoming toxic when concentrations reach high levels (Huang, 2003). Some metals are harmful to organisms even in trace amounts, as they can form stable bio-toxic compounds by binding to biomolecules like proteins and enzymes, disrupting biological functions (Duruibe *et al.*, 2007). Fish, an important part of the human diet, often bioaccumulate heavy metals in their tissues, presenting a risk of transferring these contaminants to humans. Monitoring heavy metal levels in fish is therefore essential to safeguard consumer health and to mitigate potential ecological harm (Rahman *et al.*, 2012). The Mrigi River, originating from Mrigi Bill in the Tanatihati union of Sreebardi Upazila in Sherpur District, northeastern Bangladesh, holds significant potential for fish production. However, recent years have seen the river's ecosystem decline due to pollution, habitat degradation, and diminishing fish populations. Pollution around the river is increasingly severe, with fertilizers and pesticides from agricultural lands washing into the river, as well as consistent inflows of domestic sewage, industrial waste, and oil spills, all of which disturb the aquatic ecosystem (Numan *et al.*, 2019). This study aims to assess the concentrations of five heavy metals, namely lead (Pb), cadmium (Cd), chromium (Cr), zinc (Zn), and copper (Cu) in commonly consumed fish species (*Puntius puntio, Mastacembelus armatus, Mystus vittatus, Metapenaeus spinulatus*, and *Glossogobius giuris*) from the Mrigi River. The findings are compared to standard safe levels to evaluate potential health risks to consumers and to contribute to the management and preservation of the river's aquatic resources.

Materials and Methods

Study area: This study was conducted during the dry season from January to February 2023 along the Mrigi River in Sherpur, Bangladesh. The focus was on fish species collected from various segments of the river, locally known as Mrigi upstream, Tenachhera Canal, Kharikata Canal, and Mrigi downstream. Three distinct locations along the river were selected for fish sample collection: Longor Para Bridge (Location 1), Thana Ghat Bridge (Location 2), and Kashba Kathghar (Location 3), all situated in the Sherpur Sadar Upazilla of Sherpur District, Bangladesh, as shown in Fig. 1.

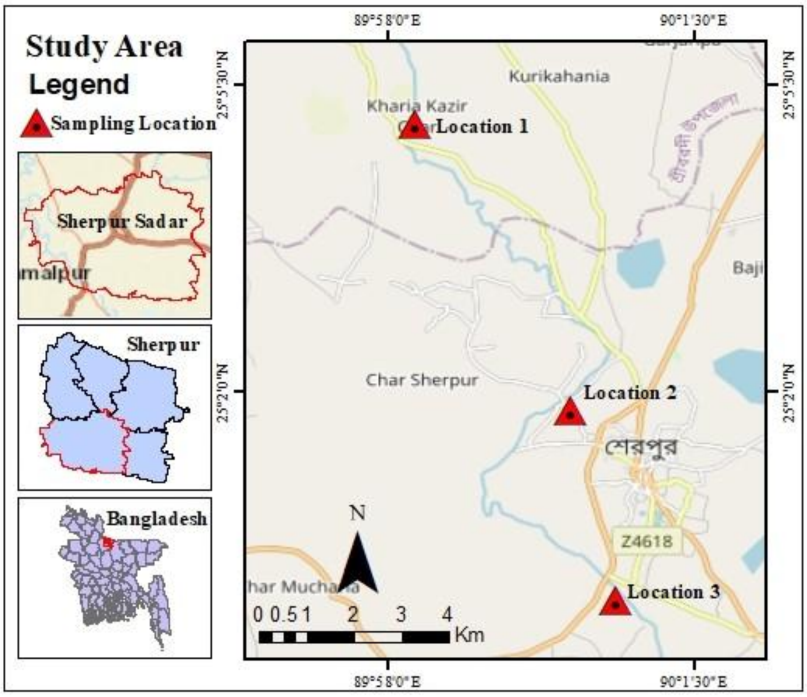

Fig. 1. Map showing the three sampling sites of the River Mrigi, Sherpur, Bangladesh

The GPS coordinates for each sampling site are provided in Table 1. These sites were chosen for their varied pollution sources, as they are near rice mills, brick kilns, clothing industries, and agricultural fields along the riverbanks.

Table 1. Sampling location with Latitude and Longitude

Station No.	Sampling Site	Latitude	Longitude
Location 1	Longor Para Bridge	25° 4'56.90"N	89°58'7.97"E
Location 2	Thana Ghat Bridge	25°03'1754 N	90°00'0258 E
Location 3	Sheri Bridge	24°99'7509 N	90°00'8764 E

Data collection: The research relied on both primary and secondary data sources. Primary data were obtained through field observations and laboratory analysis, while secondary data were sourced from journals, published and unpublished papers, personal records, articles, and online information.

Sample collection: In this study five species of fish Puti (*Puntius puntio*), Bain (*Mastacembelus armatus*), Tengra (*Mystus vittatus*), Chingri (*Metapenaeus spinulatus*) and Bele (*Glossogobius giuris*) were collected from location-1 (BSCIC Ramkrishnapur), location-2 (Thana Ghat Bridge), location-3 (Sheri Bridge) of the

Mrigi river and kept them in an ice box. Fish samples were collected during the dry season (January 2023 - February 2023). After collection, the samples were preserved and labeled properly and kept at -20˚C. then the fish samples were analyzed for heavy metals (Pb, Cd, Cr, Zn and Cu) in the Asia Arsenic Network (AAN) Environmental Laboratory in Jashore.

Heavy metals analysis in fish samples: Fish samples were prepared by washing, cutting into small pieces (2-3 cm), air drying, and then oven drying at 105°C for three days to achieve a stable weight. The dried samples were cooled, ground into a powder, homogenized, and stored in airtight vials in desiccators. For heavy metal analysis (Pb, Cd, Cr, Zn, and Cu), 0.5 g of powdered fish was digested with concentrated H_2SO_4 and HNO_3, followed by slow heating on an oil bath, with the addition of 3/4 drops of H_2O_2 until clear. After further heating, the solution was cooled, diluted with deionized water, and filtered into a 50 ml flask. Samples were analyzed for metal concentrations using an Atomic Absorption Spectrophotometer (Model: GTA 120-AA240Z with PSD 120 auto sampler, Australia) with an air-acetylene flame. The Microsoft Office Excel and SPSS IBM v26 software were used to present and analyze the collected data.

Results and Discussion

Heavy Metals in Fish Species: The concentrations of heavy metals (Pb, Cd, Cr, Zn, and Cu) in fish species from the study area ranged from 0.45-1.08 mg/kg for Pb, 0.012-0.028 mg/kg for Cd, 0.28-0.58 mg/kg for Cr, 4.79-7.51 mg/kg for Zn, and 0.54-0.79 mg/kg for Cu. The mean concentrations of these metals followed the descending order of Zn > Pb > Cu > Cr > Cd, indicating a heterogeneous distribution throughout the study area. When compared with standards recommended by the Food and Agricultural Organization (FAO, 1983; 2003), the mean concentrations of Pb, Cr, and Zn in the fish samples were noticeably higher than the FAO limits, whereas Cd and Cu levels were significantly lower than their respective FAO guidelines. The calculated coefficients of variation (CV) for Pb, Cd, Cr, Zn, and Cu were 32.27%, 30.31%, 28.38%, 17.26%, and 14.64%, respectively. Following Han *et al.*, (2006), higher CV values suggest that the metal pollution, particularly for Pb, Cd, and Cr, is likely driven by anthropogenic activities, while lower CV values are more indicative of natural sources. The descriptive statistics of heavy metal concentrations in fish samples from the Mrigi River, Sherpur district, Bangladesh, along with FAO guideline comparisons, are summarized in Table 2.

Table 2. Heavy metal concentrations (mg/kg) of fish samples collected from the Mrigi river

Samples	Pb	Cd	Cr	Zn	Cu
Tengra	0.45	0.022	0.34	4.79	0.67
Puti	0.84	0.012	0.28	7.51	0.78
Bele	0.62	0.017	0.38	6.92	0.54
Chingri	1.08	0.028	0.45	5.58	0.68
Bain	0.96	0.019	0.58	6.47	0.79
Mean, mg/kg	0.79	0.02	0.41	6.25	0.69
Standard deviation (SD)	0.25	0.01	0.12	1.08	0.10
Minimum, ppm	1.08	0.028	0.58	7.51	0.54
Maximum, ppm	0.45	0.012	0.28	4.79	0.79
Coefficient of variance (CV), %	32.27	30.31	28.38	17.26	14.64
FAO, ppm	0.2	0.05	0.05	5	30

Comparison of heavy metals in fish species collected from different rivers: Levels of Pb and Cr contamination in Tengra fish from the Mrigi River were found to be higher than in Tengra samples from the Dhaleshwari and Bangshi Rivers. For Puti fish, the most severe Pb contamination occurred in samples from the Buriganga River, which were more heavily impacted than those from the Mrigi and Dhaleshwari Rivers. In Bele fish, although Pb levels were highest in samples from the Mrigi River, Bele from the Bahirab River exhibited higher levels of Cr, Zn, and Cu. Additionally, Chingri (shrimp) from the Mrigi River showed substantially elevated Pb and Cr levels compared to Chingri samples from the Rupsa and Dhaleshwari Rivers. Considering the overall levels of Pb, Cd, Cr, Zn, and Cu across species, Bain fish from the Mrigi River exhibited the highest contamination. Table 3 presents the concentrations of these metals in fish species from the Mrigi River, while Table 3 compares these findings with similar fish species sampled from other rivers in the study.

Table 3. Comparison of metal conc. (mg/kg) in fish species from this study with values reported in other studies

Fish Species	River Name	Pb	Cd	Cr	Zn	Cu	References
Tengra (*Mystus vittatus)*	Dhaleshwari River	0.218	0.011	0.102	-	-	Ahsan *et al*., (2018)
	Bangshi River	0.180	0.023	-	5.670	0.770	Rehnuma *et al.,* (2016)
	Mrigi River	0.450	0.022	0.340	4.790	0.670	Present Study
Puti (*Puntius puntio)*	Dhaleshwari River	0.164	0.002	0.112	-	-	Ahsan *et al*., (2018)
	Buriganga River	3.160	0.020	4.33	248.20	9.040	Ahmed *et al*., (2016)
	Mrigi River	0.840	0.012	0.280	7.510	0.780	Present Study
Bele (Glossogobius giuris)	Turag River	0.060	0.003	0.383	-	0.623	Afrin *et al*., (2015)
	Bhairab River	0.451	0.041	0.896	7.959	0.806	Haque *et al*., (2006)
	Mrigi River	0.620	0.017	0.380	6.920	0.540	Present Study
Chingri (*Metapenaeus spinulatus)*	Dhaleshwari River	0.261	0.005	0.104	-	-	Ahsan *et al*., (2018)
	Rupsa River	0.691	0.049	0.084	82.28	-	Biswas *et al*., (2021)
	Mrigi River	1.08	0.028	0.45	5.58	0.68	Present Study
Bain (*Mastacembelus armatus)*	Dhaleshwari River	0.092	0.006	0.107	-	-	Ahsan *et al.,* (2018)
	Turag River	0.053	0.009	0.370	-	0.690	Afrin *et al.,* (2015)
	Mrigi River	0.96	0.019	0.58	6.47	0.790	Present Study

Lead (Pb): The elevated levels of Pb found in fish species from this study can likely be attributed to emissions from metal processing facilities and various anthropogenic activities (Nziguheba and Smolders, 2008). The highest Pb concentration was detected in Chingri, while Tengra exhibited the lowest levels, with an overall mean Pb concentration of 0.79 ± 0.25 mg/kg (Table 4). This mean value surpasses the FAO's permissible limit of 0.2 mg/kg for lead in fish (FAO, 2003), indicating that Pb concentrations in all five fish species exceeded recommended safety levels (Table 4). Comparisons with other studies in Bangladesh highlight similar findings. Rehnuma *et al.,* (2016) reported an average Pb concentration of 0.21 mg/kg in Tengra from the Bangshi River, slightly below this study's findings. However, Ahmed *et al.*, (2010) reported seasonal Pb concentrations ranging from 8.03 to 13.52 mg/kg in fish from the Buriganga River, and Ahmed *et al.*, (2009b) observed seasonal Pb variations of 7.03–12.18 mg/kg in Dhaleswari River fish. Additionally, Muiruri *et al.,* (2013) found Pb concentrations in tilapia gills ranging from 1.42 to 4.48 mg/kg. Except for Rehnuma *et al.,* (2016), these studies recorded higher Pb concentrations than those observed in the present study.

Cadmium (Cd): The higher Cd levels observed in fish species might be linked to industrial emissions, metal processing, atmospheric deposition, and the use of cadmium-plated materials. The average Cd concentration in this study was 0.02 ± 0.01 mg/kg, with the highest level detected in Chingri, mirroring the trend for Pb, while the lowest was found in Puti (Table 4). This mean concentration is below the FAO's permissible level for Cd (FAO, 2003), suggesting that Cd levels across all five fish species fall within safe limits, indicating minimal contamination. When compared to other studies in Bangladesh, similar findings emerge. Rehnuma *et al.,* (2016) reported a mean Cd concentration of 0.02 mg/kg in Tengra from the Bangshi River, consistent with our findings. However, Ahmed *et al.,* (2010) found higher seasonal Cd levels, ranging from 0.73 to 1.25 mg/kg, in six fish species from the Buriganga River. Likewise, Ahmed *et al.,* (2009) observed Cd concentrations of 0.52–0.8 mg/kg in Dhaleshwari River fish, and Muiruri *et al.,* (2013) reported Cd levels in tilapia gills between 0.71 and 1.77 m/gkg. Sharif *et al.,* (1993) found 0.11 ±

0.00 mg/kg of Cd (dry weight basis) in *T. vagina*. Thus, while Rehnuma *et al.,* (2016) aligns with the present findings, other studies show significantly higher Cd levels, indicating a substantial variation in Cd contamination across different regions and species.

Table 4. Comprasion of Pb concentration with FAO, (2003) standard in five different fish species of the River Mrigi

Heavy metals (ppm)	FAO, (2003) standard (ppm)	Tengra	Puti	Bele	Chingri	Bain
Pb	0.2	0.45	0.84	0.62	1.08	0.96
Cd	0.05	0.022	0.012	0.017	0.028	0.019
Cr	0.05	0.34	0.28	0.38	0.45	0.58
Zn	5	4.79	7.51	6.92	5.58	6.47
Cu	30	0.67	0.78	0.54	0.68	0.79

Chromium (Cr): Chromium (Cr), a toxic heavy metal, is frequently released from industrial sources into agricultural lands and subsequently flows into nearby rivers, contaminating water systems. Chromium toxicity negatively affects fish by disrupting essential metabolic processes and impairing growth. In this study, the mean Cr concentration in the fish species analyzed was 0.41 ± 0.12 mg/kg, with Bain showing the highest Cr concentration and Puti the lowest (Table 4). This mean concentration exceeds the FAO standard (1989), indicating potential environmental risks. Comparative analysis with other studies on Cr concentrations in fish species across Bangladesh shows variability. Ahmed *et al.,* (2010) reported Cr levels in Buriganga River fish species, with peak levels of 7.38 mg/kg in Chapila during monsoon and the lowest (5.27 mg/kg) in Tengra. Seasonal variations of Cr concentrations between 9.38 and 19.65 mg/kg were found in Dhaleswari River fish (Ahmed *et al.,* 2009), while similar studies in Shitalakhya River fish and oysters reported Cr ranges of 8.12–9.07 mg/kg (Ahmed *et al.,* 2009). These higher values, compared to the present study, may reflect differing accumulation patterns of Cr in fish organs and the substantial Cr pollution from tannery and other industries affecting these rivers. In regional studies beyond Bangladesh, Indrajith *et al.,* (2010) reported Cr concentrations in *E. suratensis* (0.02-0.28 mg/kg) and *A. commersoni* (0.01–0.24 mg/kg) in the Negombo Estuary, Sri Lanka. Similarly, Nwani *et al.,* (2010) found Cr levels in fish muscles ranging from 0.28 ± 0.04 mg/kg in M. tapirus and C. anguillaris to 0.66 ± 0.04 mg/kg in C. nigrodigitatus and *T. zillii* in the freshwater ecosystems of Afikpo, Nigeria. These concentrations align more closely with the results of this study, underscoring both regional and species-specific variations in Cr accumulation.

Zinc (Zn): Zinc (Zn) is an essential component of many enzymes and is typically well-regulated in fish and other organisms. However, excessive Zn levels pose risks to both aquatic animals and humans, particularly when levels exceed those found in unpolluted environments. This can lead to health risks associated with fish consumption and environmental concerns, underscoring the need for monitoring Zn levels in fish for both ecological and public health reasons. In this study, Zn levels in fish from the River Mrigi were highest in *Puti* and lowest in *Tengra*. The mean Zn concentration across all species was 6.25 ± 1.08 mg/kg, which exceeds the FAO (2003) recommended standards. Except for *Tengra*, Zn levels in the other fish species surpassed the FAO guideline, indicating contamination. Comparison with previous studies shows varying Zn concentrations in fish across Bangladesh. Mansur *et al.,* (2021) found higher Zn levels in *Heteropneustes fossilis* (29.46 mg/kg) and *Anabus testudineus* (27.60 mg/kg), suggesting significant regional variability. In contrast, Sarker *et al.,* (2020) found lower Zn concentrations ranging from 0.97 to 1.92 mg/kg in edible fish from the Meghna River, while Haque *et al.,* (2006) observed seasonal Zn variation from 5.17 to 23.2 mg/kg in the Bhairab River. The results from Sarker *et al.,* (2020) align more closely with lower Zn values, while the elevated levels reported by Mansur *et al.,* (2021) reflect a marked deviation, as does this study's finding of elevated Zn levels across several species.

Copper (Cu): Copper (Cu) is a toxic heavy metal that can accumulate in fish species, particularly through agricultural runoff containing liquid dairy waste. Excessive Cu concentrations are harmful to aquatic life, with elevated levels being toxic to both fish and microorganisms. In this study, the highest Cu concentration was observed in Bain fish, while the lowest was found in Bele. The mean Cu concentration across all fish species was 0.69 ± 0.10 mg/kg, with Bain showing 0.79 ppm and Bele 0.54 ppm (Table 4). The observed mean concentration of Cu was significantly lower than the FAO standard (1983), indicating relatively low Cu contamination in the fish species. The Cu concentrations in this study were compared to those from other studies conducted in Bangladesh. Rehnuma *et al.*, (2016) reported an average Cu concentration of 0.65 ppm in Tengra (Mystus vittatus) from the Bangshi River during the wet season. Ahmed *et al.*, (2010) studied six fish species from the Buriganga River, finding seasonal Cu concentrations ranging from 3.36 to 6.34 mg/kg, while Ahmed *et al*., (2009) observed a higher variation from 7.55 to 11.50 mg/kg in the Dhaleshwari River. The findings of Rehnuma *et al.,* (2016) are consistent with lower Cu levels, similar to those found in the current study. However, the Cu concentrations observed by Ahmed *et al.*, (2010) and Ahmed et al. (2009) were considerably higher, reflecting more severe contamination in those rivers. This highlights significant regional variability in Cu pollution levels in different water bodies across Bangladesh.

Pearson's correlation coefficient between the heavy metals: Pearson's correlation coefficients for the investigated heavy metals are presented in Table 5, providing insight into the relationships among metals in fish species from the River Mrigi, Sherpur district. These inter correlations suggest common sources and pathways of metal contamination within the aquatic ecosystem. Notably, lead (Pb) demonstrated a strong positive correlation with chromium (Cr) (r=0.535) and copper (Cu) (r=0.493), while cadmium (Cd) also correlated positively with Cr (r=0.413). This pattern suggests that these elements may originate from similar sources or share interconnected pathways in the river ecosystem.

Table 5. Pearson correlation coefficient of heavy metals in fish species of River Mrigi

Heavy Metals	Pb	Cd	Cr	Zn	Cu
Pb	1				
Cd	0.260767	1			
Cr	0.535223	0.413333	1		
Zn	0.262041	-0.801917	-0.142663	1	
Cu	0.492511	-0.201792	0.232052	0.1616337	1

The presence of positive correlations among these metals supports the hypothesis that they may have a common source of origin, likely linked to local industrial pollution, rice mills, brick kilns, and other anthropogenic activities contributing to metal loading in the water. However, zinc (Zn) and Cu did not show significant correlations with other metals, though a weak association between Cr and Cu (r = 0.232) was observed. This lack of strong correlation between Zn and other metals might indicate distinct sources or differing mobility and bioaccumulation properties in the aquatic environment. These findings emphasize the complex interaction of pollutants within the river ecosystem, which may be influenced by the nature of industrial discharges and environmental factors affecting metal dispersion and uptake in fish.

Conclusion

The results reveal that anthropogenic activities, including industrial effluents, waste disposal, and agricultural runoff, are major contributors to the contamination. The tested five fish species (Tengra, Puti, Bele, Chingri, and Bain) accumulated heavy metal as the order- Zn > Pb > Cu > Cr > Cd. The study also assesses that the levels of heavy metals, specifically chromium (Cr) and zinc (Zn), indicate a potential health risk for local consumers. Hence the study strongly recommends that authorities promptly identify and regulate unauthorized industries along the riverbanks, enforce strict laws against the discharge of untreated wastewater, and take measures to mitigate heavy metal pollution in the Mrigi River to protect aquatic ecosystems and human health.

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