

Study of Accumulation of Hazardous Metals in Edible Parts of Fishes from Kakmara River

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Abstract

The Kakmara River is rich in ichthyofaunal diversity, and it is one of the most important breeding grounds of many fresh water and estuarine fishes along the riparian zone of the Mridangabhangha River. The present study was conducted for four consecutive years at five study sites: Kuemuri, Kuemuri Bamboo Bridge (Lakshmijanardanpur), Herombogopalpur, Purbo Dwarikapur (1, 2), fish muscle tissue was collected and preserved, along with bones and intestines from each site for metal study. River water metal content was also studied from all study sites. The potential consumers' health risks are caused by six heavy metals (Cd, Zn, Co, Pb, Ni, and Cu) found in four most common fish species (*Mystus tengara*; *Amblypharyngodon mola*; *Puntius ticto*, and *Chela labuca*) which are less priced and easily available from the River Kakmara. The fish species were collected at an interval of 15 days from each site along with river water. This study reveals that at Kuemuri there was a significant effect of raised zinc metal concentration in water (highest 2 mg/L) that might have raised zinc value in fish *Chela labuca* muscle tissue. The study determined that the zinc absorption value in water at Purbadwarkapur 1 was 1.09 mg/l and at Kuemuri Bamboo bridge site 1.85 mg/l, where fish *Chela labuca* muscle tissue also showed a higher amount of absorption. The study recommended that those sites where the absorption limit in river water is significantly affecting the fish tissue (muscle) should be taken under proper conservation.

Keywords: Acceptable Limit; Edible Muscle Tissue; Hazardous Metals

Introduction

In the last few decades, rapid progression of industrialization and urbanization has caused immense environmental deterioration and as trail deforestation, damming, mining, and urbanization shot up (Islam *et al.*, 2025). Most of the water bodies became dumping grounds of wastes. The toxic metals from domestic, industrial, farmland and mining areas are deposited in the water bodies, which are dumped directly into the water bodies, causing damage to the aquatic life. The key impact rivers have is reduced flow and a slowdown effect caused by heavy siltation along with the waste deposition. Toxic metals, which are non-biodegradable, always harm aquatic life and the effect of deposition ultimately flows to the consumers who consume those contaminated edible parts. Not only industrial waste but also agricultural development and use of fertilizers and pesticides also cause immense damage to society. Examination of the water metal content and accumulation of metals in the edible parts of the aquatic organisms may indicate the risk of metal toxicity for the consumers. Fish is a highly preferred food, being a good source of protein and healthy polyunsaturated omega-3 fatty acids. The edible parts of the fish that accumulated toxic metals when exposed to contaminated water might create health hazards and sometimes be lethal to the consumers (Shaltout, 2024). The present study aimed to investigate the anthropogenic intrusion in the river contamination of toxic wastes in water, which simultaneously percolates to the aquatic life. The study intended to determine the amount of toxic metals accumulated in the tissue of fishes from a contaminated environment in which fishes are exposed. On the other hand, the value of bioaccumulation of those toxic metals in the fish (food) that passes ultimately to the consumer (human). The study was done throughout the stretch of the Kakmara River (Latitude 21°53'10.9"N, Longitude 88°26'25.3"E). The Kakmara River is a tributary of the Mridangabhangha River, which, on the other hand, is a major

tributary of the Ganga River. The Kakmara River has a total length of approximately 6.8 km. Emerging from River Mridangabhanga, South 24 Pargana, it flows through villages named Kuemuri, Herambogopalpur, PurbaDwarkapur. The river is flushed by estuarine water in every high-tide session. Moreover, the riparian zone becomes flooded during every monsoon as well. The study was conducted during four consecutive years, July 2022-July 2025, at five study sites on the river 1) kuemuri, 2) kuemuri Bamboo bridge 3) Herombogopalpur, 4) Purbo Dwarikapur-1 and 5) Purbo Dwarikapur-2 covering the total length of the river. During this study the adjacent ponds and ditches, which get drowned during each high tide, were also studied to integrate comprehensive sampling. Four fish species (*Mystus tengara*, *Amblypharyngodon mola*, *Puntius ticto*, and *Chela labuca*) were collected fortnightly from five study sites to observe the toxic metal absorption limit of muscle tissue and water parameters were also studied during every study. These four fish species had a rich population in this river and a definite breeding ground (Sarkar, 2025). The present work aimed to study the metal absorption limit in river water and four fish species in three seasons to determine the bioaccumulation values of hazardous metals that definitely harm the consumers and results will provide to the local people the firsthand knowledge of toxic metals (Cu, Pb, Ni, Zn, Co, Cd) absorbed in fish edible parts and water and also their effects when consumed. Majumder *et al.* (2024) opined that toxic chemicals that are absorbed in the edible tissue of aquatic organisms might be hazardous to the consumers. During each study, water parameters (Dissolved Oxygen, Free Carbon dioxide, Ph, Alkalinity, Turbidity and Temperature were also studied in all study sites).

Methodology

Fish samples of *Mystus tengara*, *Amblypharyngodon mola*, *Puntius ticto*, and *Chela labuca* were caught by engaging fishermen in all five study sites, including those ponds and ditches on the bank that were flooded by the river water during every high tide, fortnightly, over four consecutive years. The sample fishes were thoroughly washed, managing to remove slime from the body, and then muscle from the dorsal side, ventral side, and caudal muscle was collected. Muscle tissue was dipped and fixed in HNO_3 at the collection site immediately for future study. Digestion was done in the laboratory with HNO_3 , H_2SO_4 , and H_3PO_4 following Loon (1980). The filtrate was collected after digestion of tissue and stored in a glass-stoppered bottle before analysis. Analysis of metals was done in AAS (Varian AA 0.575). Water parameters (Dissolved Oxygen, Free Carbon dioxide, Alkalinity, Ph, salinity, Temperature of Water and Air) were studied by water testing kit.

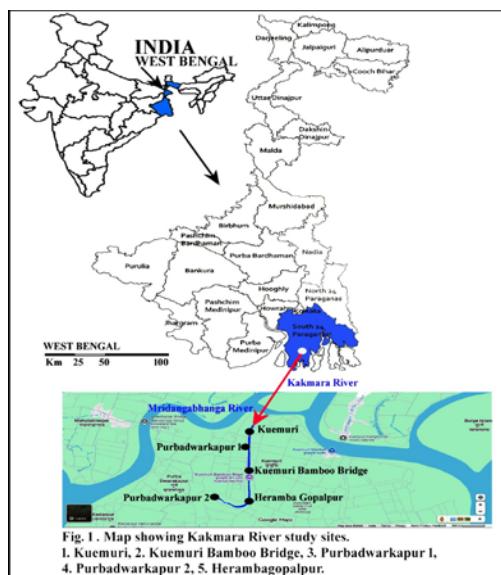


Figure 1: Map Showing Study Sites at Kakmara River

Results

Results of the study of toxic metals in fish muscle tissue and river water

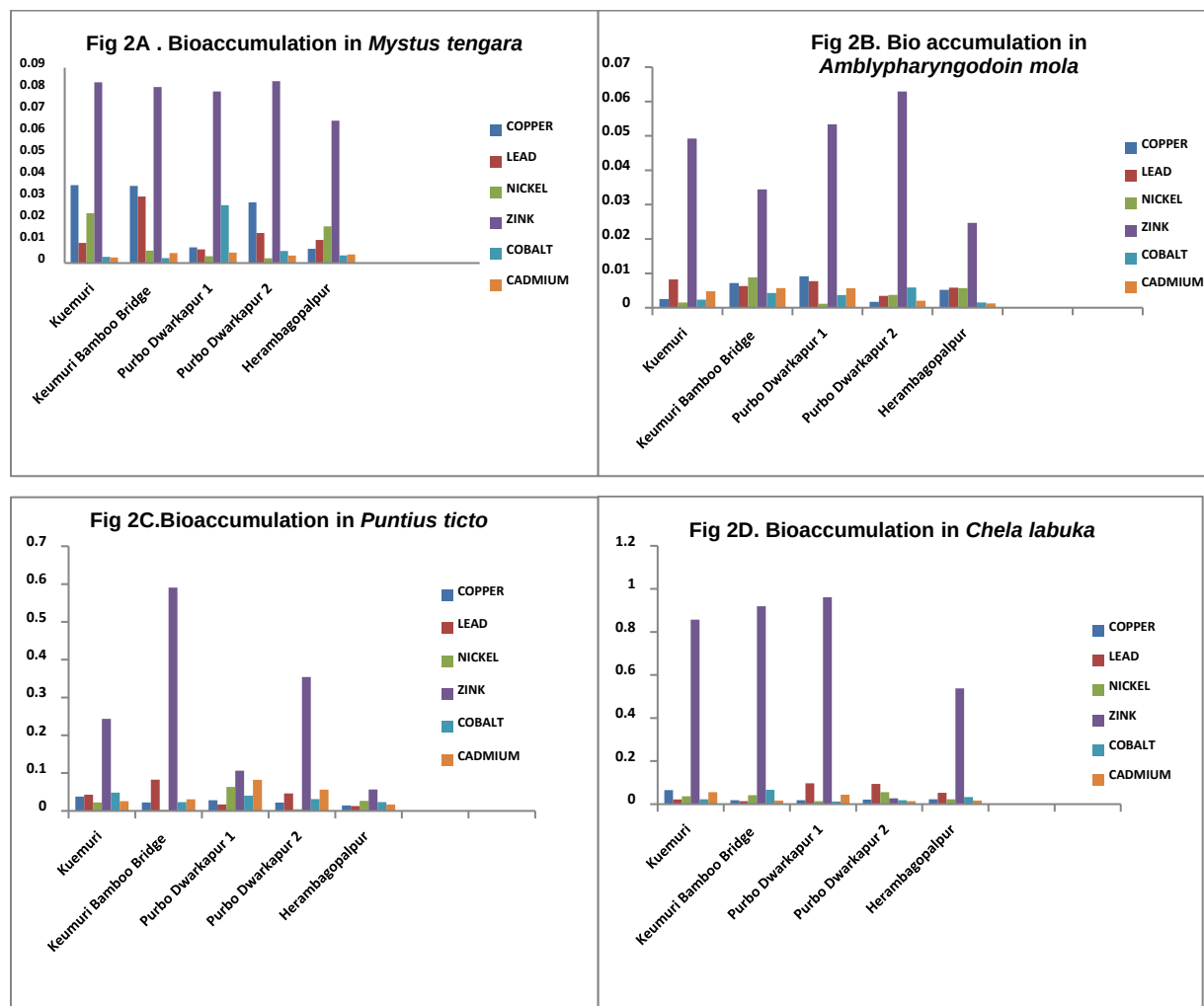


Figure 2: Bioaccumulation of Toxic Metals in Fishes (*Mystus tengara*; *Amblypharyngodon mola*; *Puntius ticto*, and *Chela labuka*) Muscle Tissue of Kakmara River

The statistical analysis of bioaccumulation of metals in fish muscle tissue (Fig. 2.A-D) indicated that Zn in muscle of *Mystus tengara* showed the highest value, $0.83 \pm 0.08 \mu\text{g/g}$, during the premonsoon season, and the lowest value was determined during the monsoon, $0.002 \pm 0.02 \mu\text{g/g}$, at the Purbadwarkapur 1 site; in *Amblypharyngodon mola*, the highest bioaccumulation value observed was $0.062 \pm 0.06 \mu\text{g/g}$, which remained within the permissible limit. This study reveals that at Kuemuri there was a significant effect of raised zinc metal concentration in water (highest 9 mg/l) that might have raised zinc value in fish *Mystus tengara* $0.098 \pm 0.09 \mu\text{g/g}$ in muscle tissue. The study determined that the zinc absorption value in water at Purbadwarkapur 1 was 1.09 mg/l and at the Kuemuri Bamboo bridge site 1.85 mg/l, where the muscle tissue of fish *Chela labuka* also showed a higher $0.091 \pm 0.09 \mu\text{g/g}$ value of absorption. The findings of Islam *et al.* (2025) indicated a higher Pb, Cu and Zn content in muscle tissue in *Mystus tengara* collected from a river in Bangladesh, but Murugan *et al.* (2008) observed lower zinc absorbed in muscle tissue of fish, though higher in water. During the present study, bioaccumulation of zinc in muscle tissue of all four fishes was found within permissible limits that corroborates with Murugan *et al.* (2008). Madhusudan *et al.* (2003) opined that the metal Zn percolates through gills and integument from the

environment and is then ultimately absorbed in muscle tissue and transferred to the other organs as well. Murugan *et al.* (2008), while working with *Channa punctata* in confined water, revealed that Zn metal absorption limit in tissue of fish was higher when it remained higher in the aquatic medium, as the fishes absorbed it more from the medium. The study indicated that Zn. Bandpe *et al.* (2016) opined that carp species that accumulated higher Zn in their muscle tissue might contaminate consumers, but the present study determined that the fishes from all five study sites in four consecutive years, all the fishes in all seasons in all years, showed a higher concentration of Zn in muscle tissue.

The metal nickel is corrosive to lung function; it damages kidneys in addition when deposited in the human body. The studied Ni bioaccumulation value (Fig. 2.A-D) in *Puntius ticto* was $0.063 \pm 0.06 \mu\text{g/g}$, indicating the highest among all other fish station-wise at Purbo Dwarkapur 1, which is within the permissible limit.

Copper is an essential metal for the human body, but when deposited in excess amounts, it is lethal to mankind. Rahman *et al.* (2012) in the Bangsi River in Bangladesh and Ahmad *et al.* (2015) in Kabul River found much higher levels of copper in fish muscle tissue and in river water as well. The bioaccumulation value of copper observed in the present study was highest at Kuemuri ($0.0652 \pm 0.06 \mu\text{g/g}$), which indicates the highest value during this study, which is within the permissible limit. The present study observed that determined copper in Kakmara River water is within the permissible limit at all study sites and the bioaccumulation value of Cu (Fig. 2.A-D) in muscle tissue in all four fish was also within the permissible limit.

Tuzen and Soylak (2007) opined that cobalt metal is essential for fish metabolism but causes damage when present in excess in the habitat. The analysis of river water in Kakmara River indicated that the highest cobalt concentration in river water was 0.07 mg/l at Herombogopalpur, but the bioaccumulation value (Fig. 2.A-D) results are within the permissible limit.

Majumder *et al.* (2024) and Tabrez *et al.* (2020) opined that the metal cadmium is toxic in smaller amounts also; when present in an aquatic body, it harms GI tract and kidneys when absorbed in the human body as well as fishes. Cadmium concentration in water in all five study sites through Kakmara River does not exceed beyond permissible limit (FAO/WHO, 1972) bioaccumulation value (Fig. 2.A-D) also was within permissible limit in edible muscle tissue in four fishes *Amblypharyngodon mola*, *Mystus tengara*, *Puntius ticto*, and *Chela labuca*.

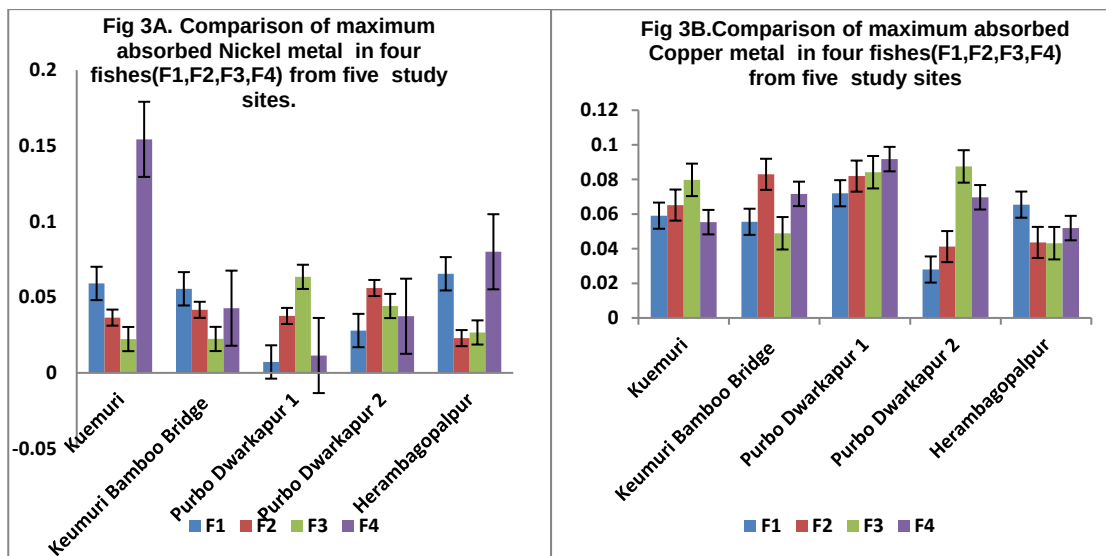
Lead causes harm to the aquatic organisms even when present in a lesser amount in an aquatic body and is also lethal to the consumers (Hossain *et al.*, 2018). The present study determined that lead in river water showed the highest value at Kuemuri Bamboo Bridge (0.001 mg/l), which was within the permissible limit and remained within the permissible limit for five stations as well.

Discussion

The hazardous effect of toxic metals that get easily absorbed in the aquatic fauna and flora is of great concern to the consumers. Rohani *et al.* (2022) and Saha *et al.* (2009) observed that nonessential metals Cd, Cr, Ni, and Co, when consumed in excess by consuming contaminated food fishes, may have carcinogenic effects, cardiovascular dysfunction in adults and in addition, retarded cognitive power in children. The research indicated that the heavy metals do not get removed and are easily transferred to consumers at the next level through the food chain. The effect of metal toxicity studied by different authors revealed that metals are very much hazardous to human life; when exposed to higher levels, it might cause damage to GI system, endocrine system, and appendicular system. Also, long-term exposure may damage grey cells and cause disorientation in normal cognition in man (Akoto *et al.*, 2014). Akter *et al.* (2021) opined that lead accumulation, when exceeding the permissible limit, may affect children's health adversely, like constant pain in the abdomen, constipation, forgetfulness, and

depression, and cadmium and metals lead and chromium might cause heavy damage to the kidney and urethral system and reproductive system, which may lead to carcinoma. The detailed study of metal contamination in fish muscle tissue by Shaltout (2024) and Emon *et al.* (2023) opined that metals ultimately cause damage to the consumers at the level of DNA and cause serious pollution that threatens life.

The studied fishes *Chela labuka*, *Mistus tengara*, *Amblypharyngodon mola*, *Puntius ticto* are the most important high-value fish species and its catch density showed very profitable data in this river. The previous study (Sarkar, 2025) indicated the Kakmara River as the best breeding ground for almost all the fish of Mridangabhangra River, therefore, proper conservation and restoration of the native fish species diversity and their breeding ground should be the utmost priority. Moreover, Kakmara River is affected less by anthropogenic intervention and in addition to it, the river gets a high-tide flow flush from Mridangabhangra River, which definitely increases faunal diversity as well. The four studied fish species have high demand in the local fish market as well as in the fish market of Kolkata as food fishes and also for its esthetic value as ornamental fishes. The fish species *Amblypharyngodon mola* (Mola carplet) is highly preferred fish for its good taste and high protein value and is also a good source of minerals (Fe, Zn, Ca) and vitamins (Alam, 2004). They are herbivorous fish and often planktivorous (Kanwal & Pathani, 2012); therefore, it is very much evident that these fishes are always exposed to absorbed metals by the water as well as planktons and weeds. But the recent study reveals that only zinc metal showed highest bioaccumulation value, which is also within permissible limit. The other fish species *Puntius ticto* is a very common minnow, rich in protein, phosphorus and minerals and also easily available in good quantities from this river. This fish is planktivore (Hoque *et al.*, 2016), and its habitat is surface water. A study of the absorption of toxic metals in the muscle tissue of this fish revealed that all the studied metals are within the permissible limit. The glass barb, *Chela labuka*, is a very common, easily available fish also found in the upper surface and bottom depth of river. This planktivore fish species is rich in protein content, fat and minerals (Epa & Narayana, 2016). Statistical analysis of bioaccumulation of metals in the muscle tissue of this fish indicated safe results, as the value was within the permissible limit. The popular catfish *Mystus tengara*, is a very good source of protein and is available in abundant quantities from this river.



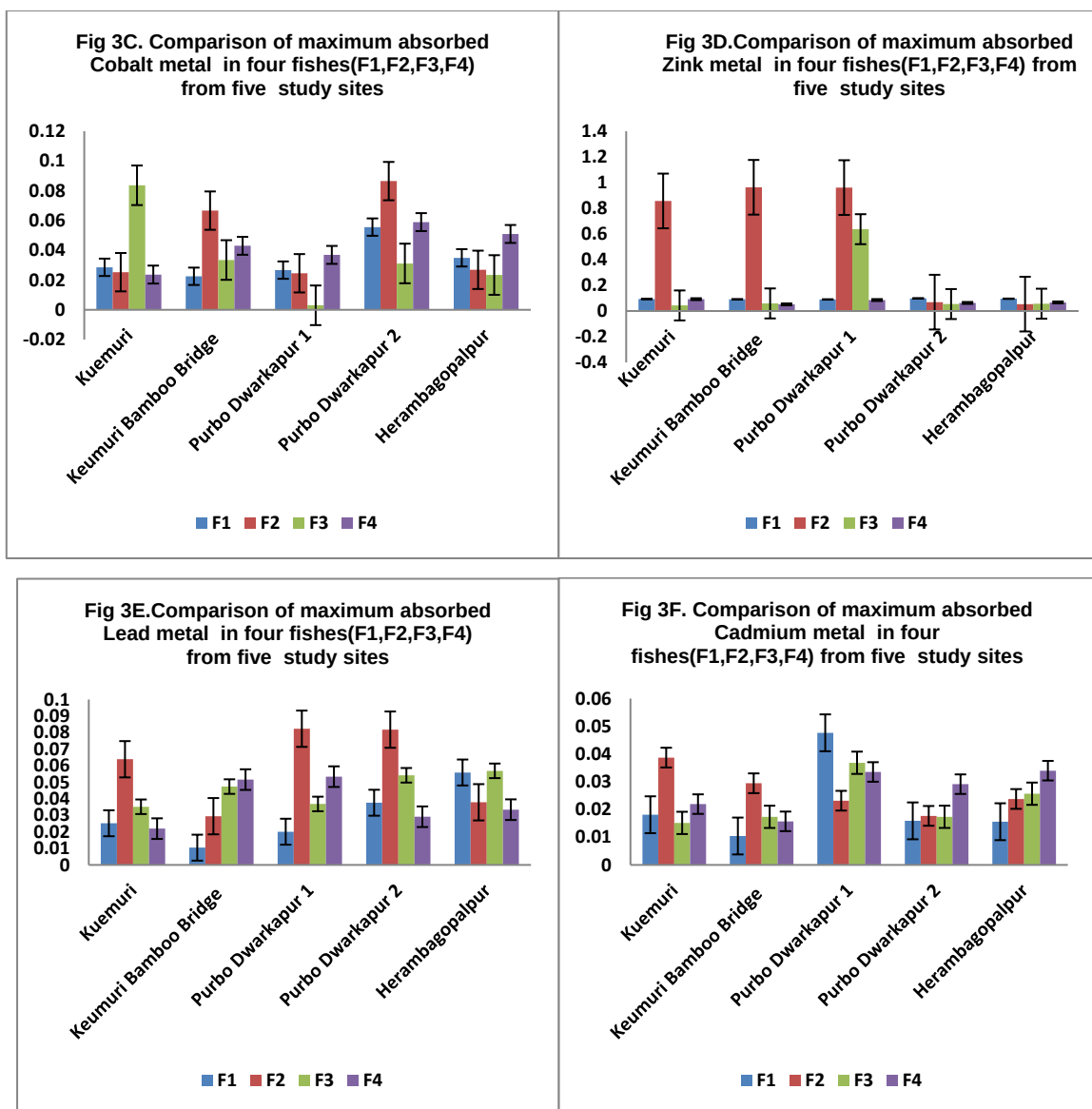


Figure 3: Comparison of Maximum Absorbed Metals (Copper, Lead, Nickel, Zink, Cobalt, Cadmium) in Four Fishes (F1-Mystus tengara, F2-Amblypharyngodon mola, F3- Puntius ticto, F4 - Chela labuka) from Five Study Sites

This species shows a variety of feeding habits (Majumder *et al.*, 2024); they feed on detritus matter, fecal debris and small fishes. Figure 3 A-F showed the graphical representation of the comparison of maximum metal absorption in muscle tissue of four studied fishes. The study indicates that the fish *Mystus tengara* showed the highest metal absorption of metal zinc (0.0983 µg/g), nickel (0.063 µg/g), and cadmium (0.047 µg/g); fish *Chela labuka* showed maximum absorption of metals lead (0.082 µg/g) and cobalt (0.086 µg/g); and fish *Puntius ticto* showed maximum limit of copper metal 0.087 µg/g (Figure 3. A-F) absorption in muscle tissue.

Conclusion

This Kakmara River flows through the area where a concrete road for vehicles is absent. Also, there are no major or small factory outlets that lead to the river; anthropogenic infiltration is also limited, which might be the reason for the lowered metal value in river water. The study of dissolved oxygen, free carbon

dioxide, and pH values of river water in three seasons—pre-monsoon, monsoon, and post-monsoon—indicates a healthy aquatic environment for the Kakmara River. The mangrove forest on both sides of the river, stretching about six km from Herombogopalpur and Purbodwarkapur 2, might be the suitable environmental cover for flowing water as well as aquatic organisms, and that might also be the cause for lowering the contamination of toxic metals. Analysis of heavy metals in the water of the Kakmara River showed a nominal (within permissible limit) value of the absorption limit for all the metals studied. The study determined that bioaccumulation of metal in muscle tissue of all the studied metals is within the permissible limit. Fig. 3.A-F showed the comparison of maximum absorbed metals (Cu,Pb,Ni,Zn,Co,Cd) in four fishes (F1-*Mystus tengara*, F2-*Amblypharyngodon mola*, F3- *Puntius ticto*, F4 - *Chela labuka*) from five study sites; all the values were within permissible limit.

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Conflicts of Interest

The authors declare no conflict of interest.

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