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A STUDY OF HEAVY METALS OF BIOACCUMULATION IN SOME TISSUES LABEO ROHITA FISH FROM HASDEO RIVER EFFECTS OF HEAVY METALS ON FISH

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ABSTRACT

This study investigates the bioaccumulation of heavy metals in various tissues of fishes collected from the Hasdeo River in order to assess the ecological and health risks associated with the river's water quality. A diverse range of fish species was sampled from multiple locations along the Hasdeo River, a major tributary of the Mahanadi River in India. Tissues from these fishes, including muscle, liver, gills, and skin, were analyzed for the presence and concentration of heavy metals, including lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As). The study employed advanced analytical techniques such as atomic absorption spectrometry and spectroscopy to determine metal concentrations. The results indicate significant variations in heavy metal concentrations among fish species and tissue types. The liver and gills showed higher metal accumulation than muscle and skin tissues. Additionally, the study found that the heavy metal levels in Labeo rohita fish from the Hasdeo River exceeded the permissible limits set by regulatory authorities, signifying a considerable threat to both aquatic life and the human population that relies on the river for sustenance.

Keywords: Bioaccumulation, Heavy Metals, Tissues of Fishes, Hasdeo River

1. INTRODUCTION

The contamination of aquatic ecosystems by heavy metals has become a pressing global environmental concern, with far-reaching consequences for both the natural world and human populations. Rivers, as vital freshwater sources and habitats for aquatic organisms, are particularly vulnerable to heavy metal pollution, which can lead to detrimental effects on ecosystem health and the safety of seafood for human consumption.

The ever growing industrialization in recent times has come to stay as a continuous threat to the well being and survival of the human beings, fish, wild as well as domestic animals, through various polluting discharges. The discharged wastes of industries are either released into the atmosphere or mixed with large bodies of water. The reaction and survival of aquatic organisms under toxic conditions depend on not only the species and its habitat but also on several factors such as the kind and concentration of the toxicants, temperature, salinity, dissolved oxygen, pH etc., in addition to the type and time of exposure to the toxicants. Environmental biologists suggest that control of the pollution at the source itself is the best remedy to maintain the quality of the environment and also food, water, air and other consumer articles. Among the industrial wastes, heavy metals cause hazards not only to mankind but also to other organisms.

The bioaccumulation of heavy metals occurs as a result of their discharge into the river through anthropogenic activities, including mining, industrial effluents, and agricultural runoff. These metals, including lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As), can persist in the aquatic environment, posing a threat to the wellbeing of both aquatic organisms and humans who consume contaminated fish.

This study aims to investigate the extent of heavy metal bioaccumulation in selected fish species inhabiting the Hasdeo River. The research focuses on an array of tissues, including muscle, liver, gills, and skin, to comprehensively assess metal accumulation patterns. The findings will provide valuable insights into the potential risks associated with heavy metal contamination in this river system and offer a basis for informed management and conservation strategies.

Understanding the dynamics of heavy metal bioaccumulation in the Hasdeo River is essential for mitigating environmental threats and protecting human health. The results of this study may inform policy measures and management actions necessary to curtail the impact of heavy metal pollution in this vital freshwater ecosystem. As a foundation for broader environmental awareness and remediation efforts, this research seeks to contribute to the sustainable management of aquatic resources in the Hasdeo River region.

Labeo rohita is one of the major Indian carp species used in carp polyculture systems. This graceful Indo-Gangetic riverine species is a natural inhabitant of the riverine system of Northern and central India and the rivers of Pakistan, Bangladesh and Myanmar. Labeo rohita, in early life stages prefers zooplankton, primarily rotifers and cladocerans, along with phytoplankton that constitute as emergency food. By contrast, adults show a strong preference for most of the phytoplankton (FAO., 2006). Hypophthalmichthys molitrix is an exotic and native species in China and Eastern Siberia (Froese and Pauly, 2006). However, it has been introduced in many other countries for aquaculture. Hypophthalmichthys molitrix is a typical planktivore and its gill rakers are the primary means of filtration. It consumes diatoms, dinoflagellates, chrysophytes, xanthophytes, some green algae and cyanobacteria (blue-green algae), as well as detritus, bacterial conglomerates, rotifers and small crustaceans (FAO., 2005).

2. MATERIALS AND METHODS

Study area: The Hasdeo River, a prominent tributary of the Mahanadi River in India, has witnessed rapid industrialization and urbanization in its catchment area. This transformation has raised concerns about the river's water quality and the potential bioaccumulation of heavy metals in its aquatic biota, especially fishes. The accumulation of heavy metals in fish tissues is of paramount significance due to its implications for the aquatic food chain and human health. Fish tissue samples were collected for all four seasons (spring, summer, autumn and winter) during 2021-2022.

Sampling and sample preparation: The fish species, L. rohita was collected for determining heavy metal concentrations in different tissues. A total of 2 samples were collected. The total length and weight of the fish were measured immediately. The samples were brought to the laboratory in an ice box. The fish were immediately dissected using a precleaned stainless steel knife and approximately 5 g of tissues of interest (muscle, liver, gill and scale) were initially rinsed with double-distilled water, packed in acid-precleaned polyethylene bottles and stored at-20°C until analysis. Samples were transferred to preweighed acid-precleaned petri dishes and dried at 80°C for 24 h. Subsequently, sample dry weights were recorded. A dried sample (1 g) was digested with 10 mL of HNO3 on a hot plate at 80°C for 1 h. Because lipids (oil) were a significant fraction of most tissues, 1-2 mL of 35% H2O2 was added for lipid digestion. The samples were further digested at 150°C for 3 h. After cooling, the samples were transferred to 50 mL volumetric flasks and diluted with deionized water to 50 mL (Darafsh et al., 2008). Blank samples were prepared in the same manner as the fish tissue samples. Heavy metal concentration was calculated using a standard equation:

$$\text{Heavy metal concentration } (\mu g\ g^{-1} \text{ dry weight}) = \frac{\text{AAS reading} \times \text{Diluted solution volume}}{\text{Weight of sample (g)}}$$

All the samples were analyzed for six metals, namely Cu, Cr, Pb, Zn, Ni and Cd by using an atomic absorption spectrophotometer (GBC Scientific SensAA).

Statistical analyses: Two-way analysis of variance was used to evaluate heavy metal concentrations in fish tissues in different seasons. Pearson’s correlation coefficient of variance was used to measure the strength of a linear relationship between heavy metal concentrations in different fish organs. Statistical analyses were performed using SPSS version 14.

3. RESULTS AND DISCUSSION

Mean concentrations of heavy metals in muscle, liver, gill and scale tissues of Labeo rohita is summarized in Table 1, respectively. The Cd concentrations detected for both fish species were below the detection limit. Cu, Pb and Zn concentrations in Labeo rohita showed a significant difference between seasons and organs, whereas, Ni concentration was statistically significant among seasons (Table 1). Figure 1 shows seasonal variations in heavy metal concentrations in fish species. Metal concentrations in different organs of Labeo rohita is shown in Fig. 2. Mean concentrations of heavy metals in the muscle, gill and scale tissues of Labeo rohita were as follows: Zn>Pb>Cr>Ni>Cu.

In L. rohita, heavy metal concentrations (μg gG1 dry weight) ranged 2.845-50.515 for Cu, 7.765-38.775 for Cr, 13.935-35.38for Pb, 1.710-31.805 for Ni and 16.705-66.395 for Zn. Zn had the highest concentration in muscle, liver, gill and scale tissues, followed by Pb and Cr for Labeo rohita. The source of high heavy metal concentrations in fish tissues could be domestic waste disposal, sewage wastewater, agricultural runoff and road runoff caused by tire wear and corrosion of bushings, brake wires and radiators (Dixit and Tiwari, 2008).

Table 1 Seasonal variations in mean metal concentrations (μg gG1 dry weight) in different organs of Labeo rohita collected between 2021-2022.

Metals and organs	Spring	Summer	Autumn	Winter
Cu				
Muscle	2.845±2.1210	8.235±5.2560	4.320±2.6890	7.615±7.175
Liver	5.825±1.5140	50.515±22.341	37.675±15.184	9.825±5.322
Gill	4.275±2.0180	13.545±3.7440	5.145±2.3990	8.395±3.078
Scale	4.450±1.6540	10.180±4.3610	3.925±1.9110	7.605±2.120
Mean	4.349±1.2190a	20.619±20.051a,b	12.766±16.614b	8.360±1.044
Cr				
Muscle	7.765±8.9380	18.370±12.578	9.425±5.4570	16.485±17.495
Liver	8.240±7.6940	30.510±5.7860	21.645±6.4000	17.920±15.864
Gill	13.435±12.801	36.630±10.156	13.200±9.5790	22.690±21.322
Scale	12.825±11.972	38.775±1.8200	24.710±12.483	20.720±19.744
Mean	10.566±2.9770	31.071±9.1630	17.245±7.1320	19.454±2.7830
Pb				
Muscle	15.695±2.924	14.535±7.147	15.065±3.931	13.935±2.934
Liver	18.010±2.097	30.450±4.694	18.835±3.189	14.195±6.566
Gill	17.800±1.242	34.688±9.891	22.090±5.234	22.305±9.016
Scale	18.925±3.166	35.380±7.760	20.515±5.918	24.750±8.719
Mean	17.608±1.365a	28.763±9.733a	19.126±3.016	18.796±5.555
Ni				
Muscle	1.710±0.3570	17.970±13.726	11.230±9.4970	4.380±3.1190
Liver	4.380±2.0130	22.555±13.242	16.145±9.9640	5.205±2.3010
Gill	3.700±2.3090	31.805±7.8090	20.420±8.8100	5.680±1.9420
Scale	4.310±2.5880	27.050±11.304	17.735±8.4150	9.215±13.973
Mean	3.525±1.248a,b	24.845±5.9390a,c	16.383±3.8620b	6.120±2.1320c
Zn				
Muscle	16.705±11.165	47.050±8.1100	42.050±12.554	35.220±13.717
Liver	32.835±8.3300	65.790±4.8190	63.395±6.7270	55.385±12.162
Gill	39.010±4.0300	66.395±11.405	57.120±12.509	64.880±20.459
Scale	37.630±4.9710	54.130±3.7760	62.600±10.585	56.860±15.171
Mean	31.545±10.241a,b,c	58.341±9.4090a	56.291±9.8960b	53.086±12.62

Heavy metal concentrations in muscle, liver, gill and scale samples showed different capacities for accumulation. The observed variability in heavy metal concentrations in different organs and tissues of different fish species depends on the physiological role of each organ (Bahnasawy et al., 2009), feeding habits (Romeo et al., 1999), ecological needs, metabolism and age, size and length of the fish as well as habitats (Canli and Atli, 2003). The gill and liver samples of the examined fish species contained highest concentrations of all the detected heavy metals (Fig. 2), whereas, muscle samples had lowest concentrations of the metals. This finding is in agreement with those of previous studies of the concentration of different metals in various organs of fish (Bahnasawy et al., 2009; Canli and Atli, 2003; Karadede et al., 2004; Romeo et al., 1999; Saeed and Shaker, 2008; Unlu et al., 1996).

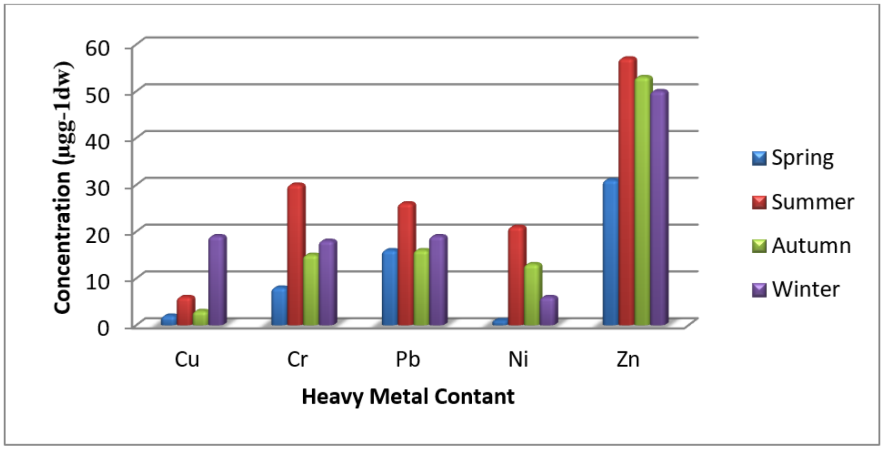

Figure 1 Seasonal variations in metal concentrations in Labeo rohita

High concentrations of heavy metals in gill tissues could be attributed to the metal-mucus complex that is difficult to remove from the gill lamellae before tissue analysis (Karadede et al., 2004). High concentrations of heavy metals in liver and gill tissues are attributed to the affinity or strong coordination of metallothioneins with metals. These proteins are synthesized in the liver and gill tissues when fishes are exposed to heavy metals and help the fish to detoxify metals. Moreover, these proteins are assumed to have a major role in protecting fish from damage caused by heavy metal toxicants (Ikem et al., 2003; Jobling, 1995; Hamilton and Mehrle, 1986). Allen-Gill and Martynow (1995) attributed low concentrations of metals in muscles to low levels of binding proteins in muscles. After liver and gill tissues, scale tissues accumulated high concentrations of heavy metals. The reason for high concentrations of heavy metals in scale tissues could be attributed to the binding of metals to mucus because, it is difficult to completely remove the metal-mucus complex from tissues during analysis.

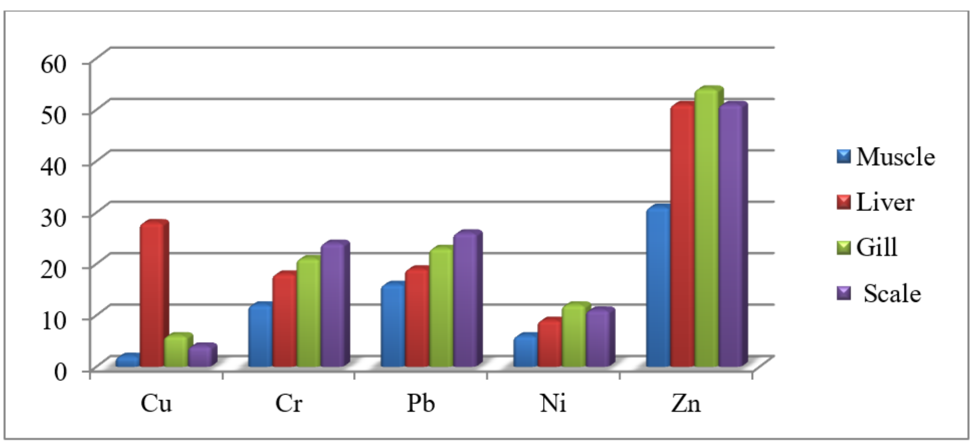

Figure 2 Mean metal concentration in different organs of Labeo rohita

Seasonal variations in heavy metal concentrations in fish have been reported by many studies (Bahnasawy et al., 2009; Hamed, 1998; Khallaf et al., 1998; Zyadah, 1997). In this study, heavy metal concentrations in different fish organs showed significant difference among seasons. For both species, metal concentrations in the organs were the highest during the summer and the lowest during the spring. Based on the data of two successive years, seasonal variations in heavy metal concentrations (at total value) were in the following order: summer> autumn> winter>spring (Fig. 1). Similar findings were reported by Mansour and Sidky (2002). These seasonal variations were in accordance to fluctuations in the surrounding environment (Abdel-Baky et al., 1998) and may be due to seasonal changes in the weight of fish tissue rather than variability in absolute metal concentration in the fishes (Ansari et al., 2004).

In this study, high metal concentrations in fish tissue samples indicated that water in Bhagwanpur fish pond was contaminated by sewage discharge, agricultural runoff and waste material dumpings. Heavy metal concentration was L. rohita.

Heavy metal concentrations in L. rohita and H. molitrix have been previously studied by various authors (Bhupander et al., 2011; Mastan, 2014; Nawaz et al., 2010; Naz and Javed, 2013; Rauf et al., 2009). Papagiannis et al. (2004) showed that variations in metal concentrations in the same tissues of two species could be caused by differences in the feeding habits, growth rate of the species, type of tissue analyzed. When metals are discharged into the aquatic ecosystem they enter the food chain and accumulate in the body of fish. Aquatic animals can accumulate heavy metals through two sources: (1) Free ions and simple compounds dissolved in water or taken up directly through the epithelium of the skin, gill and alimentary canal and (2) Consumption of heavy metal-containing food organisms or incorporated through nutrition (Javed, 2005).

4. CONCLUSION

The bioaccumulation of heavy metals in aquatic organisms is of growing concern due to its potential impact on both the ecosystem's health and human populations that depend on freshwater fish as a food source. The Hasdeo River, situated in the central Indian state of Chhattisgarh, has been a subject of increasing interest in recent years due to its critical role in supporting local communities and the surrounding ecosystem. The river is home to various fish species, including Labeo Rohita, a common and economically important fish species in the region. This study aims to investigate the bioaccumulation of heavy metals in various tissues of Labeo Rohita fish from the Hasdeo River during 2020-2021 in 4 seasons. By conducting a comprehensive analysis of heavy metal concentrations in different fish tissues (e.g., liver, gills, muscle), we intend to evaluate the extent of heavy metal contamination in the river and its potential implications for the aquatic ecosystem and human health. Heavy metals can disrupt aquatic ecosystems, affecting the health and abundance of various aquatic species, including fish, which occupy key positions in the food chain. Local communities rely on freshwater fish like Labeo Rohita as a primary source of protein. High levels of heavy metals in fish tissues can pose a direct risk to human health when consumed. The findings of this study will contribute to a broader understanding of the environmental quality of the Hasdeo River, support conservation efforts, and provide valuable insights for policymakers and local communities. Moreover, it may guide the development of strategies to mitigate heavy metal pollution and protect the river's ecosystem and the well-being of those who depend on it.

CONFLICT OF INTERESTS

None.

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