# Assessment Of Heavy Metal Bioaccumulation in Freshwater Fish Species: Implications for Ecosystem Health and Human Well-Being

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**Abstract:**
This research article investigates the bioaccumulation of heavy metals in freshwater fish species from Tekrial Lake, Kamareddy, Thimmakpally Lake, Kamareddy, and Sriram Sagar Project, Nizamabad. The study focuses on *Labeo rohita*, *Catla catla*, and *Channa punctata* as model species to assess the effects of heavy metals, namely zinc(Zn), lead(Pb), ferrous(Fe), and manganese(Mg) on their vital organs including liver, gills, and muscles.
Several experiments were conducted to evaluate the levels of heavy metal accumulation in fish tissues using advanced analytical techniques (Atomic Absorption Spectrometer(AAS),Inductively Coupled Plasma Mass Spectrometry). The results indicate a concerning presence of these heavy metals in the examined fish species, suggesting a potential threat to the aquatic ecosystem and human health through fish consumption.
Furthermore, this study proposes effective methods to alleviate heavy metal contamination in freshwater fish. The recommended approaches include ion exchange, adsorption, reverse osmosis, and solvent extraction methods. These techniques show promising potential in removing heavy metals from fish tissues and restoring the ecological balance of freshwater ecosystems.
Overall, this research sheds light on the alarming bioaccumulation of heavy metals in freshwater fish and emphasizes the detrimental effects on organ function. The proposed remediation strategies provide practical solutions for the mitigation of heavy metal pollution, ensuring sustainable aquatic environments and safeguarding human well-being.

**Keywords**: Bioaccumulation, Heavy metals, Industrialization, Indian major carps, Atomic Absorption Spectrometry, Morphometric measures, Toxic metals.

## 1. INTRODUCTION:

Due to rapid growth of population, industrialization, agricultural practices due to which the aquatic ecosystem is being polluted to an extent which is irreparable and is a problem of concern. The discharge of sewage and industrial waste waters into water bodies is leading to deposition of various pollutants/contaminants into aquatic ecosystem which may become accumulated, and toxic. These contaminants may make water unsuitable for various purposes and cause threat to human health through bioaccumulation in inland water bodies.

The most important issue arises when heavy metals that are released into the environment pose a threat to the aquatic life as well as their predators. The demand for fish consumption is gradually increasing to facilitate the growing population which in turn is increasing the pressure over the fish capturing sector. However, aquatic life is under constant threat due to pollution caused by various anthropogenic sources. Fish is at the top of an aquatic food chain and during its life it can accumulate large amount of toxic metals. Heavy metals enter the aquatic ecosystem mainly through anthropogenic sources. Fishes have been recognized as accumulators of organic and inorganic pollutants. Fishes are considered to be most significant bio monitors in aquatic systems for the estimation of metal pollution level the global consumption of fishes has gradually increased in the last few years as fish consumption possesses great therapeutic and nutritional benefits.

Fish accumulate toxic materials at various levels depending on species, age, season, feeding habits etc. The rate of bioaccumulation of heavy metals in aquatic organisms depends on the ability of organism to digest the metals in the water body. Humans consume fish as a dietary uptake without knowing the heavy metal accumulated from the polluted areas and are vulnerable to certain health risks. Toxic effects occur when excretory, metabolic storage and detoxification mechanisms are no longer able to counter the uptake of these toxicants. Entry of heavy metals in the organs of fish mainly takes place by adsorption and absorption.

## 2. MATERIALS AND METHODS:

### 2.1 .Fish sampling

Four commercial fish species were purchased from local fishermen at three fish landing areas on the Tekrial lake , Thimmakpally lake and S.R.S.P reservoir during these days. The collected sample species were - *Wallago attu, Channa punctata, Catla catla* and *Labeo rohita.* These fish species represent different biotopes and are economically importa.

**Figure 1: Sample of the fish**

### 2.2 Preservation of Collected fish:

Collected fish were immediately preserved in an ice box and transferred to the laboratory where they were classified, weighed, measured by total length and keptfrozen at -20c until further analysis.

**Figure 2: Preserving collected sample**

### 2.3 Determination of metal concentrations

Preparation of subsamples and analysis were made according to FAO technical paper. For metal analysis , frozen, fish were partially thawed , and each Fish was dissected using stainless steel instruments . Muscles , liver and gills were taken out; composite samples of 2 to 5 grams were used for subsequent analysis

The samples were digested with ultra pure Nitric acid [and perchiloric acid for gills [4:1] at 100c until the solution become clear. The solution was made up with known volume with deionized distilled water and analysed for Cu, Zn, Pb, Cd, Fe and Mn using the Atomic Absorption Spectrophotometer at Telangana University in south campus with the help of Asst prof Sri.Nagaraju. The obtained results were expressed as µg/g wet weight.

### 2.4 Equipment for AAS

**Figure 3: Atomic absorption spectrometry**

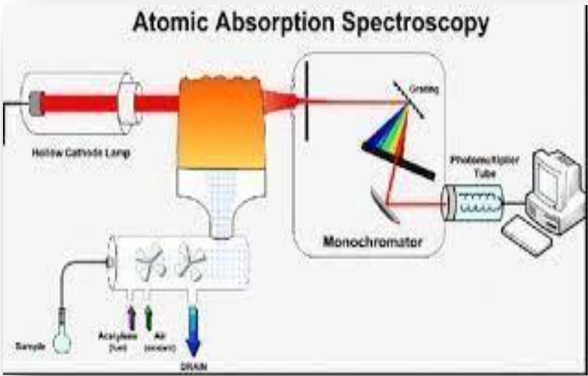



**Figure 4 :working of atomic absorption spectrometry2.5 Inductively Coupled Plasma Mass Spectrometry (ICP-MS)**

- Uses an inductively coupled plasma to ionize the sample, and has greater speed, precision and sensitivity than Atomic absorption
- Only certain types of arsenic and mercury are toxic, so speciation analysis - the process of separating and quantifying molecular versions of a compound - can be used to test whether the toxic species are present in water. ICP-MS allows this to be done.

- Treatments can be applied, as required, to deal with any metal contaminants found in the water. WCS can design, engineer, install and commission such plant.
- At WCS Group, we can test for everything to provide insights into metals in water. All the parameters set out by the Water Supply Regulations can be tested as part of our drinking water metals analysis. We can also test for materials in wastewater and establish the scaling and corrosion potential of water by testing, typically for magnesium and calcium but also barium and ions like fluoride, sulphate, phosphate, carbonate and ph.
- Concentrations of heavy metals were then analysed using a graphite furnace Atomic Absorption Spectrometer (AAS) with high-purity argon. The results from the AAS were expressed as µg/g dry weight and converted to mg/kg in the results section. All reagents used were of analytical grade, and ultrapure water was used for the preparations of solutions. To acquire ultrapure water, water was purified using the LABCONCO water purification system from LABCONCO Instruments .To create pure and ultra-pure water for research laboratory applications, impurities that include particulates, colloids, ions, dissolved gases, dissolved organic solids, nucleases (rnase, dnase) and pyrogens need to be efficiently and effectively removed. Calibration standard solutions were made by stepwise dilution of the stock solution [Butanol dehyrogenase (BDH) spectrosol. Fish samples were spiked with various concentrations of heavy metals for the recovery repeatability test and to verify the analytical methods. For each run, the spiked samples were analyzed in triplicate. The effect of the sample matrix was studied by spiking an identified concentration of each heavy metal (Ni, Pb, Cd) into fish samples. Then, the spiked samples were digested. The content of heavy metals in the spiked samples was determined by using AAS.
- The percent recoveries were calculated by using the following formula:
  - Recovery (%) = $[(x–y)/z] \times 100$,
  - where x is the average concentration of heavy metal after spiking, y is the average concentration of heavy metal before spiking, and z is the concentration of spiked heavy metal. Acceptable results with recovery percentages of 77.3%–85.3%, 82.0%–83.0% and 78.0%–83.3% were obtained for Cd, Ni and Pb, respectively.
- All reagents were of analytical grade; glassware were soaked in 10% Nitric acid and later rinsed with distilled water prior to use in order to avoid metal contamination.
- Accuracy and precision were verified by using reference materials provided by international atomic agency. Analytical results of the quality control samples indicated a satisfactory performance heavy metal determination within the range of certified values 95-111% recovery for the metals studied.

**2.6 Bioaccumulation of Heavy metals:**

- Bioaccumulation is essentially the buildup of contaminants such as heavy metals or pesticides in living organisms
- Aquatic organisms are often subject to bioaccumulation because they observe contaminants from the water around them faster than their bodies are able to excrete them
- Humans are also subject to bioaccumulation either from consuming contaminated aquatic organisms or from exposure to contaminants in our food , air or water
- Bioaccumulation in the food chain begins with the smallest micro-organisms and ends with humans
- Heavy metals are able to find to surface of micro-organisms and sometimes enter the cell themselves once they enter the cell , heavy metals can react with chemicals released by the micro-organisms to

digest food

- At every point in this process heavy metals accumulate in the bodies of each living organisms bythe time they get to us we consume the heavy metal in high concentrations
- Unfortunately heavy metals can have serious health effects for humans
- Many play a role in cancer development or case internal organ damage even at low concentrations
- Cadmium , cobalt , lead , nickel and mercury are also known to effect the formation of blood cells
- Beyond certain concentration, aquatic pollution permits exposure of organisms to genotoxic agents resulting in DNA and chromosomal damage.

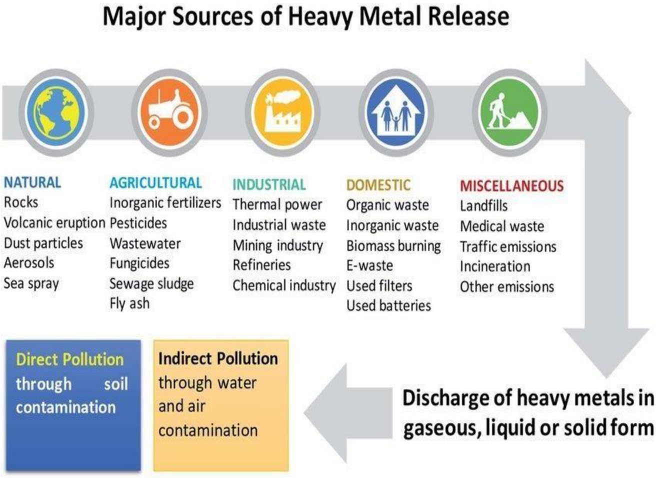



**Figure 5: Major causes of heavy metals**

## 3. RESEARCH METHODOLOGY:

**Area of Research:**

The current study was conducted in the fresh water bodies in and around Kamareddy District i.e., TekrialLake, Sriram Sagar Project (Pochampad) and Thimmakpally Lake.

### 3.1 Tekrial lake

This lake covers about 580 hectares.{ 973X+5QR, Tekriyal, Adloor Yellareddy, Telangana 503111} {18.3553° N, 78.2964° E} In this lake we can find fish species like *Labeo rohita*, *Channa punctata*, *Catla catla*, *Channa stratius* etc. The major reason for the accumulation of heavy metals is due to immersion of idols , inflow of the wastages from the nearby sugar factory, domestic wastes etc. The seasonal bioaccumulation of metal pattern was mainly associated with the type of the fish species.

**Figure 6: Tekrial lake**

**Map 1: Tekrial lake**

### 3.2 Thimmakpally lake:

This lake is totally covered in 92 hectares.{ 7887+WRG Thimmakkapalle, Telangana} In this lake, we collected species like *Labeo rohita*, *Catla catla*, *Channa punctata* and we also met Fishery department officer of Kamareddy Mrs. Poornima who shared her valuable experiences with us. Due to rapid growth of population, agricultural practices the aquatic ecosystem is being polluted to a large extent. These effluents alter the various physio- chemical parameters.

**Figure 6: Thimmakpally lake**

**Map 2 : Thimmakpally lake**

### 3.3 Sriram Sagar Project

The total water storage of the reservoir about 90 tmc.{ 18.9686° N, 78.3411° E} We observed various types of fishes caught by fishermen and also explained about the various types fish diseases. For example, gills are affected from Pb and Fe and also found some black spots on the gills, which was clearly explained by Pochampahad Fishery Department Officer Mr.T.Rajanarsaiah sir. These reservoir sediments acts as both carrier and sink for containments including heavy metals inaquatic environment.

**Figure 7: sriram sagar project**


**Map 3: sriram sagar project**

## 4 . RESULTS:

Result analysis shows that various anthropogenic activities, apart from natural sources are causing the environmental degradation. The treatment of water is not only required in Kamareddy district, but also across the world. Improvisation of existing treatment facilities to improve the quality of water is required along with measures to bring awareness among the public about these problems. Apart from advanced technological remedial measures, prevention of pollution aiming at sustainable development has to be emphasized.

Concentrations of heavy metals (Cu,Zn,Pb,Cd,Fe and Mn) in muscles , liver and gill of fish collected from Tekrial lake, Thimmakpally lake and S.R.S.P Reservior. Accumulation patterns of all metals were significantly different between the different species, organs and sites.

All fishes contained the lowest concentrations of metals in muscles, while almost all fish species showed the higest concentrations of Mn ,Zn, Pb and Fe in the liver and the highest concentrations of Cu in the gills. For Zn, the highest concentrations fluctuated between the liver in some species and gills in others, Duncan"s multiple range test indicated variation of metal Cu , Zn, Cd and Fe inthe liver and Pb and Mn in gills.

| Sl. No | akes and Reservoir | Fish species | Metals observed | Normal range of metals | Organsaffected |
|---|---|---|---|---|---|
| 1. | Tekrial lake | Labeo rohita Channa punctata Catla catla | Zn Zn, Pb Zn, Pb | Cu, Pb, Fe, Mn Cu, Fe, Mn Cu, Fe, Mn | Cu, Liver Liver, Gills Liver, Gills |
| 2. | Thimmakpally Lake | Labeo rohita Channa punctata Catla catla | Zn, PbZn Zn, Pb | Cu, Fe, Mn Cu, Pb, Fe, Mn Cu, Fe, Mn | iver, gillsLiver Liver, Gills |
| 3. | S.R.S.P reservoir | Labeo rohita Wallago attu Catla catla | Cu, PbPb, FeZn | Zn, Fe, Mn Cu, Zn, Mn Cu, Pb, Fe, Mn | Muscles, gills Gills, Liver Liver |

**TABLE 1: METALS AFFECTING ORGANS**

Note: Zn=Zinc ,Pb=Lead , Fe=Ferrous , Mn=Manganese ,Cu=copper .

**TABLE 2 : THE ECOLOGICAL CHARACTERISTICS AND RECORDED MORPHOMETRIC MEASURE OF THE EXAMINED FISH SPECIES**

| Scientific name | Common name | Feeding habits | No. Of Samples | Length (cm) | Weight (gm) |
|---|---|---|---|---|---|
| Catla catla | Catla | Surface feeder | 5 | 27-37 | 259-680 |
| Channa punctata | Spotted snake head | Ambush feeding and Small fishes | 1 | 87.1 | 24,300 |
| Wallago attu | Freshwater catfish | Ambush feeding and Small fishes | 4 | 34.1-37.4 | 44-55 |

**TABLE 3: AFFECTED TISSUES AND NORMALITIES & ABNORMALITIES OF THE HEAVY METALS**

| S.No | Metal | Affected organ | Normalities | Abnormalities |
|---|---|---|---|---|
| 1 | Cu | Liver | (0.24 ± 0.11 µg/g) | (05.76 ± 0.85 µg/g) |
| 2 | Zn | Liver and Muscles | (2.08 ± 0.28 µg/g) | (34.01 ± 3.57 µg/g) |

| | | | | |
|---|---|---|---|---|
| 3 | Fe | Liver and muscles | (46.05 ± 5.17µg/g) | (224.43 ±32.68 µg/g) |
| 4 | Pb | Gills | (2.61 ± 0.33 µg/g) | (4.46 ±1.17 µg/g) |
| 5 | Mn | Gills | (0.10 ± 0.03 µg/g) | (6.57 ±1.81 µg/g) |

**TABLE 4 : Concentrations of Heavy Metals in some organs of Fish species collected from Tekrial lake:**

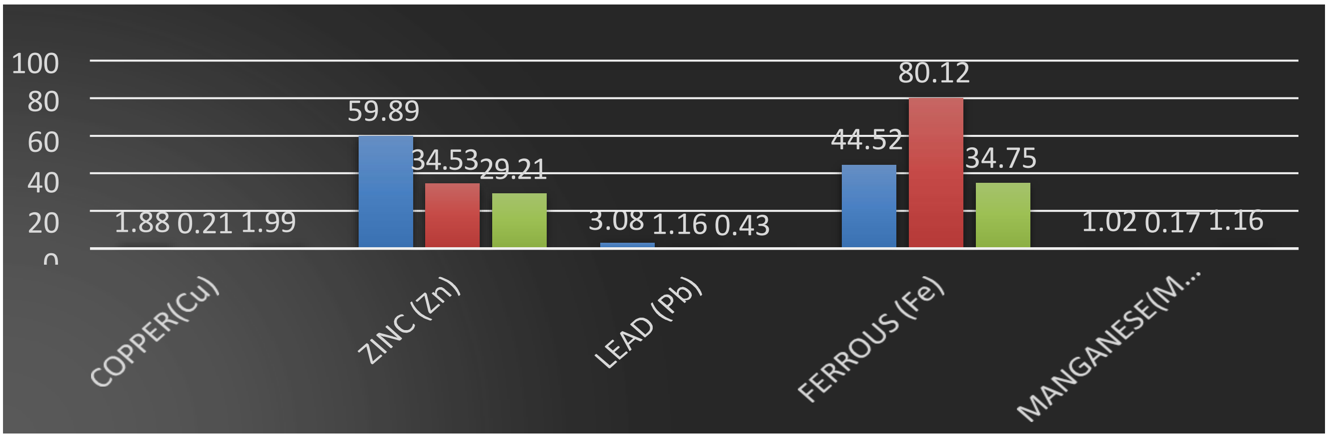
| Fish species | Cu | Zn | Pb | Fe | Mn |
|---|---|---|---|---|---|
| Labeo rohita | 1.88 µg/g | 59.89 µg/g | 3.08 µg/g | 44.52 µg/g | 1.02 µg/g |
| Channa punctata | 2.93µg/g | 48.30 µg/g | 1.92 µg/g | 48.05 µg/g | 1.94 µg/g |
| Catla catla | 2.97µg/g | 42.87 µg/g | 1.00 µg/g | 74.99 µg/g | 0.86 µg/g |

**TABLE 5 : Concentrations of Heavy Metals in some organs of Fish species collected from Thimmakpally lake:**

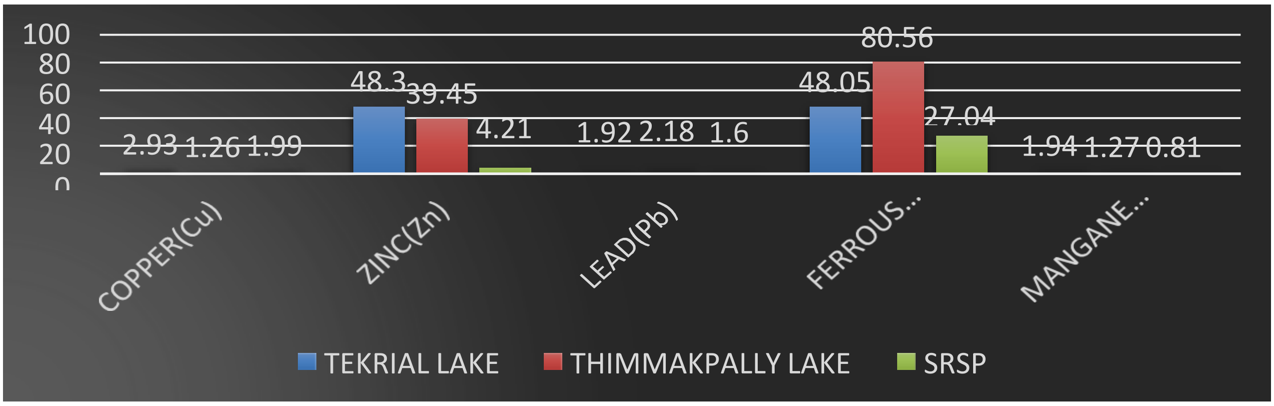
| Fish species | Cu | Zn | Pb | Fe | Mn |
|---|---|---|---|---|---|
| Labeo rohita | 0.21 µg/g | 34.53 µg/g | 1.16 µg/g | 156.78 µg/g | 0.17 µg/g |
| Channa striatus | 1.26 µg/g | 39.45 µg/g | 2.18 µg/g | 80.56 µg/g | 1.27 µg/g |
| Catla catla | 2.38 µg/g | 51.70 µg/g | 2.32 µg/g | 67.68 µg/g | 0.27 µg/g |

**TABLE 6 : Concentrations of heavy metals in some organs of fish species collected from S.R.S.P reservoir:**

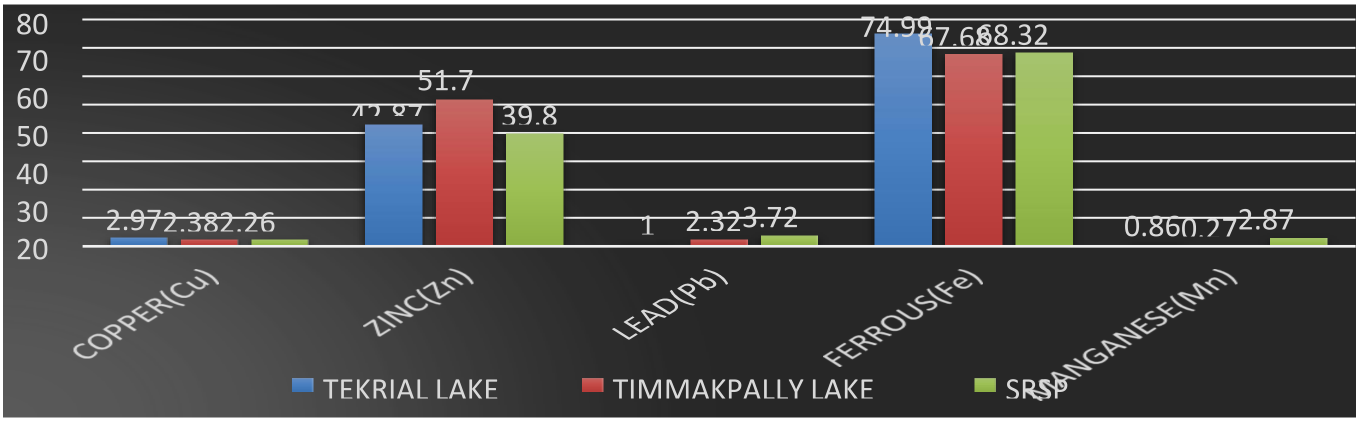
| Fish species | Cu | Zn | Pb | Fe | Mn |
|---|---|---|---|---|---|
| Labeo rohita | 8.51 µg/g | 29.21 µg/g | 0.43 µg/g | 34.75 µg/g | 1.16 µg/g |
| Channa striatus | 1.99 µg/g | 4.21 µg/g | 1.60 µg/g | 27.04 µg/g | 0.81 µg/g |
| Catla catla | 2.26 µg/g | 39.80 µg/g | 3.72 µg/g | 68.32 µg/g | 2.87 µg/g |




**GRAPH 1 : CONCENTRATIONS OF HEAVY METALS IN {µg/g} Of *Labeo rohitha***




**GRAPH 2 : CONCENTRATIONS OF HEAVY METALS IN {µg/g} OF *CHANNA STRIATUS***




**GRAPH 3 : CONCENTRATIONS OF HEAVY METALS IN {µg/g} OF *CATLA CATLA***

Concentrations of heavy metals (Cu,Zn,Pb,Cd,Fe and Mn) in muscles , liver and gill of fish collected from Tekrial lake, Thimmakpally lake and S.R.S.P Reservior. Accumulation patterns ofall metals were significantly different between the different species, organs and sites. All fishes contained the lowest concentrations of metals in muscles, while almost all fish species showed the higest concentrations of Mn ,Zn, Pb and Fe in the liver and the highest concentrations of Cu in the gills. For Zn, the highest concentrations fluctuated between the liver in some species and gills in others, Duncan"s multiple range test indicated variation of metal Cu , Zn, Cd and Fe inthe liver and Pb and Mn in gills.

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