Accumulation of Trace Metals in Tissues of *Heteropneustes fossilis*
Collected from Chaliyar River, Kerala, India

*M.V. Radhakrishnan*

Department of Zoology, Annamalai University, Annamalainagar-608 002, Tamilnadu, India

**Abstract:** The present investigation was carried out to explore the extent of accumulation of trace metals in different tissues of the freshwater catfish *Heteropneustes fossilis* collected from Chaliyar river in India to understand the uptake and distribution through nutrition. AAS (Atomic Absorption Spectrophotometry) studies were employed to estimate metal (Cr, Mn, Fe, Cu, Zn and Pb) concentration in water, sediment and fish tissues (gill, liver and muscle). The concentrations of metals in sediment were found higher than those of water. Gill showed maximum accumulation of the elements and muscles were the site of least metal accumulation. Non-essential metals Pb and Cr were also detected.

**Key words:** Trace metals • Gill • Liver • Muscle • Chaliyar river

**INTRODUCTION**

The accumulation of contaminants in fish occurs through biological uptake and retention of chemical contaminants derived from various exposure pathways such as the uptake of dissolved chemical constituents from the water and the ingestion and assimilation of pollutants from food sources. For this reason, levels of contaminants in tissues of fish are often related to those found in the environment [1], thus making them useful in biomonitoring programs. Industrial wastes are considered critical factors for disturbing the natural environment. Composite effluents tainted with different heavy metals are major environmental pollutants of ecosystems [2]. Therefore, these fish could be regarded as an indicator species in the context of ecotoxicology [3]. The extents of accumulation of potentially hazardous metal contaminants in the tissues of fish cultured in some other contaminated areas in India and abroad are already on record [3-7]. In the present paper, concentrations and distribution of six metals namely Cr, Mn, Fe, Cu, Zn and Pb in different tissues of *Heteropneustes fossilis* of Chaliyar river was investigated. The study on the accumulation pattern in different tissues of *H. fossilis* would render a platform to understand the amount of non-essential toxic metal ions available within the body and the adaptability of the fish with the environment.

**MATERIALS AND METHODS**

Two sampling stations were selected. Five fish were collected on 10th day of each month for a period one year (January 2009 - December 2009). Fish weighing 60 ± 2 g were collected and the organs such as gills, liver and muscles were dissected out. Sediments and water were also collected. All samples were prepared following standard protocols [8]. 10g of the native organs were taken into Platinum crucibles and dried inside a Muffle furnace at 150°C for 3h. These were then cooled to room temperature and the dried weights were taken. These were then transferred inside the cooled Muffle furnace and slowly the temperature was raised to a range 500 ± 50°C for 11 h. The samples were removed and cooled inside desiccators to room temperature. 2.0 ml 15% of concentrated HNO3 was added into the crucible and swirled, the acidified ash was slowly heated on a hot plate till evaporation of NO2 ceased and then heating was continued to evaporate the acid completely. The mass thus formed was transferred into the cool Muffle furnace once again. The furnace was gradually heated to a range of 450-500°C for 2 h. Then the mass was cooled to room temperature. If the carbon still remained, then the process was repeated once again until white coloured ash was obtained. 10 ml of 1.0 N HCl was added and the mixture was gently warmed until a clear solution was obtained.
These were then cooled and transferred into 25 ml volumetric flasks.

About 200 ml of collected water samples were filtered through Whatman 0.45-μm glass fibre filter and transferred to acid cleaned 250 ml polypropylene bottles and then acidified with concentrated nitric acid to pH not exceeding 2.0. Sediment samples were dried (80 ± 10°C for 10 h in a hot air oven), homogenized and sieved for extraction of Ca, Cr, Mn, Fe, Cu, Zn and Pb from dry ashes. About 1.0 ± 0.05 g dried and grounded sediment sample (carefully weighed through analytical balance, Mettler AE240) was placed inside a silicone crucible and ignited in a Muffle furnace at 500°C for 3 h. The ignited mass was cooled inside desiccators and transferred into a 100 ml BoroSil beaker. Inside the beaker was added 10 ml concentrated HCl (Merck India) and the suspension swirled. The suspension was kept inside a thermostat controlled water bath in a temperature range of 70-80°C for 1 h. The supernatant was decanted and kept inside a 100 ml volumetric flask. This contains mostly alkaline earth metals. To the residue in the beaker 10 mlach of HCl (concentrated) and HClO₄ (concentrated, 70% pure, Merck India) and few porous beads were added and was evaporated to complete dryness over a hot plate. This process was repeated when necessary. The dried residue was dissolved completely by using minimum amount (few drops) of concentrated HCl. This solution was then transferred to the same volumetric flask where previous extract containing alkaline earth metal extracts was stored and was analyzed for elements. Atomic Absorption Spectrophotometry (Perkin-Elmer) using element-specific hollow cathode lamps in default condition, by flame absorption mode was used to approximate the metal concentration within samples. Metal standards recommended by Perkin Elmer were used for checking the sensitivity of the instrument and calibration.

RESULTS

Metal concentrations of water and sediment were presented in Table 1. In the present study concentrations of all six elements in the sediment samples were higher than that of water. The order was Fe > Cu > Zn > Mn > Cr > Pb (Table 1). Fe concentration in sediment was found to be the highest (215.82 mg kg⁻¹) among all other elements. In water, the Fe concentration recorded as 7.10 mg L⁻¹. Zn had the highest concentration in sediment (28.1 mg kg⁻¹) with a water concentration of 2.1 mg L⁻¹. The Mn level in water and sediment were 0.26 mg L⁻¹ and 28.0 mg kg⁻¹ respectively. Pb, being a toxic pollutant of the environment, was recorded higher in water (0.25 mg L⁻¹) with respect to the sediment (0.10 mg Kg⁻¹). The concentration of Cr and Cu in water were 0.09 mg L⁻¹ and 0.71 mg L⁻¹, respectively. Sediment showed high concentrations of Cr and Cu than water (Table 1). Metal concentration in fish tissues such as gill, liver and muscle tissues of H. fossilis collected are presented in table 1 and the results were expressed in mg kg⁻¹ of dry weight of the tissues. Variations in the distribution patterns of different metals in the fish organs were noted. Liver was found to be the dominant site for metal accumulation. Bioactive element like Fe showed almost high accumulation pattern with liver was found as major site followed by gill and muscle. Gill accumulated more amount of Mn (Table 1).

DISCUSSION

The higher elemental concentrations in sediment of the river were in agreement with the concept that sediments contain higher concentrations of metals than that of water [9]. It was evident from the present study, that the amount of Mn in sediment was quite high which may be due to element specific rate of sedimentation from

<table>
<thead>
<tr>
<th>Trace elements</th>
<th>Cr</th>
<th>Mn</th>
<th>Fe</th>
<th>Cu</th>
<th>Zn</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium/Tissues</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>0.09±0.02</td>
<td>0.26±0.01</td>
<td>7.10±1.16</td>
<td>0.71±0.03</td>
<td>2.1±0.02</td>
<td>0.25±0.06</td>
</tr>
<tr>
<td>Sediment</td>
<td>16.25±2.18</td>
<td>28.0±1.15</td>
<td>215.82±1.28</td>
<td>32.2±2.09</td>
<td>28.1±1.25</td>
<td>0.10±3.97</td>
</tr>
<tr>
<td>Gill</td>
<td>2.5±0.10</td>
<td>26.0±1.62</td>
<td>110.23±2.75</td>
<td>6.2±0.30</td>
<td>32.72±3.50</td>
<td>0.18±0.05</td>
</tr>
<tr>
<td>Liver</td>
<td>7.12±1.30</td>
<td>21.5±0.24</td>
<td>325.6±12.62</td>
<td>35.2±1.72</td>
<td>42.32±2.18</td>
<td>0.20±0.03</td>
</tr>
<tr>
<td>Muscle</td>
<td>0.12±0.01</td>
<td>2.5±0.22</td>
<td>76.95±2.10</td>
<td>0.62±0.03</td>
<td>17.42±1.04</td>
<td>0.06±0.01</td>
</tr>
</tbody>
</table>
the water into the sediment as reported by other authors [10]. The rate of sedimentation of different elements was also influenced by different components present in the composite effluents from industries, subsequently resulting in different distribution patterns in sediments and water, which was specific to a particular element [11]. Organic contents present in the environment play an important role in the sedimentation of specific heavy metals in sediments as reported by earlier works [12]. It has been well documented that sediment composition include metal speciation, nature of complexes, metal-metal interactions and factors such as temperature, pH, dissolved oxygen and organic ligands, play important role in respect to bioavailability of elements and concentration in tissue level of the consumer organisms [13,14]. Metal speciation between dissolved and particulate phases and competitive interactions play a major role in bioavailability of metal. Thus, bioaccumulation is the result of competing rates of chemical uptake and elimination [15,16]. Metal ions like, Mn and Fe play key role in uptake and accumulation in the tissues of the organisms by competing with other toxic and/or bioactive metal ions influencing the bioconcentration of the metals in fish organs [17]. Concentrations of heavy metals in fish tissues were always higher than that of water [18]. Entry of metal occurs either through gill or through ingestion. A difference in metal accumulation in different fish organs, as indicated in the present study, was also reported [6,19,20]. Bioactive metals like Fe, Mn, Cu and Zn accumulation can actively controlled by the fish through different metabolic processes and usually independent of ambient concentrations. On the other hand, environmental concentrations affect the accumulation of non-essential toxic elements like Pb [21]. Bioactive metals play important role in metabolism, thus in physiology and pathology of fish. Metals like Zn, Cu, or Mn function as a cofactor in several enzyme systems [20] while Fe is directly involved with hemoglobin formation in fish blood. However, when in excessively high concentrations, these bioactive metals may pose serious threats to normal metabolic processes. Among the tissues studied in fish, gills are considered to be the dominant site for contaminant uptake because of their proximity and structural and functional organization. However, liver showed maximum accumulation for the elements while muscle was the over all site of least metal accumulation. Considerable amounts of Fe and Pb were also present in gills. Liver showed highest accumulation rate. The metals from the gill and other organs will be transported to liver for their detoxification. Moreover liver is the site of various proteins and other molecules which have high affinity with metals forming complexes. This may be due to the transport of metals from other tissues including gill and muscle for the elimination. Among the tissues the muscle is one of the ultimate part for heavy metal accumulation. In the present study the observed values were relatively lower than the other potential organs. The reason is that the muscle is not an active site for detoxification, but the transport of metal from muscle to kidney and /liver take place for elimination/detoxification.

REFERENCES


