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*Full Length Research Paper*

# Heavy metals concentration in various tissues of two freshwater fishes, *Labeo rohita* and *Channa striatus*

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**Heavy metals like cadmium, zinc, copper, chromium, lead and mercury were measured in the various tissues of *Labeo rohita* and *Channa striatus* and in the water samples collected from the Kolleru Lake, Andhra Pradesh during 2009-2010. The concentrations of heavy metals in the different organs of fishes varied. In *L. rohita*, the concentrations of heavy metals were in the order of liver > kidney > gills > muscles and in C*. striatus,* it was liver > kidney > gills > muscle. The values of heavy metals concentration in the present study are within the maximum permissible levels for drinking water and fish.**

**Key words:** Heavy metals, tissues, fish, Kolleru Lake.

## INTRODUCTION

The contamination of aquatic systems with a wide range of pollutants has become a matter of concern since the last few decades (Canli et al., 1998; Dirilgen, 2001; Vutukuru, 2005; Amaraneni, 2006; Rao and Rao, 2007; Vinodhini and Narayanan, 2008; Gupta et al., 2009). The natural water bodies may extensively be contaminated with various heavy metals released from domestic, industrial effluents, idol immersion, draining of sewage, dumping of hospital, other wastes and anthropogenic activities, etc. (Conacher et al., 1993; Velez and Montora, 1998; Chandra Sekhar et al., 2004; Vinodhini and Narayanan, 2008; Malik et al., 2010; Laxmi Priya et al., 2011). Pollution of heavy metals in aquatic ecosystem is growing at an alarming rate and has become an important problem of many countries of the world. Heavy metal contamination may cause devastating effects on the ecological balance of the recipient environment and its diversity of aquatic organisms (Farombi et al., 2007; Vosyliene and Jankaite, 2006; Ashraj, 2005; Vinodhini and Narayanan, 2008). Fish occupies higher level in the food chain and is an important source of protein food for human beings. The heavy metals in aquatic ecosystem are transferred through food web into human beings. Some of heavy metals can cause health problems to fish consumers (Uysal et al., 2008; Taweel et al., 2011). Therefore, in the present study attempts have been made to assess the heavy metal concentration in water and fishes of Kolleru Lake, Andhra Pradesh.

## MATERIALS AND METHODS

### Study area

The study area, lake Kolleru (16° 32 and 16° 47' N and 81° 5 and 81° 21 E) is a natural wetland located between two major deltas, Godavari on the east and Krishna on the west of costal Andhra Pradesh, India. The freshwater enters the lake through a number of rivers, stream and agricultural drains. The lake has rich aquatic life, the lake has always been exploited by local population (Figure 1).

A total of one hundred and forty four fishes (ranging between 90-100 g in weight and 16-81 cm in length and three months in age) were collected with the help of a fisher man using the gill net. The water samples were collected in sterilized bottles from three sites, with one meter in depth to analyze the various physico-chemical parameters such as water temperature, pH, free carbon dioxide,

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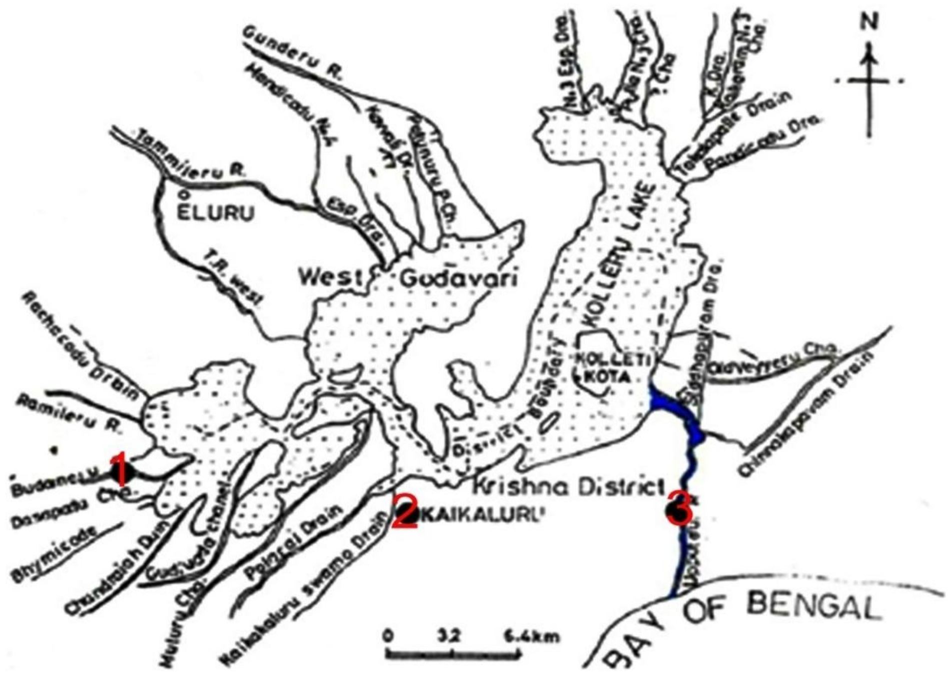


**Figure 1.** Geographical distribution of sampling sites in Kolleru Lake, Andhra Pradesh.

total hardness and dissolved oxygen. Dissolved oxygen (DO) was fixed at sampling site itself and estimated in the laboratory. Both fish and water samples were collected for one year from July 2009 to June 2010.

100 ml of water sample was collected in sterilized bottles from each site and was acidified with 10% $HNO_3$ and brought to the laboratory. The samples were filtered through what's man filter paper (No. 42) and kept in refrigerator until further analysis. The samples were subjected to analysis directly.

In each month of all the three seasons, 6 fishes of *Labeo rohita* and *Channa striatus* were caught from the lake. They were brought to the laboratory and dissected, and the organs viz. liver kidney, gills and muscles were removed with clean sterilized instruments. Tissues such as liver, kidney, gills and muscles were washed with double distilled water and put in sterilized Petri dishes to dry at 120°C in oven until they reached a constant weight. One gram of each dried tissue of liver, kidney, gills and muscles were then digested with diacid ($HN0_3$ and $HClO_4$ in 2:1 ratio) on a hot plate set at 130°C until all materials were dissolved. Digested samples were diluted with double distilled water appropriately in the range of the standards, which were prepared from the stock standard solutions of the metals (Merck). The metal concentration in the samples was measured using a Perkin-Elmer Analyst 300 Absorption Atomic Spectrophotometer (AAS). The results were expressed as µg $g^{-1}$dry weight and mg $L^{-l}$for fish and water, respectively.

Physico-chemical parameters of the water were analyzed as per the procedures described in APHA (2012). The obtained data were subjected to statistical analysis using a computer program (SPSS, 2001) for mean and standard deviation.

## RESULTS AND DISCUSSION

The physico-chemical parameters are paramount, important and influenced by natural and manmade activities. They are also depends upon the depth of water body and ecological conditions of ecosystem. In the present study, water temperature ranged between 22 and 34.8°C from summer to winter. The pH of the water was alkaline throughout the study ranging from 7.2 to 9.0. Similar findings were recorded by Mohan et al. (2007) and Malik et al. (2010). Free carbon dioxide showed an irregular pattern and ranged from 0 to 3.8 mg $L^{-l}$. Dissolved oxygen (DO) is an important water parameter indicating the quality of water and organic production in lake (Wetzel and Likens, 2006). Survival of aquatic flora and fauna especially fish fauna, depends on the dissolved oxygen in water. In the present study, DO levels ranged between 6.0 and 8.6 mg $L^{-l}$. Low DO levels were recorded during summer season, indicating that DO level decreases with the increase in temperature. The hardness of water varied from 58-192 mg $L^{-l}$ (Table 1) which was within the permitted levels for drinking water proposed by of Bureau of Indian standards.

In the water of Kolleru Lake, average concentration of heavy metals namely, Pb, Cd, Zn, Cu, Cr and Hg, were 0.034, 0.012, 0.304, 0.013, 0.436 and 0.001 mg $L^{-l}$, respectively (Table 2).

Zinc content was highest and Hg was the lowest in water. The concentration of heavy metals was in the range of Zn, Cr, Pb, Cu, Cd and Hg. Gupta et al. (2009) have reported that the concentration of Zn in the water of river Ganges at Allahabad was highest and followed by Pb, Cu, Cr and Cd, The high content of Zn and the lowest content of Hg were also reported by Jain and Sharma (2001), Sarkar et al. (2007) and Malik et al. (2010). The concentrations of heavy metals were highest in summer

**Table 1.** The range of water quality parameters of Kolleru Lake, A. P. in different seasons during the study period.

| Physico-chemical parameter | Spring | Summer | Rainy | Winter | Permissible limits for drinking water (BIS, 1991) |
|---|---|---|---|---|---|
| Temperature (ºC) | 26 - 32.1 | 28 - 34.8 | 26 - 29 | 22 - 25.6 | - |
| $P^H$ | 7.6 - 7.8 | 7.6 - 8.0 | 8.2 - 8.6 | 8.2 - 9.6 | 6.5 - 8.5 |
| Free $CO_2$ (mg $L^{-l}$) | 0.20 - 2.8 | 0.20 - 3 | 0 - 2 | 0 - 3.8 | - |
| Total hardness (mg $L^{-l}$) | 120 - 189 | 120 - 192 | 68 - 172 | 56 - 86 | 300 |
| D.O (mg $L^{-l}$) | 6.0 - 6.5 | 6.0 - 6.8 | 6.8 - 7.9 | 6.8 - 8.6 | 6 |

**Table 2.** Heavy metal concentration (mg $L^{-1}$) in water of Kolleru Lake, Andhra Pradesh, in different seasons during the study period.

| Heavy metal (mg $L^{-1}$) | Spring | Summer | Rainy | Winter | BIS, 1991 limit |
|---|---|---|---|---|---|
| Pb | 0.019 ± 0.014 | 0.034 ± 0.002 | 0.027 ± 0.001 | 0.038 ± 0.001 | 0.1 |
| Cd | 0.011 ± 0.001 | 0.012 ± 0.001 | 0.001 ± 0.000 | 0.010 ± 0.000 | 0.01 |
| Zn | 0.301 ± 0.001 | 0.304 ± 0.002 | 0.279 ± 0.017 | 0.299 ± 0.006 | 15 |
| Cu | 0.012 ± 0.001 | 0.013 ± 0.001 | 0.113 ± 0.001 | 0.012 ± 0.001 | 1.5 |
| Cr | 0.014 ± 0.001 | 0.043 ± 0.002 | 0.042 ± 0.005 | 0.039 ± 0.001 | 0.05 |
| Hg | 0.001 ± 0.000 | 0.001 ± 0.000 | 0.001 ± 0.001 | 0.001 ± 0.001 | 0.001 |

Values expressed in mean ±SD of three replicates.

**Table 3.** Heavy metal concentration (µg/ g/d.w) in various tissues of *L. rohita*.

| Heavy metal (µg $g^{-1}$) | Liver | Kidney | Gill | Muscle | FAO*/WHO** guideline |
|---|---|---|---|---|---|
| Pb | 1.483 ± 0.206 | 0.553 ± 0.032 | 0. 300 ± 0.010 | 0.223 ± 0.152 | 4 |
| Cd | 0.616 ± 0.249 | 0.250 ± 0.046 | 0.383 ± 0.153 | 0.316 ± 0.006 | - |
| Zn | 1.036 ± 0.004 | 0.943 ± 0.031 | 0.19 ± 0.0173 | O.380 ± 0.020 | 50 |
| Cu | 1.056 ± 0.124 | 0.233 ± 0.042 | 0.090 ± 0.000 | 0.090 ± 0.000 | 10 |
| Cr | 0.696 ± 0.349 | 0.716 ± O.035 | 0.196 ± 0.015 | 0.023 ± 0.012 | 2 |
| Hg | 0.270 ± 0.552 | 0.070 ± 0.001 | 0.047 ± 0.001 | 0.036 ± 0.015 | - |

Values expressed in mean ± S.D of three replicates, unit- µg /g/d.w,*FAO (1983), **WHO (1985).

and the lowest in rainy months due to the dilution effect of water. Similar results have also been reported by Jain and Sharma (2001) and Malik et al. (2010). In the present study, it has been observed that, all the metals were below the permitted levels of BIS.

The heavy metals were accumulated at varying levels in different tissues of *L. rohita* and *C. striatus*. The concentration of heavy metals in different organs of fishes followed the decreasing order Pb > Cd > Zn > Cu > Cr > Hg. The concentration of Pb varied between 1.483 ± 0.206 and 0.223 ± 0.152 µg $g^{-1}$. While that of Cd, 0.616 ± 0.249 and 0.250 ± 0. 045, Zn, 1.036 ± 0.004 and 0.19 ± 0.017, Cu, 1.056 ± 0.124 and 0.0.090 ± 0.001, Cr, 0.716 ± 0.357 and 0.023 ± 0.012, Hg, 0.270 ± 0.552 and 0.036 ± 0.015 µg $g^{-1}$ in *L. rohita* whereas the respective values for *C. striatus* were recorded as Pb 1.353 ± 0.070 and 1.30 ± 0.010, Cd 0.480 ± 0.314 and 0.160 ± 0.040, Zn 1.140 ± 0.295 and 1.013± 0.050, Cu 1.033± 0.646 and 0.028 ± 0.002, Cr 0.853 ± 0.535 and 0.326 ± 0.050, Hg 0.256 ± 0.060 and 0.123 ± 0.086 µg/g/d.w. The concentrations of metals were higher in the livers than gills and muscles (Tables 3 and 4).

Heavy metals in aquatic environment and aquatic biota pose a risk to fish consumers and other wild life. Heavy metals may enter aquatic ecosystem from different natural and anthropogenic sources including industrial or domestic sewage, storm runoff, leaching from landfills-/dump sites and atmospheric deposit (Forstner and Wittmann, 1983; Bhupander et al., 2011; Laxmi et al., 2011).

**Table 4.** Heavy metal concentration (µg/g/d.w.) in various tissues of *C. striatus*.

| Heavy metal | Liver | Kidney | Gill | Muscle | FAO*/**WHO guideline |
|---|---|---|---|---|---|
| Pb (µg $g^{-1}$) | 1.353 ± 0.070 | 1.333 ± 0.704 | 1.30 ± 0.529 | 1.30 ± 0.010 | 4 |
| Cd (µg $g^{-1}$) | 0.480 ± 0.314 | 0.160 ± 0.040 | 0.316 ± 0.125 | 0.456 ± 0.109 | - |
| Zn (µg $g^{-1}$) | 1.013 ± 0.050 | 1.213 ± 0.208 | 1.140 ± 0. 295 | 0456 ± 0.109 | 50 |
| Cu (µg $g^{-1)}$ | 0.993 ± 0.600 | 1.033 ± 0.646 | 0.028 ± 0.002 | 0.530 ± 0.305 | 10 |
| Cr (µg $g^{-1}$) | 0.326 ± 0.050 | 0.470 ± 0.160 | 0.596 ± 0.205 | 0.853 ± 0.535 | 2 |
| Hg (µg $g^{-1)}$ | 0.203 ± 0.125 | 0.256 ± 0.060 | 0.123 ± 0.086 | 0.140 ± 0.135 | - |

Values were expressed as mean ± S.D of three replicates, unit- µg $g^{-1}$/d.w. *FAO (1983), **WHO (1985).

In the present study, Pb concentration in all the tissues of *L. rohita* was higher than that of *C. striatus*. In *L. rohita*, highest concentration of Pb was recorded followed by Cu, Zn, Cr, Cd and Hg.

In nature, Cd is always associated with zinc ores (ZnS) due to its similarity with Zn. The Cd concentration in lake water and fishes has been reported by various workers (Malik et al., 2010; Bhupander et al., 2011). In the present study, Cd concentration in *L. rohita* was in the order of liver, kidney, gills and muscles. The highest level of Cd concentration was observed in liver, whilst the lower concentration was observed in muscles. In the case of *C. striatus,* highest level of Cd concentration was observed in liver and lowest concentration was observed in kidney. Similar results were also reported by Chandra Sekhar et al. (2004), Gupta et al. (2009) and Abdel-Baki et al. (2011).

Zinc is an essential trace element which plays an important role in the physiological and metabolic process of many organisms. However, in higher concentrations it can prove to be toxic. Zn showed protective effect against the Cd and Pb toxicity. The amount of Zn was highest in *L. rohita* than *C. striatus*. In *L. rohita* Zn content was higher in liver and kidney and lowest in gills. While in the case of *C. striatus*, Zn content was higher in gills followed kidney, liver and muscles. The results were in agreement with that of Gupta et al. (2009), Malik et al. (2010) and Ayejuyo et al. (2009) for *Clarias lazera*, but, were in disagreement with the work of Yang et al. (2007) for *G. nanensis* and *Ptychobarbus diposon*. Chandra Sekhar et al. (2004) reported that large fraction of Zn, Cd and Cu were associated with mobile fraction of sediment and showed grater bioaccumulation in fishes of Kolleru Lake. The concentration of heavy metals in liver and gills of *L. rohita* and *C. straitus* was found to be higher than the other organs, because liver acted as an important organ for storage and detoxification and gills acted as depot tissue. There was significant accumulation of metals in these organs, as was also reported by Yilmaz (2005), Malik et al. (2010) and Taweel et al. (2011).

Cu is an essential part of various enzymes necessary for the synthesis of hemoglobin (Sivaperumal et al., 2007); but at higher concentration it causes various health problems. In the present study, it has been observed that the concentration of Cu was higher in liver and followed by kidney, gills and muscles. While in the case of *C. striatus*, the concentration of Cu was highest in kidney followed by liver, muscles and gills. The same was also reported by Chandra Sekhar et al. (2004), Gupta et al. (2009), Abdel-Baki et al. (2011) and Laxmi Priya et al. (2011).

Cr plays an important role in carbohydrate (glucose) metabolism. The total amount of Cr was higher in *C. striatus* than in *L. rohita* .The concentration Cr was highest in liver and followed by gills and muscles. In the case of *C. striatus*, the highest accumulation of Cr was observed in muscle followed by gills, kidney and liver. Hg was the least accumulated metal in both fishes. The accumulation amount was slightly higher in *L. rohita* than in *C. striatus.* The same was also reported by Mackeviciene (2002), Malik et al. (2010) and Laxmi Priya et al. (2011). In the present study, values of all the heavy metals in the water and fish were within the permissible levels as per the codes of FAO (1983). The lake is very much suitable for fish culture.

## Conclusion

The present study shows that the water quality parameter (temperature, pH, free $CO_2$, DO and hardness) were within the BIS standards for drinking water and fish culture. The concentration of heavy metals in the water of Kolleru Lake is under prescribed limits of BIS for drinking water. Liver was the highly metal accumulated organ, while muscle is lowest accumulated tissue of *L. rohita* and *C. striatus*. This is mainly important because muscle contributes major mass of flesh that is consumed as food. Heavy metal concentration in different tissues of fishes is below the limits of FAO. The fish of Kolleru Lake is suitable for human consumption.

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