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Heavy metals accumulation in two fish species (*Labeo rohita* and *Cirrhina mrigala*) from Pulicat Lake, North of Chennai, Southeast Coast of India

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ABSTRACT

We present the results from a detailed study based on five metals (Cr, Cd, Zn, Pb and Fe) measured in four organs (gills, liver, intestine and muscle) of two fish species (Labeo rohita and Cirrhina mrigala) collected from Pulicat lake that receives effluents from industries located in north Chennai, southeast coast of India. The results show limited differences between the two species and organs as well as significant variations within the five analyzed metals. Although the metal concentrations measured in fish muscle are low, high levels of Fe and Pb were observed in the liver and gills followed by other organs of the two fish species. The concentrations of heavy metals in edible parts (muscle) of fish were within the permissible levels and are safe for the human consumption. However the results of the study clearly show the biomagnifications of metals in Pulicat lake.

Keywords: Bioaccumulation, biomagnification, Fish, heavy metals, Pulicat lake

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INTRODUCTION

The ever-growing list of chemical contaminants released into the coastal areas includes aliphatic and aromatic chemical compounds, phthalate esters, radio-nucleotides and heavy metals. Presence of these pollutants causes undesirable changes in the physico-chemical or biological factors of an ecosystem, which in turn directly or indirectly affects the ecological balance of the environment that ultimately has its effect on human beings. Among these innumerable contaminants, pollution by heavy metals in coastal regions has become a global threat because of its toxicity which are persistent for several decades in the environment by bioaccumulation and biomagnifications in the Food Chain [1]. However, in recent years heavy metal concentrations were found to be raised in coastal ecosystems by the release of industrial effluents, agricultural and mining activities. As a result, aquatic organisms were exposed to elevated levels of heavy metals [2, 3].

The aquatic organisms exposed to the heavy metal from the runoff water tend to accumulate in their body but fishes are more commonly affected then other species. [4,5] Studies carried out in different fish species have revealed that both essential and non-essential metals can produce toxic effects in fish by disturbing their growth, physiological, biochemical, reproduction activities, and mortality [6,7]. Hence, fishes are considered as one of the best indicator of heavy metal contamination in coastal environment [8, 9].

Pulicat Lake in the North Chennai coastal region is a typical brackish water ecosystem of great importance with regards to the biodiversity and its aesthetic value. Due to its morphological and brackish water characteristics, it is the best suitable habitat for breeding and nursing ground for fishes in North Chennai coastal region. And now it is being considered as a “Ramsar Site” by the International Union for the Conservation of Nature and Natural Resources (IUCN), The World Wide Fund for Nature (WWF)–India, including the Ministry of Environment and Forests. In addition to these, it is home to 50 species of water birds and also a source for white and tiger prawns, mud and lagoon crabs, mullets and catfishes and clam varieties.

Over exploitation, mismanagement and improperly treated industrial effluents from more than 25 industries are continuously released into North Chennai Coastal region, which bring the great challenge in the ecosystem balance. As part of a monitoring study of the anthropogenic pollution of Pulicat, the heavy metal pollution in water, sediments, fish, plants, mullet, oyster, and algae species populating the Pulicat lake has been investigated in the previous studies [10, 11, 12, 13]. However, there is no report about the metal pollution level in crustaceans of Pulicat lake. Hence, the aim of the present study is evaluate the level of heavy metal contamination in two commonly available fish species *(Labeo rohita and Cirrhina mrigala)*, which appears to have great economic and ecological importance in the Pulicat lake.

Study area
Pulicat Lake the second largest brackish water lagoon in India running parallel to the Bay of Bengal, bordering the east coast of south Andhra Pradesh State, with a portion of it extending into the northern part of the Tamil Nadu State (Fig. 1). The lake is about 360 km^2 in size, and its depth (water column) varies from 1 to 6 m. The improperly treated industrial effluents from the Ennore Creek and Buckingham Canal, ultimately reach Pulicat Lake through its bar mouth and the Bay of Bengal coastal waters. Point sources of pollution are mainly from North Chennai Thermal Power Plant, Ennore port activities, Manali Petrochemical Industries, other nearby industries and untreated urban wastes from Chennai metropolitan [14, 15] .

EXPERIMENTAL SECTION

Sampling
Ten samples of each fish species (*Labeo rohita* and *Cirrhina mrigala*) were collected during two seasons (pre-monsoon and post monsoon) by professional fishermen using a multifilament, nylon gill net and trawl from inside the Pulicat Lake. Samples were washed with clean water at the point of collection, separated by species, placed on ice, brought to the laboratory on the same day and then frozen at −20°Cuntil dissection.

Sample preparation
Frozen fish samples were thawed at room temperature and dissected using stainless steel scalpels. One gram of accurately weighed epaxial muscle on the dorsal surface of the fish, the entire liver and intestine and two gill racers from each sample were dissected for analysis. They were washed with distilled water, dried in filter paper, weighed, packed in polyethylene bags and kept at −20°C until analysis.

Analytical procedure
The digestion was performed in a microwave digester to prepare the sample for analysis (Kenstar Closed vessel Microwave digestion) using the microwave digestion program, according to [10], the samples were digested with 5 ml of nitric acid (65%) and after complete digestion, the samples was cooled to room temperature and diluted to 25 ml with double distilled water. All the digested samples were analyzed three times for metals Cd, Cr, Zn, Pb and Fe using Atomic Absorption Spectrophotometer (PerkinElmer, AA 700) and are expressed as μg/g wet weight of tissue [16]. Analytical blanks were run in the sameway as the samples and the concentrations were determined using the standard solutions prepared in the same acid matrix. The quality of the data was checked by the analysis of standard reference material (MESS-1 and DORM-2, National Research Council, Canada). All reagents used during analysis were of analytical grade and de-ionized water was used throughout the study. All the plastics and glassware were washed in nitric acid for 15 min and rinsed with deionized water before use. The recovery rates were 97.1%, 102%, 95.4%, 95%, and 97.6% for Cr, Cd, Zn, Pb, and Fe, respectively. All the reagents used during analysis were of analytical grade, and deionized water was used throughout the study.

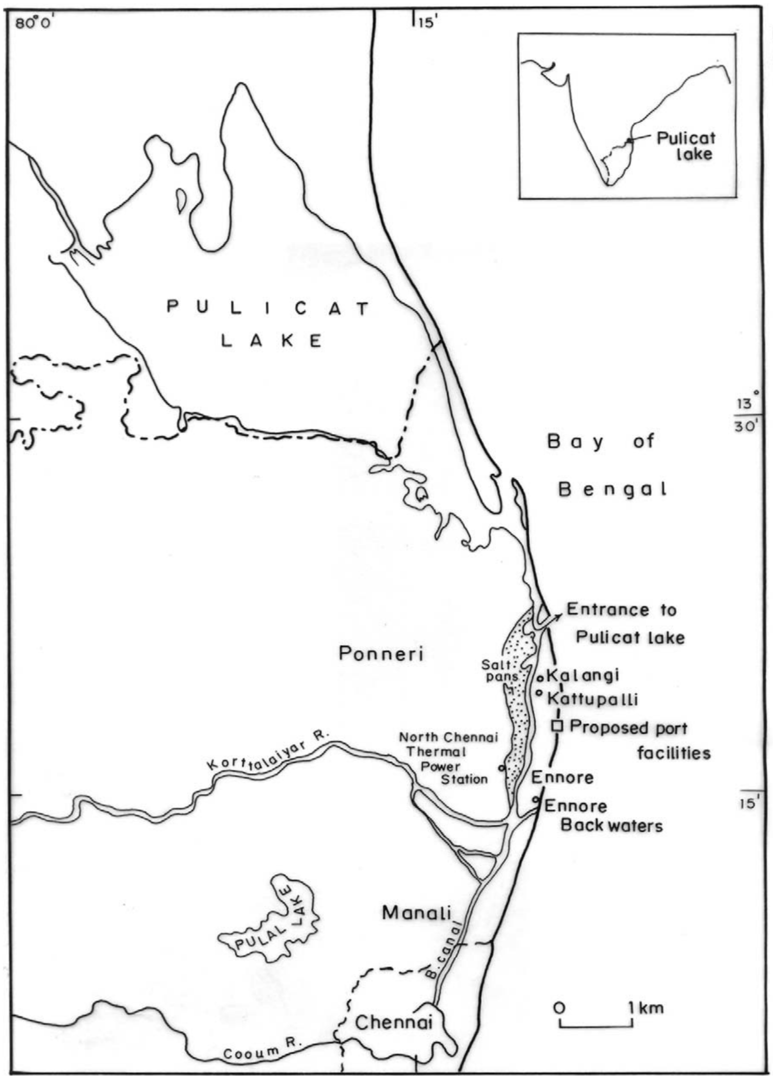

Fig. 1. Map showing the study area

RESULTS AND DISCUSSION

Knowledge about heavy metal concentration is important with respect to both the ecosystem management and human consumption. In the present study, the level of Cu, Cd, Cr, Zn, Pb, and Fe accumulation in muscle, gills, intestine, and hepatopancreas of *L. Rohita and C. Mrigala* was determined during pre-monsoon and postmonsoon seasons and summarized in Table 1. In general, the accumulation of heavy metals in different organs shows difference with respect to their capacity. In *L. Rohita*, the mean concentration of Cu (0.2 and 0.29µg/g), Cd (0.18 and 0.8µg/g), Cr (0.09 and 0.10µg/g) Zn (0.24 and 0.27µg/g), and Pb (2.37 and 2.60µg/g) concentrations appeared considerably higher in liver than in other tissues during premonsoon. However, high mean concentration of Fe (3.22 and 4.38µg/g) was observed in *L. Rohita*.

In *C. mrigala* the mean concentration Cu (0 and 0.10µg/g), Cd (0.08 and 0.12µg/g), Cr (0.10 and 0.20µg/g) Zn(0.24 and 0.36µg/g) Pb (2.30 and 2.33µg/g) and Fe (2.20 and 5.71µg/g). However the high mean concentration of Fe higher in both species in post-monsoon and pre-monsoon conditions. Several possible explanations could account for the differences in metal concentration between two fish species. The organisms may be unable to incorporate the metals present in water or sediment. Alternatively, the accumulated metal might be excreted by metabolic activity of the organisms [17, 18].

Table 1.Concentration (µg/g) of heavy metals in different organs of fishes during pre-monsoon and postmonsoon

Season	Species	Organ	Metal (µg/g)					
			Cu	Cd	Cr	Zn	Pb	Fe
Pre-monsoon	*Labeo rohita*	Liver	BDL	0.130	0.260	0.173	4.237	3.567
		Gills	BDL	0.094	0.060	0.442	1.322	2.262
		Intestine	0.022	0.144	0.029	0.292	2.456	11.426
		Muscle	0.022	0.120	0.020	0.206	1.468	0.264
	Chirrhina mirgala	Liver	BDL	0.106	0.248	0.274	2.222	3.636
		Gills	BDL	0.150	0.056	0.414	3.402	1.774
		Intestine	BDL	0.096	0.015	0.101	1.851	3.313
		Muscle	BDL	0.128	BDL	0.188	1.944	0.198
Post-monsoon	*Labeo rohita*	Liver	BDL	0.062	0.224	0.205	5.200	1.200
		Gills	0.023	0.106	0.109	0.506	1.560	2.600
		Intestine	0.034	0.123	0.064	0.156	2.602	7.800
		Muscle	BDL	0.044	0.026	0.093	1.056	1.317
	Chirrhina mirgala	Liver	BDL	0.104	0.154	0.302	1.604	3.202
		Gills	BDL	0.062	0.042	0.554	3.600	1.800
		Intestine	0.023	0.104	0.154	0.082	2.202	3.106
		Muscle	0.188	0.064	0.473	0.507	1.808	14.750

BDL: Below detection level

The order of mean concentration of metals analyzed in various organs *L. rohita*, the sequence is as follows: liver, Pb> Fe > Cd> Cr> Zn> Cu; gills, Pb> Fe> Zn > Cd>Cr > Cu; intestine, Fe>Pb> Zn> Cd > Cr >Cu and muscle Pb>Fe> Zn> Cd > Cr >Cu respectively as shown in figure 2. During postmonsoon, the concentration of metals in liver, gills, intestine and muscle of *Labeo rohita* has the following sequence Pb> Fe> Zn> Cr> Cd > Cu; Fe >Pb> Zn > Cd> Cr> Cu >; Fe >Pb> Cd > Zn> Cr> Cu and Fe >Pb> Zn> Cd >Cr > Cu respectively as shown in the figure 3. The mean concentration of Cd, Zn, Pb Cr, Cu and Fe in *Labeo rohita* during premonsoon and postmonsoon are of the following order Fe>Pb> Zn> Cr> Cd > Cu as shown in figure 4 . The following two metals Pb and Fe shows the higher values in liver, gills, intestine and muscle and the order being intestine > liver> muscle> gills during the premonsoon and intestine > liver> gills> muscle in postmonsoon seasons.

The analyzed concentration of trace metals during premonsoon season in various organs of *C.mirgala*, gives the following sequence: liver, Fe >Pb> Cr> Zn> Cd> Cu; gills, Pb> Fe>Zn > Cd>Cr > Cu; intestine, Fe>Pb> Cd > Zn> Cr >Cu and muscle Pb>Fe> Zn> Cd > Cr >Cu respectively as shown in figure 5. The postmonsoon has concentration of metals in liver, gills, intestine and muscle of *Chirrhina mirgala* with the following sequence, Fe>Pb> Cr> Zn> Cd > Cu; Pb> Fe > Zn > Cd> Cr> Cu >; Fe >Pb> Cr> Cd > Zn> Cu and Fe >Pb> Zn> Cr > Cd > Cu respectively as shown in figure 6. The mean concentration of Cd, Zn, Pb Cr, Cu and Fe in *Chirrhina mirgala* during premonsoon and postmonsoon are of the following order Fe>Pb> Zn> Cr> Cd > Cu as shown in the figure7. The two metals Pb and Fe has the highest values in liver, gills, intestine and muscle with the order being given as muscle> liver> gills > intestine for both premonsoon and postmonsoon.

In general, Fe and Pb was found to be the highly accumulated metal and Cu was the least accumulated metal in both fish, (Table 1). The results are consistent with previous studies, indicating high concentration of Fe and Pb in fish, *Ulva lactuca*, mullet, and oyster collected from the Pulicat lake, India [10, 13, 19]. The variation in metal accumulation rate could be due to the metabolic rate, exposure route, metal mobility, bioavailability, and species of the chelator present in water and sediment of the Pulicat lake [20, 21]. In addition, the environmental factors such as pH, temperature, salinity, nutrients, organic matter, organic carbon, and environmental conditions of the ecosystem influence the bioavailability and bioaccumulation rate of metals [12]. The pH of the water samples ranged from 8.1 to 8.47 during postmonsoon and 8.3 to 8.65 during pre-monsoon. High salinity was observed during pre-monsoon (42 ppt) and low salinity was observed during post-monsoon (20.49 ppt). Nitrite and nitrate concentrations in lake water samples were in higher range (1.93 and 0.146 mg/l) during monsoon and in lower range (0.1 and 0.01 mg/l) during post-monsoon. The concentration of metals in water samples was high (Cr 11.4 mg/l, Pb 3.3 mg/l, and Cd 0.07 mg/l) in pre-monsoon and low (Cr 1.4 mg/l, Pb 2.4 mg/l, and Cd 0.04 mg/l) in post-monsoon. The maximum level of Cd (88.7 mg/g) in sediments was observed during monsoon and minimum level (32.7 mg/g) was observed during pre-monsoon. Chromium concentration observed in the sediments was found to be maximum (45.3 mg/g) in pre-monsoon and minimum (19.8 mg/g) in post-monsoon. The maximum Pb concentration of 43.7 mg/g was observed during monsoon and minimum level of 7.2 mg/g was observed during pre-monsoon [12, 13].

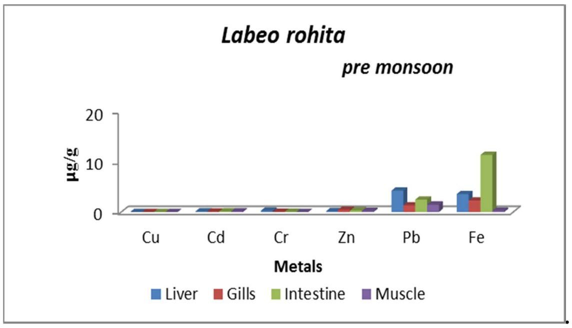

Fig. 2. Bioaccumulation of Heavy metals in Labeo rohita in pre monsoon

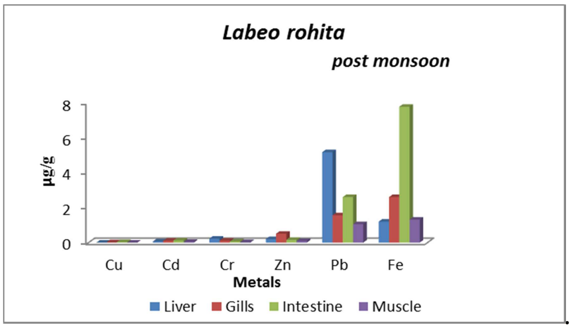

Fig. 3. Bioaccumulation of Heavy metals in Labeorohita in post monsoon

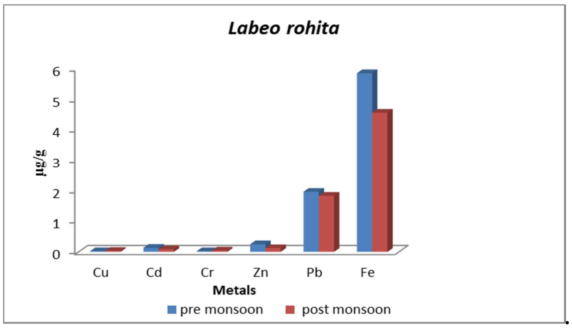

Fig. 4. Bioaccumulation of heavy metals in Labeorohita

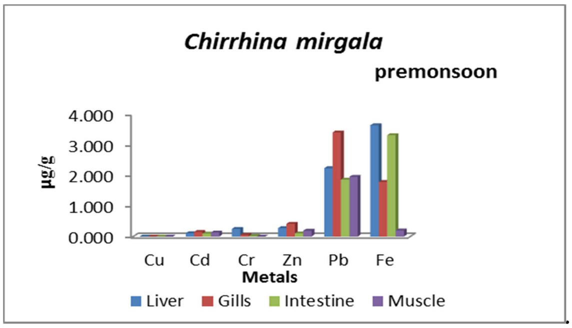

Fig. 5. Bioaccumulation of heavy metals in Chirrinamigrala in premonsoon

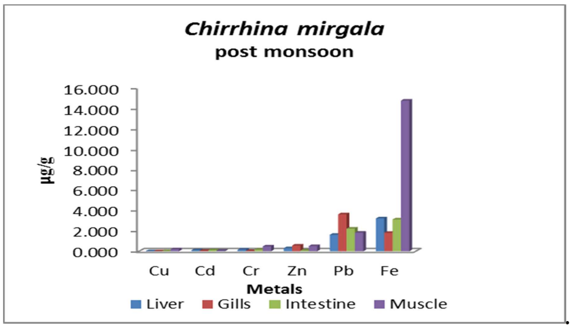

Fig. 6. Bioaccumulation of heavy metals in Chirrinamigrala in postmonsoon

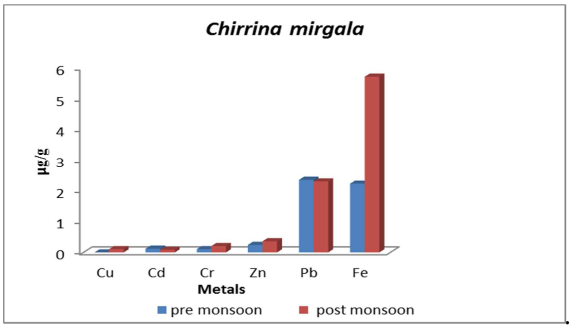

Fig. 7. Bioaccumulation of heavy metals in Chirrinamigrala

CONCLUSION

The present study provides information on accumulation of Fe, Pb and other toxic metals in fish (*L. Rohita and C. Mrigala*) from Pulicat lake. Although the concentration of metals in edible parts of fishes was below the limited value prescribed by Food and Agriculture Organization of the United Nations (1983), the results of the present study and previous study clearly indicate the biomagnification of Pb and other metals in aquatic biota of Pulicat lake.

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