Research Article

TOXICOLOGICAL EVALUATION OF HEAVY METALS IN TISSUES OF FRESHWATER FISH *OREOCHROMIS NILOTICUS* COLLECTED FROM LAKES OF COIMBATORE DISTRICT, TAMILNADU, INDIA

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ABSTRACT

The aquatic ecosystem has received considerable attention due to their heavy metals toxicity which are dangerous to aquatic biotas as it can be bio-accumulated in them through food chain. Pollutants mainly that enter the inland water bodies may extensively be contaminated with heavy metals released through atmospheric deposition, erosion, due to anthropogenic activities, mixing of untreated industrial effluents, draining of domestic sewage, dumping of mining wastes, hospital wastes and temple wastes from adjacent places in and around the selected study sites. Heavy metals, even at quite low concentrations can cause devastating effects on recipient environment and especially on fish which occupies the higher level in food chain. And these heavy metals get transferred through food web into human beings creating public health problems. As man is the major consumer it is important to determine the bioaccumulation level by edible fishes to assess the potential risk. So, heavy metals (cadmium, copper, zinc, nickel and lead) concentrations were determined in Muscle, Gill and Liver tissues of fish *Oreochromis niloticus* from lakes in and around Coimbatore district. Fish samples were collected from five stations (Perur, Kurichi, Suler, Koolipalayam and Orathupalayam). Heavy metal concentrations in the fish samples were analyzed using an atomic absorption spectrophotometer. Heavy metal concentration in the fish samples were decreased in the following order Zn>Cu>Pb>Ni>Cd. Heavy metal concentrations were high in liver and gill tissue while muscle tissue had low concentration. Cd, Zn and Pb had higher concentrations in fish samples than recommended benchmarks of FAO and WHO an indication of risk to human health. So, there is need for a constant monitoring of the heavy metals concentrations in fresh the water ecosystem.

Key words: Aquatic system, Heavy metals, Pollution, *Oreochromis niloticus*, Muscle, Gill, Liver.

INTRODUCTION

Aquatic ecosystems are highly complex, dynamic and subject to many internal and external relationship that are subject to change over time. The pollutants that enter the aquatic system and create serious problems causing extensive damage to the life and activities of the living aquatic organisms and even to mass mortality. Pollution changes the water chemistry which affects the water quality and upset the ecological balance in the aquatic ecosystem; eventually it can disturb the productivity also. Most pollutants that enters the aquatic environment are chemical in nature and range from completely toxic substance such as agricultural pesticide, cyanide and salt of various heavy metals to nutrient such as phosphate, nitrate, fertilizer and organic matter of domestic and industrial origin¹. There are two main sources for heavy metals into the environment that is lithogenic (natural process) and anthropogenic (Human activities). During recent decades, urban and industrial activities are increasing heavy metals into the aquatic ecosystem, when they exceed standard concentration, they have toxic effects on living organisms also they decrease survival growth and species diversity.

The heavy metals generally enter the aquatic environment through atmospheric deposition, erosion of geological matrix or due to anthropogenic activities caused by industrial effluent, domestic sewage and mining wastes. The metal contaminants in

aquatic systems usually remain either in soluble or suspension form and finally tend to settle down to bottom are taken up by the organisms. The progressive and irreversible accumulation of these metals in various organs of aquatic creatures leads to metal related disease in the long run because of their toxicity, there by endangering the aquatic biota and other organism. Fish being one of the main aquatic organisms in the food chain may often accumulate large amounts of certain metals. Today fish has become the main supply of protein besides meat and poultry products and contributed to a large percentage of dietary protein globally. Fish is also high in essential fatty acids (EFAs) known as Eico- Sapentaenoic acid (EPA) and Doco- sahexaenoic acid (DHA) that are important to the diet.

Heavy metal intakes by fish in polluted aquatic environment are varies depends on ecological requirement, metabolisms and other factors such as salinity, water pollution level, food and sediment. Fish accumulates metals in its tissue through absorption and human can be exposed to metals via food web. This will cause acute and chronic effect to human. Bioaccumulation of heavy metals affects the organisms by accumulation in their tissues and transferred to the next trophic level. The accumulation of heavy metals becomes toxic when it crosses the permissible limit. The fish have been found as a good indicator for heavy metal contamination in aquatic system because they are lived in different trophic levels with different sizes and ages.

MATERIALS AND METHODS

Coimbatore is the second largest city in the Indian state of Tamil nadu. It is located at 11°00'58"N 76°58'16"E 11.0161°N 76.971°E. Surrounded by the Western Ghats mountains range to the west and the North. Coimbatore the south Indian Manchester, is known for its textile factories, engineering firms, automobile parts manufacturers, health care facilities, educational institutions, pleasant weather, hospitality and for its Kongu Tamil. The Noyyal River forms the southern boundary of the city. Noyyal's basin contains many lakes and ponds. They are the main water resource for the nearby villages mostly for various domestic activities. In the present study 5 lakes were selected they are namely Perur lake, Kurichi lake, Sular lake, Koolipalayam lake and Orathupalayam lake.

Plate 1: Satellite image of Perur Lake

Perur lake(L1): Location: Perur Big lake is situated in the Perur Village close to Sundakkamuthur village. **Latitude:** 10° 58'06" N and **Longitude:** 76° 55'41" E. **Size of wetland:** Catchment area: 2.227 Sq. Km (RTI); Lake Bed area – 265.00 acres (RTI). **Storage capacity** – 51.94 MCft (RTI); Water Level (FTL) – 4.51 m; Lake Bund length – 1350m. (Plate:1)

Plate 2: Satellite image of Kurichi Lake

Kurichi lake(L2): Location: Kurichi lake is surrounded by Attupalam-Palghat road on the North, Pollachi road on the East, Kurichi town on the South and Kuniyamuthur on the west. **Size of wetland:** Catchment area: 4014 Acres (6.272 Sq.miles); Water Spread area – 334 Acres (1.352 Sq.km); Length of the Bund – 2400.00 M; **Capacity** – 60.00 M.cft; **Depth** – 10.75 Feet. This lake receives water from the Noyyal River from Kurichi Anicut through Kurichi channel. Kurichi channel is of 3.4 kms length.(Plate:2)

Plate 3: Satellite image of Perur Lake

Sular lake(L3) : Location: Taluk – Coimbatore; **Village** – Sular; **Latitude:** 11° 01'40" N and **Longitude:** 77° 07'20" E; **Size of Wetland:** Catchment area: 8.704 Sq.miles; Water Spread area – 0.332 Sq.km; Length of the Bund – 1450.00 M; **Capacity** – 17.94 M.cft; **Depth** – 8.50 Feet. (Plate:3)

Plate 4: Satellite image of Koolipalayam Lake

Koolipalayam lake (L4) : Location: Taluk-Tirupur; village-Mannarai; **Latitude:** 11.134238° N and **Longitude:** 77.386521° E; **Size of Wetland:** Catchment area: 4.144 Sq. Km; **Lake bed area** – 243.35 acres; **Industries-** There are quite a few textile processing units and textile garmenting industries near to the lake.(Plate:4)

Plate 5: Showing the Orathupalayam Lake

Orathupalayam lake (L5) : Location: Taluk- Tirupur; village-Kangayam; **Latitude:** 11°06'31Z and **Longitude:** 77°32'23"E; **Size of Wetland:** Catchment area: 22.4555 sq.km; The maximum water level of 248 m and 250 m of top bund level. The capacity of the reservoir is 616 MCft . **Depth-** 71 feet.(Plate:5)

Experimental fish: *Oreochromis niloticus* (Linnaeus, 1758)-Cichlidae.

Collection of fish samples: The study species *Oreochromis niloticus* was collected from the selected study areas Perur lake, Kurichi lake, Sular lake, Odatupalayam lake, Koolipalayam lake using gill net from the selected sites. From each sampling sites 10 fishes were collected as sample material with average weight ranging from 250 - 300 g, average length of 8-10cm and the target organs (gills, intestine, liver and muscles) were excised for further analysis.

Heavy Metal Analysis from fish samples: Fish samples of 1.0 g dry weight were digested with 6ml of HNO_3 (65%) and 2ml of H_2O_2 (30%) at 280°C on a hot plate for 4hour. To the digested sample 2ml of 1N HNO_3 is added to the residue and the solution is evaporated again on the hot plate, till the sample gets completely digested. After cooling, the above sample 10ml of 1N HNO_3 was added. This solution gets diluted and filtered through a 0.45μ nitrocellulose membrane filter². The filtered solution is measured for metal concentrations using Atomic Absorption spectrometer. The entire triplicate sample was analyzed in the Department of Chemistry, South India Textile Research Association (SITRA), Coimbatore.

Statistical Analysis

Mean and Standard deviation of the measured parameters were estimated and comparison of heavy metal in fish tissues were statistically analyzed by using one way analysis of variance (ANOVA) with the 5% level by DMR using the SPSS (Version 17.0 for Window) computer program

RESULT AND DISCUSSION

Contamination of aquatic environment by heavy metals, the most dangerous toxic substance due to their toxicity, tendency to accumulate and most important is its persistent nature is of growing concern in developing countries like India especially in the South Indian Manchester, Coimbatore, an Industrial city. The escalating aquatic contamination with special emphasis on heavy metals is mainly due to over population, expansion of industries, enhancement of technologies, and exploitation of land and water bodies by introducing domestic and agricultural runoff^{3,4}. When such toxic heavy metals are released in to the environment with proper treatment they tend to find their way by getting depositing in the major macro vertebrate fish through the effects of bio-concentrations, which is placed in the end of food chain which in turn threatens the health of consumer who consume them. Now a day's good quality foods are very important for the wellbeing of human health. Heavy metal contamination in aquatic ecosystem exerts an extra stress on biota, fish, which tend to accumulate the heavy metals in metabolically active tissues and organs are usually monitored by measuring their accumulation level in various organs like brain, muscle, gills, liver, kidney and blood⁵. The analysis of heavy metals in different organs of fish *Oreochromis niloticus* from the selected areas (Lakes) where shown in Table-2 and the permissible limits for selected heavy metals were represented in Table- 1. All the three organs of *Oreochromis niloticus* (muscle, gills and liver) shows different values of heavy metals concentration. Liver shows highest level of metals succeeded by gill and muscle. The distribution of heavy metal in the all fish organs analyzed were in the order of $\text{Zn} > \text{Cu} > \text{Pb} > \text{Ni}$ and Cd . Among the metal analyzed the highest concentration level of Zn and the minimum metal concentration is Cd.

Cadmium: In nature, cadmium is always associated with zinc ores (ZnS) due to its similarity with zinc. The cadmium concentration in lake water and fishes has been reported by various workers^{6,7}. Cadmium is more readily absorbed through the lungs than the digestive system. It can damage kidneys, central nervous system and immune system. It can cause bone fractures, stomachaches, diarrhea, vomiting and reproductive problems. In the present study, accumulation of cadmium was higher in Koolipalayam and lower in Kurichi. Cadmium concentration in *Oreochromis niloticus* was in the order of liver > gills > muscle. The highest level of cadmium concentration was observed in liver ($2.22 \pm 0.023 \mu\text{g/g}$), whilst the lower concentration was observed in muscle tissue ($1.26 \pm 0.014 \mu\text{g/g}$). The observed values of our study were higher than the permissible limit (FAO/WHO). Similar results were also reported by^{8,9,10,11}.

Copper: Copper in aqueous systems received attention mostly because of its toxic effect on biota. Copper is an essential part of various enzymes necessary for the synthesis of hemoglobin. ¹²in his study stated that but at higher concentration of copper would cause various health problems. It also produces pathological changes in brain tissue. In the present investigation accumulation of copper was highest in liver tissue which is collected from Koolipalayam ($13.40 \pm 0.388 \mu\text{g/g}$). The lowest accumulation of copper was found in the muscle tissue from Kurichi ($8.49 \pm 0.337 \mu\text{g/g}$). The accumulated levels were lesser than the permissible limit of ¹³ and ¹⁴.

Lead: Lead is a non- essential element and higher concentrations in aquatic organisms may be due to discharge of industrial, sewage and agricultural wastes into aquatic environment ¹⁵. Lead profile in the fish organ for this study is in sequence of muscles < gills < liver. In this study, Lead (Pb) level recorded in this study were above the recommended limits. The maximum amount of lead was found in liver tissue collected from Orathupalayam ($13.24 \pm 0.872 \mu\text{g/g}$) and minimum was found in muscle tissue from Sular ($6.57 \pm 0.736 \mu\text{g/g}$). The accumulation of lead in organs of fish were above the permissible limit^{13, 14}. The present results was in accordance with¹⁶.

Nickel: Nickel is neurotoxic, genotoxic, and carcinogenic agent which may cause health problems like nickel dermatitis etc.¹⁷. Nickel poisoning in fishes include surfacing, rapid mouth and opercular movements and, prior to death, convulsions and loss of equilibrium. In the present study concentration of nickel was high in liver tissue collected from Koolipalayam ($7.14 \pm 0.165 \mu\text{g/g}$) and low in muscle tissue from Perur ($3.39 \pm 0.174 \mu\text{g/g}$). However, the concentration was found to be significant at ($P < 0.05$) confidence limit. Similar results were also reported by¹⁸ in *Clarias gariepinus* and *Labeo umbratus*, ¹⁹ in *Oreochromis niloticus* and ²⁰ in *Channa striatus* and *Heteropneustes fossilis*).

Zinc: Zinc is an essential trace element which plays an important role in the physiological and metabolic process of many organisms. However, higher concentrations it can prove to be toxic. Zinc showed protective effect against the cadmium and lead toxicity. Zinc content was noted to be higher in liver and gill and lowest in muscle. The amount of zinc was highest in the liver tissue of the collected from Orathupalayam ($35.40 \pm 1.28 \mu\text{g/g}$). The amount of zinc was low in the muscle tissue from Perur ($19.59 \pm 1.02 \mu\text{g/g}$). The present results agree with the work of ^{6,9}.

Table 1: Standard Heavy metal values prescribed by WHO (2004), FAO (2007)

Heavy metals ($\mu\text{g/g-1}$)	WHO	FAO
Cadmium (Cd)	1.00	0.50
Zinc (Zn)	30.00	35.00
Lead (Pb)	0.50	0.50
Nickel (Ni)	15.00	10.00
Copper (Cu)	30.00	30.00

Table 2: Statistical analysis of heavy metal concentration in the Muscle, Gill, and Liver tissues of *Oreochromis niloticus* from selected study areas

Metals $\mu\text{g/g-1}$	Samples	Perur	Kurichi	Sulur	Koolipalayam	Orathupalayam
Cadmium (Cd)	Muscle	1.35 $\pm$ 0.017 ^d	1.26 $\pm$ 0.014 ^e	1.38 $\pm$ 0.016 ^c	1.59 $\pm$ 0.014 ^a	1.53 $\pm$ 0.018 ^b
	Gill	1.57 $\pm$ 0.021 ^d	1.47 $\pm$ 0.027 ^e	1.61 $\pm$ 0.023 ^c	1.85 $\pm$ 0.017 ^a	1.78 $\pm$ 0.023 ^b
	Liver	1.89 $\pm$ 0.022 ^d	1.76 $\pm$ 0.025 ^e	1.93 $\pm$ 0.028 ^c	2.22 $\pm$ 0.023 ^a	2.14 $\pm$ 0.026 ^b
Zinc (Zn)	Muscle	19.59 $\pm$ 1.02	20.92 $\pm$ 0.97	18.38 $\pm$ 0.93	24.45 $\pm$ 1.27	25.94 $\pm$ 1.19
	Gill	22.43 $\pm$ 1.27 ^d	23.96 $\pm$ 1.02 ^c	21.05 $\pm$ 1.25 ^e	28.14 $\pm$ 1.25 ^b	29.71 $\pm$ 1.24 ^a
	Liver	26.73 $\pm$ 1.19 ^d	28.55 $\pm$ 1.18 ^c	25.08 $\pm$ 1.29 ^e	33.37 $\pm$ 1.31 ^b	35.40 $\pm$ 1.28 ^a
Lead (Pb)	Muscle	6.57 $\pm$ 0.736 ^d	7.05 $\pm$ 0.802 ^c	5.91 $\pm$ 0.872 ^e	8.64 $\pm$ 0.747 ^b	9.69 $\pm$ 0.822 ^a
	Gill	7.66 $\pm$ 0.821 ^d	8.22 $\pm$ 0.786 ^c	6.89 $\pm$ 0.863 ^e	10.08 $\pm$ 0.792 ^b	11.30 $\pm$ 0.864 ^a
	Liver	8.97 $\pm$ 0.799 ^d	9.63 $\pm$ 0.753 ^c	8.07 $\pm$ 0.789 ^e	11.80 $\pm$ 0.827 ^b	13.24 $\pm$ 0.872 ^a
Nickel (Ni)	Muscle	3.39 $\pm$ 0.174 ^e	4.65 $\pm$ 0.152 ^c	4.17 $\pm$ 0.173 ^d	5.43 $\pm$ 0.154 ^a	5.37 $\pm$ 0.167 ^b
	Gill	4.06 $\pm$ 0.153 ^e	5.58 $\pm$ 0.167 ^c	5.01 $\pm$ 0.165 ^d	6.51 $\pm$ 0.161 ^a	6.44 $\pm$ 0.158 ^b
	Liver	4.46 $\pm$ 0.189 ^e	6.12 $\pm$ 0.159 ^c	5.49 $\pm$ 0.168 ^d	7.14 $\pm$ 0.165 ^a	7.07 $\pm$ 0.171 ^b
Copper (Cu)	Muscle	8.61 $\pm$ 0.387 ^c	8.49 $\pm$ 0.337 ^d	8.73 $\pm$ 0.288 ^b	9.69 $\pm$ 0.345 ^a	9.63 $\pm$ 0.347 ^a
	Gill	10.04 $\pm$ 0.410 ^d	9.90 $\pm$ 0.395 ^c	10.18 $\pm$ 0.373 ^c	11.30 $\pm$ 0.385 ^a	11.23 $\pm$ 0.372 ^b
	Liver	11.91 $\pm$ 0.418 ^c	11.74 $\pm$ 0.401 ^c	12.07 $\pm$ 0.395 ^b	13.40 $\pm$ 0.388 ^a	13.32 $\pm$ 0.274 ^a

Values are mean $\pm$ SD of three samples in each group;^{a-e} Row means followed by a common superscript are not significant at 5% level by DMRT

CONCLUSION

Heavy metals which are derived from natural sources (soil formation), non-point sources, transportation, domestic wastes, urbanrun-offs, agricultural and industrial activities enter aquatic environments and cause severe toxic pollution to macro invertebrate fish which in turn spoils water health and human health. Moreover, a lot of other anthropogenic activities has been observed around the selected lakes which could also contribute significant pollutants to these water bodies. The results of this present finding will be a valuable baseline data on the heavy metals accumulation in fish tissues from selected lakes around Coimbatore district which will create a kind of awareness among the people who consume fishes cultured from these lakes. It was observed that the concentrations of heavy metals like Copper, Zinc and Nickel recorded in the different fish samples were below the WHO and FAO recommended limits while the Cadmium and Lead concentrations were above the permissible limit. Overall data of this research states that bioaccumulations of heavy metals like lead and cadmium in fish tissues is an indication of severe toxicity which will cause ill health in human beings. So, efforts shall be made to recycle the waste (pollutants) entering the lakes to avoid contamination of water bodies and constant monitoring of the water bodies should be carried out because the surrounding villagers depend on the water downstream for domestic and agricultural purposes. For the welfare of the water bodies Government shall devise strategies for the safe disposal of industrial waste and domestic sewage. The NGO's (Non-Governmental Organizations) and EPA's (Environmental Protection Agencies) shall regularly monitor and implementation rules for the well-being of human population and to protect our environment for the future generations.

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