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BIOACCUMULATION OF HEAVY METALS IN SELECTIVE TISSUES OF THE FISH OREOCHROMIS MOSSAMBICUS (PETERS) EXPOSED TO WATER SAMPLE COLLECTED FROM PALLIKARANAI WETLAND ECOSYSTEM, CHENNAI, TAMILNADU.

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ABSTRACT

In the present investigation water sample was collected from Pallikaranai wetland ecosystem (12.9377°N 80.2153°E) and then brought to the laboratory. The fingerlings of freshwater fish was collected from Mohanoor (11.0599° N, 78.1422° E), Namakkal District of Tamilnadu, India. In the laboratory, the fish were segregated into three group (Group I, II and III) each group had 20 fish fingerlings average length of 4 to 5 cm and weight of 9.0 ± 0.5 g of sublethal concentrations of 1% and 3% (Group I: control (tap water free from chlorine); Group II: 1% (1 liter of tap water with 100 ml of experimental water) and Group III: 3% (1 liter of tap water with 300 ml of experimental water)) for a maximum period of 30 days. The accumulation of heavy metals such as copper, chromium, cadmium, zinc and lead were assessed in the selected target organs such as gill, liver, muscle and kidney of the selected fish fingerlings. The maximum level accumulation of Cu, Cr, Cd, Zn and Pb were recorded in the liver > kidney > muscle > gill of the fish *O. mossambicus.* The accumulation of selected heavy metals in various organs and the extent of heavy metal contamination of the Pallikaranai wetland ecosystem (unpublished data) indicates that there is an urgent need to frame strict legislative measures to prevent environmental pollution and save the reserve land of Pallikaranai wetland ecosystem.

KEYWORDS: Pallikaranai wetland ecosystem, heavy metal, environmental pollution, Oreochromis mossambicus.

INTRODUCTION

Heavy metal pollutants in aquatic ecosystem have a serious environmental problem because of their persistence and toxicity in aquatic ecosystem. Day by day the level of contamination in aquatic ecosystem increased and affected by human activities like industrial effluents, agricultural runoff, domestic untreated sewage water, etc... The effluents contains a variety of organic and inorganic pollutants, such as solvents, oils, heavy metals, pesticides, fertilizers and suspended solid (Woodling *et al.* 2001; Pandey *et al.* 2003). So the water bodies easily contaminated and accumulated by foreign particles in sediment and organs of aquatic animals (Mendil and Uluozlu, 2007). Heavy metals have possible to accumulation in bio-systems through contaminated water, soil and air (Jayanthi and Padmavati, 2014). Contaminants in aquatic regions have a major threat for its toxicity, persistence, bioaccumulation and biomagnification in the food chain, (Elenka Georgieva *et al*. 2014; Khanipour *et al*. 2018). Heavy metals can accumulate in fish organs from food, water and sediments (Yilmaz *et al*. 2007; Zhao *et al*. 2012; Kh M El-Moselhy *et al*. 2014). Fish species inhabiting such reservoirs will pose to bioaccumulate the heavy metal ions from the aquatic medium to a level that prompt pathogenicity. The freshwater fish received heavy metal ions from the aquatic ecosystem and accumulated in various organs and tissues and thus exhibiting prompted toxicological effects (McCarthy and Shugart 1990; Muhammad Fawad *et al*. 2017). Heavy metals entered in to the fish body directly or indirectly may cause serious health hazards (Guan *et al*. 2014; Chen *et al*. 2016). Shovon *et al*. (2017) indicated the accumulation of heavy metals in the fish organs could create serious health problems of neuro-, nephro-, carcino- to immunological disorders. The deposition of heavy metals loads in aquatic regions leads to accumulation of complex mixtures with toxic and genotoxic abilities, which may compromise the biodiversity. The processes of bioaccumulation are hypothetically damaging to cell organs (Ohe *et al.* 2004). Commonly the heavy metals are accumulated in gills and gastrointestinal tracts of fishes. Many investigate evidenced that the heavy metals generally accumulated in gill, liver, muscle and kidney in different fishes (Akan *et al.* 2012; Selvanathan *et al.* 2013; Yousafzai *et al.* 2017).

In general, metals can be categorized as biologically essential and non-essential. The nonessential metals (e.g., aluminum (Al), cadmium (Cd), mercury (Hg), tin (Sn) and lead (Pb)) have no proven biological function (also called xenobiotics or foreign elements), and their toxicity rises with increasing concentrations (Sfakianakis *et al*., 2015). Essential metals (e.g., copper (Cu), zinc (Zn), chromium (Cr), nickel (Ni), cobalt (Co), molybdenum (Mo) and

iron (Fe)) on the other hand, have a known important biological roles (Abadi *et al*., 2014), and toxicity occurs either at metabolic deficiencies or at high concentrations (Krishnani *et al*., 2013). The deficiency of an essential metal can therefore cause an adverse health effect, whereas its high concentration can also result in negative impacts which are equivalent to or worse than those caused by non-essential metals.Accumulation of heavy metals could lead to morphological amendments in the fish tissues (Monteiro *et al*. 2005). The fish *Oreochromis mossambicus* is one of the most consumed fish species by humans (Kotze *et al.,* 1999). In the present investigation, the toxic effects of heavy metals in fish have been attempted in the Pallikaranai wetland ecosystem with special reference to the inhabiting the freshwater fish species, *Oreochromis mossambicus* (Peters).

MATERIALS AND METHOD

Live specimens of *Oreochromis mossambicus* fingerlings were collected from river Cauvery, at Mohanoor, Namakkal District of Tamilnadu, India with the help of hand net used by the local fishermen. They were safely brought to the laboratory in well packed polythene bags containing aerated water and acclimatized in the aquarium of 120 liters capacity containing well aerated water for a period of one week prior to experiment. The aquarium was previously fumigated with potassium permanganate to prevent any fungal infection. During acclimatization, the fish were fed *ad libitum*. Food was withheld one day before the commencement of the experiment. The water was changed along with waste feed and feacal matter every 24 hours feeding in order to maintain a healthy environment for the fish. After a week the fish were introduced into separate groups (Group I, II and III) each group had 20 fish fingerlings average length of 4 to 5 cm and weight of 9.0 ± 0.5 g of sublethal concentrations of 1% and 3% (Group I: control (tap water free from chlorine); Group II: 1% (1liter of tap water with100ml of experimental water) and Group III: 3% (1liter of tap water with 300ml of experimental water)) for a maximum period of 30 days. The experimental water collected from Pallikaranai wetland, Chennai Tamilnadu, India.

In the present investigations following heavy metals such as copper, chromium, cadmium, zinc, and lead were determined in gill, muscle, liver and kidney of *O. mossambicus* using Atomic Absorption Spectrophotometer. The experimental fish was exposed to sublethal concentrations (1% and 3%) of the effluent for a maximum period of 30 days. The 7^{th} day of exposal period, 10 fishes were collected from each group for analyzed the accumulation of heavy metals and remaining had continued still day 30. Subsequently the organs were

dissected out and 5 mg of each tissue was taken in a 125 ml Erlenmeyer flask and glass beads were added with 25 ml of deionised water along with 10 ml of (1:1) mixture of concentrated nitric acid and perchloric acid. The samples were boiled until the solution was clear and transferred to a 100 ml volumetric flask and diluted with deionized water and the readings were taken using standard solutions. The results obtained were expressed in µ/g. Statistical comparisons were made using Two way ANOVA, One way ANOVA and Turkey - HSD test (Multiple range test) with Statistical package for social science (SPSS Package).

RESULT

The pattern and extent of bioaccumulation of copper, chromium, cadmium, zinc and lead in various tissues were monitored by analysis of the metal content of gill, muscle, liver and kidney of the fish *O. mossambicus* exposed to the different concentration 1% and 3% for two different exposure periods (7 days and 30 days). In the control group fish showed normal activities like active movements and enthusiastic swimming, normal gill movements, free guzzling of air at the surface water and zero mortality rates were observed. During the different concentration of exposure period of 7 and 30 days (Group II - 1%, and Group III - 3%), the fish activities are differ from the control group. At the lower concentration of toxicant 1%, the fish behavior was progressively changed in day 7 to 30 days and no mortality was found but at higher concentration of toxicants 3%, some behavioral differences were observed, that is fishes repeatedly coming to the water surface, loss of stability, defective and rushing swimming movements, rapid gill movement, reduction of body pigmentation (Nguyen and Janssen, 2002), increased opercular movements, excess mucus secretion and restlessness (Somaiah *et al.*, 2014), throughout the experimental period of day 7 and 30 days. The present investigation the elevated level of various heavy metals had accumulated and instigated severe damage in the tissues liver, kidney, muscle and gill of *O. mossambicus.* The maximum level accumulation of copper, chromium, cadmium, zinc and lead was recorded in the liver then kidney > muscle > gill of the fish *O. mossambicus* on 7 and 30 days of exposure periods in 1% and 3% concentrations (Table 3.1 to 3.6).

Accumulation of copper (µg/g) observed in the tissues of *Oreochromis mossambicus* exposed to sublethal concentrations (% 96 hrs LC_{50}) of the water sample.

Exposure Periods	Concentration levels (% 96 hrs LC_{50})			
	Tissues	Control	1%	3%
7 Days	Gill	0.014 ± 0.003	2.230 ± 0.072	2.310 ± 0.092
	Muscle	0.016 ± 0.004	3.149 ± 0.199	3.233 ± 0.13
	Liver	0.047 ± 0.001	16.200± 0.072	17.320 ±0.09
	Kidney	0.035 ± 0.003	16.130 ± 0.173	17.100 ± 0.07
30 Days	Gill	0.021 ± 0.004	2.515 ± 0.095	2.824 ± 0.10
	Muscle	0.037 ± 0.002	3.340 ± 0.127	3.400 ± 0.022
	Liver	0.054 ± 0.003	18.255 ± 0.092	19.510 ± 0.052
	Kidney	0.051 ± 0.002	17.344 ± 0.053	18.410 ± 0.075

Table 3.2. Accumulation of chromium (µg/g) in the tissues of *Oreochromis mossambicus* exposed to sublethal concentrations (% 96 hrs LC_{50}) of the test sample.

Exposure Periods	Concentration levels (% 96 hrs LC_{50})			
	Tissues	Control	1%	3%
7 Days	Gill	0.019 ± 0.010	1.053 ± 0.013	1.083 ± 0.010
	Muscle	0.034 ± 0.003	1.455 ± 0.013	1.383 ± 0.026
	Liver	0.079 ± 0.009	1.625 ± 0.010	1.722 ± 0.032
	Kidney	0.065 ± 0.011	1.565 ± 0.010	1.638 ± 0.051
30 Days	Gill	0.033 ± 0.006	1.128 ± 0.014	1.173 ± 0.015
	Muscle	0.063 ± 0.006	1.467 ± 0.008	1.443 ± 0.010
	Liver	0.096 ± 0.001	1.782 ± 0.017	1.813 ± 0.010
	Kidney	0.084 ± 0.003	1.613 ± 0.017	1.725 ± 0.013

Table 3.4. Accumulation of cadmium (µg/g) in the tissues of *Oreochromis mossambicus* exposed to sublethal concentrations (% 96 hrs LC_{50}).

Exposure Periods	Concentration levels (% 96 hrs LC_{50})			
	Tissues	Control	1%	3%
7 Days	Gill	0.021 ± 0. 013	0.250 ± 0. 068	0.185 ± 0. 076
	Muscle	0.034 ± 0. 010	0.425 ± 0. 092	0.611 ± 0. 062
	Liver	0.041 ± 0. 013	1.350 ± 0. 052	1.342 ± 0. 072
	Kidney	0.040 ± 0. 010	1.225 ± 0. 102	1.323 ± 0. 179
30 Days	Gill	0.021 ± 0. 008	0.350 ± 0. 044	0.565 ± 0. 066
	Muscle	0.024 ± 0. 013	0.625 ± 0. 095	0.705 ± 0. 087
	Liver	0.037 ± 0. 013	1.575 ± 0. 044	1.820 ± 0. 080
	Kidney	0.036 ± 0. 008	1.325 ± 0.076	1.410 ± 0. 123

Table 3.5. Accumulation of zinc (µg/g) in the tissues of *Oreochromis mossambicus* exposed to sublethal concentrations (% 96 hrs LC_{50})

Exposure Periods	Concentration levels (% 96 hrs LC_{50})			
	Tissues	Control	1%	3%
7 Days	Gill	0.670 ± 0.001	12.350 ± 0.124	13.630 ± 0.129
	Muscle	0.075 ± 0.003	15.500 ± 0.084	17.300 ± 0.082
	Liver	0.085 ± 0.014	130.300 ±0.091	137.450 ± 1.063
	Kidney	0.083 ± 0.021	40.470 ± 0.129	48.235 ± 0.096
30 Days	Gill	0.075 ± 0.010	12.335 ± 0.076	15.250 ± 0.129
	Muscle	0.049 ± 0.007	15.745 ± 0.036	16.825 ± 0.096
	Liver	0.108 ± 0.003	147.920 ±0.515	150.330 ± 0.129
	Kidney	0.054 ± 0.007	50.200 ± 0.082	55.240 ± 0.020

Table 3.6. Accumulation of lead (µg/g) in the tissues of *Oreochromis mossambicus* exposed to sub-lethal concentrations (% 96 hr LC_{50}).

Exposure Periods	Tissues	Concentration levels (% 96 hrs LC_{50})		
		Control	1%	3%
7 Days	Gill	0.021 ± 0.001	3.222 ± 0.042	4.715 ± 0.026
	Muscle	0.025 ± 0.001	4.462 ± 0.091	5.600 ± 0.032
	Liver	0.041 ± 0.001	9.712 ± 0.083	10.500 ± 0.042
	Kidney	0.039 ± 0.001	7.533 ± 0.084	8.325 ± 0.076
30 Days	Gill	0.023 ± 0.001	5.700 ± 0.126	5.275 ± 0.066
	Muscle	0.035 ± 0.001	6.200 ± 0.081	6.440 ± 0.052
	Liver	0.047 ± 0.001	10.323 ± 0.091	11.295 ± 0.016
	Kidney	0.033 ± 0.001	7.220 ± 0.077	8.625 ± 0.023

DISCUSSION

The toxic heavy metals are inflowing the aquatic ecosystem can lead to geo-accumulation, bio accumulation and biomagnification. Various water regions are progressively polluted because of the addition of pollutants from the surroundings (Lokeswari and Chandrappa, 2006). Many researchers substantiated the freshwater fish *O. mossambicus* is one of the great indicator for the level of aquatic pollution (Basa Siraj and Usha Rani, 2003; Neelanjana Choudhurya *et al*. 2017; Ramachandiran *et al*. 2017). Present study also proved the heavy metals (Cu, Cr, Cd, Zn and Pb) accumulated in selective organs of the fish *Oreochromis*

mossambicus. Generally prominent level of heavy metals present in liver, kidney, mussels and gill of fish was good indicator of heavy metal pollution occurrence in the aquatic environment (Muawiya Musa Abarshi *et al*. 2017). Liver and kidney signify the rates of bioaccumulation and decontamination of pollutants and gills and skin are reflects the metal concentrations in the enclosed environment (Zauke *et al*. 1999). Heavy metals utilize an extra stress on fishes and accumulate in metabolically active tissues and organs (Mercy and Dhanalakshmi, 2017). Ambedkar *et al*. (2017) also recorded the heavy metals accumulated in significantly high in liver and kidney and significantly lowest in muscle of selective five fish species.

Heavy metals highly accumulated in liver than other tissues like kidney, mussels and gill of *O. mossambicus*. Many other studies also revealed that heavy metal highly accumulated in liver than other organs in different fishes (Karayakar *et al.*, 2010; Crafford and Avenant-Oldewage, 2011; Aladesanmi Omolara Titilayo and Awotoye Olusegun Olufemi, 2014). Various heavy metals are accumulated in different amounts in different organs of fishes and depend on the physiological role of each organ (Sara Raeisi *et al* 2014).Many studies revealed the Pallikaranai wetland ecosystem has highly contaminated by human activities like rapid industrialization, urbanization and abandoning of solid waste and may affect different type of animals. Because this wetland has highly ecological significance as it is a home for other accompanying with biodiversity. The water quality of the Pallikaranai wetland has very poor (Karpagavalli *et al*. 2012; Aravindkumar *et al.* 2014; Juniet M. Jose, *et al.* 2012). Present study clearly indicated the Pallikaranai wetland ecosystem has highly polluted by various factors. We also need immediately to remove non-biological resources and continuously monitor industrial pollutants and wastewater in Pallikaranai wetland ecosystem.

CONCLUSION

Critical analysis of the present study clearly indicated the Pallikaranai wetland ecosystem has highly polluted by human activities. Pallikaranai wetland ecosystem also offers a good platform for sustenance of life of various organisms like birds, fish and local fishermen. Thus, there is an urgent need to protect the ecosystem by strict legislation thereby, we can prevent the influx of various industrial effluents or mixing of domestic drainages.

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