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Research Article

DETERMINATION OF HEAVY METALS IN DIFFERENT TISSUES OF TILAPIA FISH (*OREOCHROMIS MOSSAMBICUS*) AND WATER SAMPLES OF MULA DAM IN AHILYANAGAR DISTRICT OF MAHARASHTRA, INDIA

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ABSTRACT

The present study was aimed at investigating five heavy metals (Lead, Cadmium, Chromium, Nickel and Zinc) in the muscles and gills of tilapia fish (*Oreochromis mossambicus)* and water samples of a major reservoir, Mula dam from Ahilyanagar district of Maharashtra. The samples were collected during three different seasons viz. summer, monsoon and winter. The results obtained from collected water sample showed ascending order of heavy metals as Cd<Pb<Cr<Ni<Zn. Maximum amount of heavy metal was Zinc (3.21 mg/L) during monsoon, whereas lead was not detected in the water during summer. The accumulations of heavy metals in the gills of fish were found to be more than muscles. The ascending order of heavy metals detected in the tissues was Cd<Pb<Ni<Cr<Zn. Maximum amount of heavy metal was Zinc (18.27 mg/Kg) found in the gills during monsoon, whereas minimum value was of Cadmium (0.18 mg/Kg) found in the muscles during summer. However, the concentrations of heavy metals in the water and tissues of fish, collected during three seasons were within the permissible levels and are safe for the human consumption and public health.

Keywords: Dam water, Gill, Heavy metal, Muscle, *Oreochromis mossambicus.*

INTRODUCTION

The pollution of different water bodies with heavy metals has become a worldwide problem and of scientific concern because these heavy metals are indestructible and most of them have toxic effects on organisms. Heavy metals generally enter aquatic environment through natural activities like atmosphere deposition and erosion of geological matrix or anthropogenic activities like domestic sewage, industrial effluents, mining processes and agricultural wastes (G.Ambedkar and M.Muniyan, 2011). As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals and thus, causing heavy metal pollution in water bodies (Malik *et al*., 2010). Some heavy metals such as copper (Cu), zinc (Zn), iron (Fe), chromium (Cr), manganese (Mn) and nickel (Ni) though essential to human body, are toxic at elevated levels, whereas cadmium (Cd) and lead (Pb) are non-essential metals and are toxic even in trace amounts. Toxicity is highly aggravated by their non-degradability and tendency to bio-accumulate to toxic levels (M.Tuzen, 2003).

Fishes are considered as one of the most vulnerable aquatic organisms to toxic substances present in water (Alibabic *et al*., 2007). At the same time, they are considered as the major part of the human diet due to high protein content, low saturated fat and sufficient omega fatty acids which are known to support good health therefore; various studies have been taken worldwide on the contamination of different fish species by heavy metals (Sivaperumal *et al.,* 2007; Bhattacharya *et al.,* 2010). Accumulation of heavy metals in the body of fish is either through consumption of water or through tissues like gills, skin and digestive system (Burger *et al.,* 2002). Eventually, dietary intake of these heavy metals increases risk to human health as fish occupies a major part of human diet (Turkmen *et al.,* 2005). For these reasons, accumulation of heavy metals in fish has become an important worldwide concern, not only because of the threat to fish but also due

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to the human health problems associated with fish consumption (Begum *et al.,* 2013).

Fish contain high amount of protein with minimum calories and supports effective health condition in human (Ayotunde *et al.,* 2012). Fish is an important bio-indicator which plays a significant role in the monitoring of water pollution, because they respond with great sensitivity to changes in the aquatic environment (Naigaga *et al.,* 2011). Fish naturally contains vitamins and minerals. These vitamins carry out several functions like improving energy production, metabolism, concentration and body beauty (Madison, 2007). Heavy metal contamination of fish species can be very serious considering the health implications of consumption of high levels of heavy metals or continuous consumption of small amount of metals for a long period (Galadima and Garba, 2012). Tilapia is widely cultured fish in Mula dam, near Rahuri in Ahilyanagar district. It is highly demandable fish species as it is tasty and low-price fish. Hence, this study was undertaken to analyze the heavy metal concentration in muscles and gills of Tilapia fish and habitat water collected from Mula dam.

MATERIAL AND METHODS

Study Area

Mula dam is an earth gravity dam constructed in 1972 on Mula River in Ahilyanagar district of Maharashtra, India. The dam lies between latitude 19.329^{0}N and longitude 74.529^{0}E. The dam is freshwater dam serving as major reservoir in the district and water utilized for consumption, agriculture, industrial purpose and fish farming.

Sample Collection

Water sample was collected in a 1-liter bottle during three different seasons viz. summer, monsoon and winter during April 2022 to February 2023. All sample bottles were cleaned before use with detergents and rinsed with deionized water for the sampling purpose. Tilapia fish samples were collected with the help of fisherman, by using gill net. Five fish species of nearly equal size and weight were selected and immediately transported to the laboratory for further treatment.

Figure 1. Sample Collection site of Mula dam.

Figure 2. Photograph of collected Tilapia fish.

Sample Analysis

Water samples were digested by nitric acid digestion method for total metal concentration according to APHA, 2000. Fishes were dissected using stainless steel scalpels. The gills and muscles on the dorsal surface of fish were removed and dried in an oven at 80^0C for two days until they reached a constant weight. A porcelain mortar and pestle was used to grind each dried sample. One-gram dry weight of the powdered form of gills and muscles were digested using closed vessel microwave digestion. The sample was digested with the addition of 3 ml of nitric acid (65%) and 1 ml of hydrogen peroxide (35%) (Taghipour and Aziz, 2010). The microwave was adjusted for 20 minutes at 150^0C and left for 40 minutes to cool in the microwave until they reached room temperature. The samples were then transferred to clean volumetric flasks, and diluted to 100 ml with deionized water. Then Whatman filter paper (0.45 µm) was used for filtration of the samples. Concentrations of lead (Pb), cadmium (Cd), chromium (Cr), nickel (Ni) and zinc (Zn) were then determined using Atomic Absorption Spectrophotometer (Perkin Elmer).

Statistical Analysis

Statistical analysis were done using a computer program SPSS version 15- and two-way ANOVA, and the significance was reported at $P< 0.005$ levels.

RESULTS AND DISCUSSION

The concentration of heavy metals in the sample water is given in Table-1 and the concentration of heavy metals in two different tissues is shown in Table-2. The results of heavy metals in sample water shows the descending sequence as Zn>Ni>Cr>Pb>Cd, calculated as mean of all the three seasons. The highest amount of heavy metal is zinc (3.21 mg/L) found during monsoon season whereas, the average of zinc concentration during a complete year was 2.77mg/L. Second highest heavy metal found in the sample water was nickel. The maximum value of nickel was 0.062mg/L during monsoon, whereas minimum value was 0.034mg/L in summer. The mean concentration of chromium found in sample water was 0.034mg/L and during summer it was recorded as 0.023mg/L. During summer season lead is not detected in the sample water. Lowest amount of heavy metal detected is cadmium (0.001mg/L) during summer. All the five heavy metals show maximum values in monsoon season. The seasonal descending order was monsoon >winter >summer.

The concentration of heavy metals in the muscles and gills of Tilapia fish is shown in Table-2. The maximum concentration of lead (0.57mg/Kg) was found in gills during monsoon and minimum amount of lead (0.21mg/Kg) was found in muscles during summer. The mean concentration of lead, combining all the three seasons results to 0.33mg/Kg in the muscles and 0.45mg/Kg in the gills. The maximum concentration of cadmium (0.42 mg/Kg) was found in gills during monsoon and minimum amount of cadmium (0.18mg/kg) was found in the muscles during summer. The mean concentration of cadmium was found to be 0.27mg/Kg in the muscles and 0.34mg/Kg in the gills. The concentration of chromium is however more in both the tissues. During monsoon season, chromium is found to be 1.64mg/Kg in the muscles and 1.82mg/Kg in the gills. During winter, the values drop down to 1.24mg/Kg in muscles and 1.59mg/Kg in gills. The concentration of nickel during summer was 0.36mg/Kg in muscles and 0.44mg/Kg in the gills. The nickel concentration was decreased in winter and increased to 0.41mg/Kg in the muscles and 0.63mg/Kg in the gills during monsoon season. The mean concentration of zinc in the gills was found to be 15.98 mg/Kg, whereas that in the muscles was 12.69 mg/Kg.

Table1. Concentration of heavy metals in water (mg/L) of Mula dam.

Season	Pb	Cd	Cr	Ni	Zn
Summer	ND	0.001 ±0.0002	0.023 ±0.002	0.034 ±0.004	2.37 ±0.4
Monsoon	0.005 ±0.001	0.003 ±0.0005	0.042 ±0.003	0.062 ±0.007	3.21 ±0.6
Winter	0.003 ±0.001	0.002 ±0.0005	0.037 ±0.002	0.043 ±0.005	2.74 ±0.5
Mean	0.004 ±0.001	0.002 ±0.0005	0.034 ±0.002	0.046 ±0.005	2.77 ±0.5
WHO (2011) Limit	0.01	0.003	0.05	0.07	3.0

Table 2. Concentration of heavy metals in the tissues (mg/Kg dry weight) of Tilapia fish from Mula dam.

Season	Tissue	Pb	Cd	Cr	Ni	Zn
Summer	Muscles	0.21 ±0.04	0.18 ±0.04	1.18 ±0.06	0.36 ±0.05	10.65 ±0.5
	Gills	0.36 ±0.05	0.24 ±0.04	1.27 ±0.06	0.44 ±0.06	12.82 ±0.5
Monsoon	Muscles	0.43 ±0.06	0.38 ±0.06	1.64 ±0.08	0.41 ±0.05	15.10 ±0.6
	Gills	0.57 ±0.08	0.42 ±0.06	1.82 ±0.08	0.63 ±0.07	18.27 ±0.6
Winter	Muscles	0.35 ±0.05	0.27 ±0.04	1.24 ±0.07	0.27 ±0.04	12.34 ±0.5
	Gills	0.42 ±0.06	0.36 ±0.05	1.59 ±0.07	0.29 ±0.05	16.86 ±0.6

	Muscles	0.33 ±0.05	0.27 ±0.05	1.35 ±0.07	0.35 ±0.05	12.69 ±0.5
Mean	Gills	0.45 ±0.06	0.34 ±0.05	1.56 ±0.08	0.45 ±0.06	15.98 ±0.5
WHO (2011) Limit	Fish Tissues	0.7	0.5	2.00	0.5	30

The results of heavy metal concentration in the collected sample water shows ascending order as Cd<Pb<Cr<Ni<Zn, calculated as mean of all the three seasons. All the five heavy metals are maximum during monsoon and minimum during summer season. These results correlate with Joystu D. *et al.,* (2017) who worked on edible fishes of eastern Kolkata. The seasonal variation might be the effect of monsoonal runoff from agricultural, industrial and domestic waste. The accumulated concentration of heavy metals was estimated from muscles and gills of Tilapia fish. The overall result shows that the accumulation of heavy metals in gills is higher than muscles. This may be due to direct contact of dam water with the gills. Also, the ascending order of heavy metals in both the tissues is Cd<Pb<Ni<Cr<Zn. All the concentrations of lead in both the tissues were lower than permissible level recommended by WHO, (2011). Lead does not have a significant biological function in fish. Instead, it is not metabolized by human and if consumed get accumulated in the human body (Yousafzai *et al.,* 2009). These results are quite similar to the results found by M. Mahmuda *et al*., (2020). Study revealed that the seasonal changes in the concentration of chromium can be ordered as monsoon>winter> summer. Though chromium is an essential element, but also elicits the long-term sufferings from chromium toxicity in human upon consumption of contaminated fish. Both these values were found to be less than the permissible limits of WHO, (2011). Though zinc serves as a co-factor of enzymes involved in the metabolism of the fish (Tapia *et al.,* 2012), bioaccumulation of excessive zinc in the flesh fish can cause toxicity, slow grown and reproductive disorders (Ntiforo *et al.,* 2012) in human. In natural aquatic ecosystems, metal occur in low concentrations, normally at microgram to milligram per liter level. In recent years, there has been an issue with metal contaminants, particularly heavy metals, being present in excess of natural loads. This situation has arisen as a result of the rapid growth of population, expansion of industrial activities, exploitation of natural resources and excess use of modern agricultural practices.

CONCLUSION

This study reveals that the concentration of heavy metals found in the water of Mula dam shows ascending order as Cd<Pb<Cr<Ni<Zn. Also, it shows maximum amount in monsoon and minimum amount during summer. The concentration of heavy metals in two different tissues shows the ascending order as Cd<Pb<Ni<Cr<Zn. Due to bio-accumulation and bio-magnification of these metals in the body of fish, the concentration of fish tissues was higher than that of the water concentration. There is a need for continuous monitoring of the heavy metal concentration in Mula dam, since this dam is serving as a place of tourism, source of water for consumption, irrigation and aquaculture.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

The author declare that the experimental work involving animals, has been carried out in accordance with Prevention of Cruelty to Animals act 1960 and permission order from Institutional Animal Ethics Committee established under CPCSEA in our institution, has been obtained in March 2022.

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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