



CONCENTRATIONS OF HEAVY METALS IN THREE TILAPINE SPECIES OF AN ABANDONED GOLD MINE RESERVOIR IN IGUN, NIGERIA

*LAWAL, O.A & O.O. KOMOLAFE

Department of Zoology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria

*Correspondence: rocksept01@yahoo.com +234 805 512 6060

ABSTRACT

The concentrations of Arsenic, Chromium, Lead and Zinc in the fillet and gills of three economically important tilapine species: *Tilapia zillii*, *Hemichromis fasciatus* and *Sarotherodon galilaeus* from an abandoned gold mining reservoir in Igun village, Osun state, Nigeria were investigated between May 2008 and May 2009. Varying high concentrations of Arsenic, Chromium and Zinc were recorded in all fish organs collected from the reservoir in wet and dry seasons. Irrespective of the time of collection, Chromium was the most bioaccumulated heavy metal in the gills and fillet of all fish species. Analysis, showed that *H. fasciatus* bioaccumulated Arsenic, Zinc and Chromium at higher concentrations when compared to other fishes. It was noted that the concentration of Arsenic, Chromium and Zinc in *T. zillii*, *H. fasciatus* and *S. galilaeus* were generally high when compared to the World Health Organisation and Federal Environmental Protection Agency maximum allowable standards in fish food. Lead concentrations in all fish samples were non-detectable.

Keywords: metal accumulation, anthropogenic activity, environmental pollution, bio-indicator

INTRODUCTION

The family Cichlidae is endemic to Africa. Tilapias are of considerable economic importance for aquaculture and fisheries and serve as a valuable food source of animal protein to man (Trewavas, 1982). Their rising popularity is due to their hardiness, resistance to disease, prolific breeding, reasonable fast growth rate, good taste, and tolerance to a wide range of environmental conditions such as temperature, low dissolved oxygen, high turbidities and salinity (Balarin and Hatton, 1979). However, in spite of their economic value, immense contribution to human nutrition and valuable qualities of tilapine species for aquacultural purposes; they are constantly faced with threats from environmental pollution.

In recent years, excessive pollution of the aquatic system and the accumulation of toxic metals by aquatic biota especially fishes has been a problem of increasing concern (Idodo-Umeh, 2002), hence fishes are used as bio-indicators of metal pollution in aquatic environments (Gledhill and Morgan, 2002). Gledhill and Morgan (2002) reported two main ways of metal entry into the aquatic food chain; these are through the consumption of contaminated water and food and also through the non-dietary routes which are the gills, liver and fillet. The gills are always in direct contact with water and serve as the first route of heavy metal entry into the fish body. On absorption, the pollutant is carried in blood stream to the liver for transformation and (or) storage in the flesh (fillet) which is made up of muscle (Heath, 1999; Nussey *et al.*, 2000). Obasohan (2007) reported the presence of elevated levels of heavy metals in the

offal, gills, muscle and liver of freshwater mudfish from Ogba River in Benin City.

The concentration of metals is a function of species and accumulation occurs more in some fish tissues than in others (Adeyeye *et al.*, 1996). It is in the light of this that this study investigated the variations in heavy metal concentrations in the fillet, gills and liver of three cichlids which are economically important namely, *Tilapia zillii*, *Sarotherodon galilaeus* and *Hemichromis fasciatus* found in an abandoned gold mining reservoir in Igun, Osun State, Nigeria. The choice of these fish species was based on their relative economic importance in the Igun reservoir fisheries and their value as relished food items on the tables of both rural and urban dwellers.

MATERIALS AND METHODS

Study area

Specimens for this study were obtained from an abandoned gold mining reservoir in Igun, Atakumosa West Local Government Area, Osun State, Nigeria. The area extends over longitudes 004° 30' E - 004° 45' E and latitude 07° 35' N - 07° 38' N. In order to meet the mining needs of the Nigerian Mining Corporation in 1941, three streams (Oika, Eleripon and Osun streams) were impounded. Igun village lies in a thick equatorial rain forest zone. The climate is typical of an equatorial rain forest which is hot and humid all year round. Annual temperature range is 23 °C to 33 °C. Igun is characterised by two seasons which are rainy season and dry season, with

the dry season extending from November to February while March to October marks the rainy season.

The sampling station was an open water body with an average depth of 2.75 m. The reservoir receives high discharge of water during the rainy season and becomes turbid at this time because of the allochthonous materials carried from the surrounding farmlands and deposits of wastes from illegal mining activities. The substratum is made of clay while the shoreline is sandy. The reservoir shoreline vegetation is made of aquatic macrophytes such as *Rhyrchosia butner*, *Cyclosoru afer* and *Melanthera scanderna*.

Sample collection

Fishes were collected from Igun reservoir between May 2008 and May 2009 using traps and gill nets. Samples of fish caught were brought to the laboratory in ice-chest for identification using standard keys prepared by Reed *et al.* (1967) and Adesulu and Sydenham (2007). Standard morphometric parameters such as the total length, standard length and weight of each fish sample were measured with meter rule and Denward weighing instrument respectively and carefully recorded.

Sample digestion and analysis

The gill of each fish sample was excised from the head region and 2 g piece of fillet from its body. The fillet and gills were kept frozen in labeled test tubes until the time of analysis. Each sample of gills and fillet were transferred into a clean glass petri dish and dried in an oven at 60 °C for 10 hours. The organ and tissue were wet-digested using concentrated nitric acid following standard methods. Each filtrate was then analysed for As, Cr, Pb and Zn using Inductively Coupled Plasma Optical Emission Spectrometer.

RESULTS

Tilapia zillii

In *T. zillii* specimens, the concentrations of As and Cr were higher in the rainy season when compared to the dry season while Zn bioaccumulated most in the dry season (Tables 1 and 2). However, the difference in bioaccumulation between the seasons was found to be statistically insignificant ($P > 0.05$). The amplitude of variation in metal uptake

between the fillet and gills was non-significant though As, Cr and Zn uptake in the fillet was high when compared to its gill uptake (Table 1).

Hemichromis fasciatus

All the samples of *H. fasciatus* in this study were caught in the dry season (Table 2). Metals analysed were highly concentrated in the fillet and gills (Table 1) but the variation in metal accumulation between the fillet and gills was insignificant ($P > 0.05$). The differential uptake of As and Zn in the gills was found to be statistically different from their fillet uptake ($P < 0.05$). Chromium was noted as the heavy metal with the highest mean concentration at $560.91 \mu\text{g/g} \pm 42.526$ in the gills.

Sarotherodon galilaeus

S. galilaeus was well represented, occurring in both dry and wet season samples. In the dry season, high concentration of heavy metals was recorded when compared to the wet season. Table 1 shows the mean concentration of heavy metals in the fillet and gills of *S. galilaeus*. Table 2 revealed that As was highly concentrated in *S. galilaeus* during the wet season; while Cr and Zn were found to be higher in specimens obtained in the dry season. The concentration of As during the wet season was statistically significant ($P < 0.05$) when compared to the dry season while the difference in accumulation of Cr and Zn in the dry months was statistically insignificant ($P > 0.05$) when compared to the wet months. In comparing the level of heavy metal uptake, the difference in the uptake of As and Cr in the gills was found to be statistically insignificant to the level of heavy metal uptake in the fillet at $P > 0.05$.

General observations

Irrespective of the time of collection, Cr was found to be the most bioaccumulated heavy metal in the fillet and gills of the three tilapia species assayed; with a concentration range of $348.52 \mu\text{g/g} \pm 126.90 - 729.29 \mu\text{g/g} \pm 50.045$. The level of Zn uptake in the gills was found to be statistically significant at $P < 0.05$ when compared to the fillet. Lead was non-detectable as it was found to be below the detectable limit of the equipment.

Table 1: Mean concentrations of heavy metals ($\mu\text{g/g}$) in the fillet and gills of fishes in Igun reservoir

	Fish species	Elements			
		As	Cr	Pb	Zn
Fillet	<i>H. fasciatus</i>	61.6 \pm 3.54	460.7 \pm 87.43	ND	64.1 \pm 4.41
	<i>S. galilaeus</i>	31.7 \pm 3.48	565.6 \pm 37.47	ND	85.6 \pm 11.42
	<i>T. zilli</i>	46.6 \pm 4.90	657.3 \pm 109.4	ND	154.7 \pm 40.97
Gills	<i>H. fasciatus</i>	44.1 \pm 4.07	560.9 \pm 42.53	ND	148.5 \pm 18.31
	<i>S. galilaeus</i>	29.9 \pm 3.74	462.1 \pm 89.76	ND	295.9 \pm 85.65
	<i>T. zilli</i>	36.6 \pm 2.79	523.1 \pm 55.35	ND	138.7 \pm 6.33

Table 2: Seasonal variation of heavy metals ($\mu\text{g/g}$) in the fish species in Igun reservoir

Season	Fish species	Elements				
		As	Cr	Pb	Zn	
Dry	<i>Hemichromis fasciatus</i>	49.36 \pm 7.57	620.72 \pm 39.3	ND	132.43 \pm 40.62	
		62.96 \pm 4.98	470.95 \pm 55.0	ND	107.76 \pm 17.76	
		46.23 \pm 3.89	434.74 \pm 120.96	ND	78.57 \pm 14.74	
	<i>Sarotherodon galilaeus</i>	25.02 \pm 2.39	643.20 \pm 87.84	ND	397.02 \pm 158.81	
		26.38 \pm 4.71	578.3 \pm 17.82	ND	157.40 \pm 66.59	
	<i>Tilapia zillii</i>	32.38 \pm 7.03	553.26 \pm 53.67	ND	255.91 \pm 81.34	
Wet	<i>Sarotherodon galilaeus</i>	42.43 \pm 2.13	487.41 \pm 82.98	ND	104.00 \pm 26.75	
		28.06 \pm 3.89	403.85 \pm 35.28	ND	86.00 \pm 6.38	
	<i>Tilapia zillii</i>	43.73 \pm 2.04	430.06 \pm 158.45	ND	122.60 \pm 11.00	
		41.15 \pm 5.84	729.30 \pm 50.05	ND	131.03 \pm 21.97	
			43.65 \pm 11.75	608.74 \pm 68.48	ND	116.19 \pm 7.78
			48.59 \pm 2.73	572.28 \pm 304.26	ND	126.23 \pm 1.86

DISCUSSION

In this study, varying levels of Arsenic, Zinc and Chromium were recorded in all fish species at high concentrations irrespective of the time of collection. The result obtained is similar to the findings of Obasohan *et al.* (2006) and Obasohan (2008). *S. galilaeus* and *T. zillii* had high concentration levels of As while *T. zillii* had a higher concentration of Cr during the rainy season. Accumulation of these heavy metals in tissues and organs was probably due to pronounced leaching of heavy metals from the surrounding agricultural

farmlands and deposited mine tailings into the stream watershed as well as increased surface run off. In the dry season, *H. fasciatus* had high concentrations of all heavy metals assayed. *T. zillii* bioaccumulated Zn most, while *S. galilaeus* bioaccumulated Cr and Zn, agrees with the findings of Idodo-Umeh (2002) in Olomoro water bodies. High concentration of heavy metals in the dry season could be attributed to the reduced water volume as reported by Obasohan *et al.* (2006) and Obasohan (2008). This might increase metabolic rates which induced feeding on variety of

food items, hence high heavy metal concentration in fishes through the food chain (Nussey *et al.*, 2000).

In the fillet and gills, high concentration of heavy metals at varying levels was observed. Arsenic was bioaccumulated most in the fillet of *H. fasciatus* while Cr and Zn were high in its gills. *T. zillii* had high concentrations of As, Zn and Cr in its fillet, while *S. galilaeus* showed high concentrations of Zn in its gills and a high concentration of As and Cr in its fillet. According to Hayton and Barron (1990), gills are dominant site for contamination uptake because of their anatomical and physiological properties which enhance absorption from water. Gills are therefore considered as an important part for direct metal uptake from the water as demonstrated by Wepener *et al.* (2001) in banded tilapia where the gill was the initial site of waterborne contaminants. The fillet which comprises of the fish skin and muscle has been reported by several authors to bioaccumulate the least concentrations of heavy metals when compared to other fish organs (Yilmaz, 2005; Yilmaz *et al.*, 2007) but in this present study, the fillet was found to bioaccumulate some heavy metals at a high concentration. This could be as a result of high concentrations of heavy metals introduced into Igun reservoir through mine tailings.

WHO (1985) and FEPA (2003) recommended standard of Cr in fish food is 0.15 mg/g. In comparison with the concentration of Cr in the fillet and gills of the three tilapine species assayed, it was found to be relatively high. In a recent study, Cr levels in fishes in water bodies at Olomoro ranged from 0.28 - 0.33 mg/g which exceeded the WHO/FEPA recommended standard in food fish (Idodo-Umeh, 2002) but the Cr that occurred in fishes in Igun reservoir was much higher than Cr concentrations recorded in these water bodies. This could be attributed to the natural entry sources which include leaching of top soil and from the parent material.

Out of all fishes analysed, *Hemichromis fasciatus* bioaccumulated As, Zn and Cr at higher concentrations when compared to the other fishes. The high metal accumulation in *H. fasciatus* could be connected to the feeding habit of the fish, being an aggressive omnivore; it feeds on a variety of food items which include shrimps, insects, zoobenthos, detritus, fruits, seeds and smaller fishes (Fish base, 2008).

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CONCLUSION

The present result shows bioaccumulation of metals in the cichlids of the Igun reservoir. Hence, there is urgent need to educate the people through the health personnel of the local and state governments about the risk of its consumption.

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