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Bioaccumulation of Heavy Metals in Fish (*Clarias gariepinus)* Organs from Selected Streams in South Western Nigeria

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Abstract. The study assessed the heavy metal content in the organs/tissues of *Clarias gariepinus* from Yah, Arula and Rara Streams and their associated fish ponds in Osun state, South West Nigeria. The analysis was carried out using atomic absorption spectrophotometer. A significant ($p<0.05$) difference was observed in the heavy metal concentrations across the organs/tissues of *C. gariepinus*. Liver showed the highest concentration of all the detected heavy metals, followed by the gills and muscle, while the fins had the lowest metal concentration. In addition, locational variation of the metal content in the fish showed highest concentration of most metals in the tissues of fish collected from Yah stream and the associated fish pond in Ilesha. In the three locations, the fish fins appeared to be the least preferred site for the bioaccumulation of metals while the liver appeared to be the most preferred site for bioaccumulation. This study, however, confirms *C. gariepinus* as a good bio-indicator for environmental pollution monitoring.

Keywords: *Clarias gariepinus,* Liver, Muscle, Gills, Fins.

1. Introduction

The pollution of aquatic environment with heavy metal has been a worldwide problem during the recent years because they are indestructible and most of them have toxic effect on organism [1]. Among environmental pollutants, metals are of particular concern due to their toxic effect and ability to bioaccumulate in aquatic ecosystems [2]; body tissues and organs [3]. Forstner and Wittman [4] defined metal bioaccumulation as the process whereby an organism concentrates metals in its body from the surrounding medium or food, either by absorption or ingestion. Bio-monitoring of hazardous substances in tissues of aquatic organisms has been successfully applied during recent years for heavy metals pollution [5]. Fish are often at the top of the aquatic food chain and metals are accumulated in them to concentrations many times higher than that present either in water and/or sediment. Fish can absorb heavy metals through epithelial or mucosal surface of their skin, gills and gastrointestinal tract [6], and since they play important role in human nutrition, they need to be carefully screened to ensure that unnecessary high levels of some toxic trace metals are not being transferred to man through fish consumption [7].

African catfish (*Clarias gariepinus*) is of great commercial importance because it is the most widely consumed freshwater fish in Nigeria [8]. It is therefore a good choice to study its response to environmental pollutants, particularly the heavy metals. Therefore, the present study investigated heavy metal pollutants in fish tissues from three selected earthen fish ponds being fed by natural streams in Osun State, Southwest, Nigeria. The study provides information on the heavy metal concentrations in the tissues/organs of African catfish, *C. gariepinus,* with a view to determine the safety of its consumption by man.

1.1. Study Design

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A purposive sampling method was used to select three earthen fish ponds each with inflow from natural stream located in Osogbo, Ilesha and Yakoyo all in Osun State, South-Western Nigeria. The three towns represent each of the three senatorial zones in the state and well noted for fish farming.

1.2. Methodology

Clarias gariepinus specimen was collected from each of the three fish ponds with the aid of cast nets. The fish was brought alive in aerated container to the laboratory avoiding any injury during transportation. It was then weighed, body length (standard length and total length) measured using a measuring board, placed on a dissection board and excised with a scapel to remove the liver, fins, muscles and gills [9], [10]. From the wet weight of each tissue type, 20.0 g was collected and stored in the freezer pending analysis. Heavy metal analysis was carried out on the fish samples using Atomic Absorption Spectrophotometer for the following nine heavy metal mercury (Mg), lead (Pb), chromium (Cr), zinc (Zn), nickel (Ni), cadmium (Cd), copper (Cu), Iron (Fe), Cobalt (Co), Manganese (Mn) [11].

2. Result and Discussion

Relatively high Na concentration was observed in UAC feed brand when compared to Duratee and Multifeed (Fig. 1). In the three feeds, P, S, Cl, K and Ca were available in abundance while Al, Si, Ti, Mn, Fe, Zn, Rb, and Sr were available in trace quantities. However, Pb, Cd, Co, Mg, As, Ni, Cu and Cr were not detected in the three feeds. This analysis was carried out to rule out feeds as source of heavy metal bioaccumulated in the fish tissue. Table 1 shows the bio-accumulation level of Heavy Metals in the tissues/organs of *C. gariepinus* from Ilesha, Osogbo and Yakoyo fish ponds. It was generally observed from the table that the accumulation of the ferrous metals (Fe, Mn, Ni, Cr) were higher than the non-ferrous metals (Pb, Zn, Cu, Co) in the tissue/organs of *C. gariepinus* from the three locations.

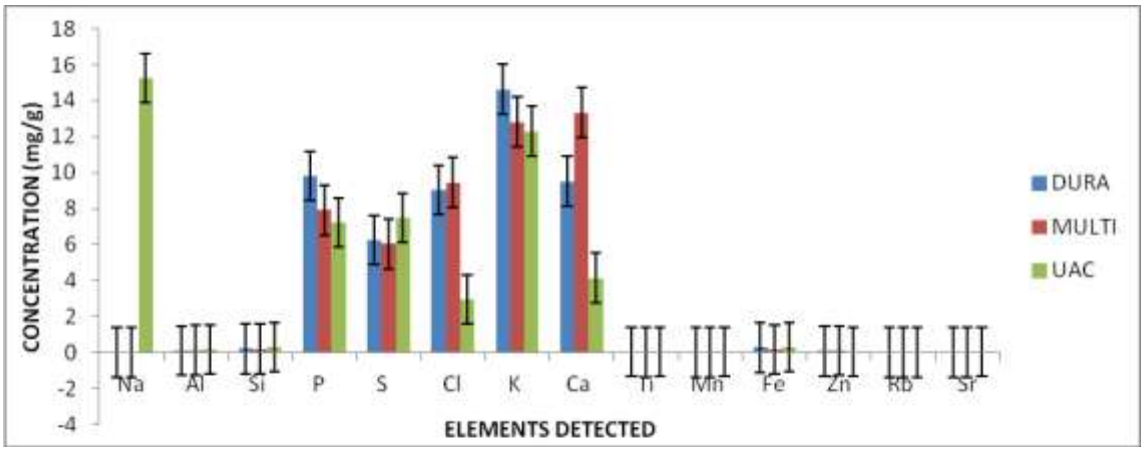

Fig. 1: Mean Concentrations of Detectable Elements in the Fish Feeds (Durantee, Multifeeds and UAC) NOTE: Pb, Cd, Co, Mg, As, Ni, Cu, and Cr were below the detectable limit in the three feed brands.

However, the concentration of Cd in the tissue/organs of *C. gariepinus* from the three ponds was below detection limit (BDL) of 4.00 µg/kg. The fish liver was significantly higher ($p<0.05$) in Pb, Fe, Cu, Zn, Cr, Cu, Mn and Ni (Ilesha pond); Cu and Fe (Osogbo pond); as well as Ni, Cu, Fe and Mn (Yakoyo pond). This conforms with the result of previous studies that heavy metals were more concentrated in the liver than other parts of the fish tissues/organs [12]. It has been reported that enhanced metal levels in fish tissues arise through bio-magnification at each trophic level and their omnivorous bottom feeders concentrate highest metal levels [4]. *C. gariepinus* is a known voracious bottom feeder and could thus have bio-accumulated high metal levels from the pond sediment. However, Fig. 1 ruled out the possibility of the metal uptake from the fish feed.

The distribution pattern of most of the heavy metals in Ilesha, Osogbo and Yakoyo was liver>gills>muscle>fins. This agrees with other peoples' findings in some other places [13]-[15] showing that muscle is less active than the liver in accumulating heavy metals. Heavy metals in excess of the body needs of fish or man, may constitute a major pollution source and pose a serious health risk [16]. The toxicity of Fe may lead to heamochromatosis and, in severe cases, to thalassaemia [17] while excessive intake of Zn may lead to diarrhea and vomiting in humans. Also, in man, the toxicity of Mn leads to a syndrome called manganism which involves both psychiatric symptoms and features of Parkinson disease [18]. In addition, locational variation of the metal content in the fish showed highest concentration of most metals in the tissues of fish collected from Yah stream and the associated fish pond in Ilesha. This could be as a result of the dumpsite located beside Yah stream and other anthropogenic activities going on around the stream. The concentrations of heavy metals recorded in this study revealed that the heavy metals of interest (except Pb in fish muscle from Ilesha) found in measurable quantities are still within safe limits for consumption [19], [20].

Table 1: Bio-accumulation Level of Heavy Metals Compared in the Tissues/Organs of *C. gariepinus* from Ilesha, Osogbo and Yakoyo Fish Ponds

	Heavy Metals (µg/g)	**Muscle**	**Gills**	**Fins**	**Liver**
Ilesha	Pb	53.01[a]	3.00[b]	1.78[b]	6.01[ab]
	Cr	13.00[b]	99.01[a]	33.01[ab]	82.32[a]
	Zn	30.03 [b]	45.11[ab]	60.08[a]	70.17[a]
	Ni	27.02[b]	17.01[b]	33.02[b]	573.34[a]
	Cd	BDL	BDL	BDL	BDL
	Cu	302.02[a]	446.00[a]	457.03[a]	703.01[a]
	Fe	12.12[b]	27.13[b]	10.10[b]	133.03[a]
	Co	34.14[ab]	103.01[a]	19.11[b]	44.17[ab]
	Mn	62.11[b]	373.12[a]	746.02[a]	345.13[a]
Osogbo					
	Pb	10.11[a]	11.20[a]	2.34[b]	2.11[b]
	Cr	93.21[a]	101.01[a]	42.00[b]	89.22[a]
	Zn	33.00 [a]	14.22[b]	10.18[b]	11.10[b]
	Ni	152.21[a]	47.31[b]	53.17[b]	43.34[b]
	Cd	BDL	BDL	BDL	BDL
	Cu	132.23[a]	44.00[b]	57.77[b]	201.01[a]
	Fe	333.41[a]	127.11[b]	112.12[b]	410.53[a]
	Co	114.12[a]	103.01[a]	14.41[b]	83.12[a]
	Mn	475.23[a]	94.22[b]	79.02[b]	399.51[a]
Yakoyo					
	Pb	3.41[a]	1.03[a]	1.14[a]	1.34[a]
	Cr	113.10[a]	29.51[b]	7.01[c]	72.33[a]
	Zn	76.13[a]	15.12[b]	69.13[a]	72.22[a]
	Ni	97.32[a]	7.71[b]	3.02[b]	177.13[a]
	Cd	BDL	BDL	BDL	BDL
	Cu	72.56[a]	66.10[a]	11.21[c]	83.62[a]
	Fe	253.24[a]	271.11[a]	72.12[b]	310.00[a]
	Co	111.14[a]	10.88[b]	9.01[b]	97.12[a]
	Mn	221.71[a]	73.42[b]	46.01[b]	245.11[a]

Means with the same letter along the same rows are not significantly different at 0.05 level

BDL: Below Detectable Limit.

3. Conclusion

Zn, Fe, Cu, Cr and Mn are essential in human diet, efforts should however be concentrated on ensuring that these concentrations do not exceed standards limits of FEPA, WHO and FAO. The high concentration of Pb in Ilesha fish sample could render the fish dangerous for consumption. In view of the importance of fish to diet of man, it is necessary that biological monitoring of the fish meant for consumption should be done regularly to ensure continuous safety of food.

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