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HEAVY METAL CONCENTRATIONS IN SOME ORGANS OF AFRICAN CATFISH (*Clarias gariepinus*) FROM EKO-ENDE DAM, IKIRUN, NIGERIA.

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ABSTRACT
The contents of the heavy metals Fe, Zn, Cu, Mn, Pb, Cd and As were examined in the liver, heart, gills, kidney and muscles of the fish *Clarias gariepinus* from Eko-Ende dam in Ikirun, the capital of Ifelodun Local Government of Osun State, Nigeria. *C. gariepinus* is the fish of choice and the most demanded in the southwest of Nigeria. The highest metal concentrations were in the liver and the gills while the lowest was in the muscles. The general deceasing order of metal accumulation in the organs was Fe > Zn > Cu > Mn > Cd. Lead and arsenic were not detected in any organ. The values were of lower concentrations than found in many other dams and rivers in Nigeria and some other countries. The values were also lower than the FAO/WHO recommended maximum limits in fish samples, making the fish to be safe and not of any hazards for the consumers.

KEYWORDS: Heavy metals; organs; *Clarias gariepinus*; Eko-Ende dam; Nigeria.

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INTRODUCTION

The indispensable need for portable water has necessitated the need for construction of dams in various locations in Nigeria, and particularly in the southwest of the country, as reservoirs to supply portable water and thereby prevent water-borne diseases and improve the quality of life of the people. These dams also serve as sources of various species of fish for the populace. However, the contamination of fresh waters with a wide range of pollutants has become a matter of concern over the last few decades. Among the pollutants, the natural aquatic systems may extensively be contaminated with heavy metals released from domestic, industrial and other man-made activities, and through weathering of rocks and leaching of soils. Such metals may be precipitated, adsorbed on solid surface, remain soluble or suspended in water, or may be taken up by fauna and flora and eventually be accumulated in marine organisms including fish that are consumed by human beings (Adefemi *et al*., 2008). Compared to other types of aquatic pollution, heavy metal pollution is less visible but its effects on the ecosystem and on man are intensive and extensive (Edem *et al*., 2009). The fact that the toxic heavy metals are non-biodegradable and have the ability to accumulate in the environment makes them deleterious to the aquatic environment and consequently to man who depend on aquatic products including fish as sources of food. Fishes particularly are notorious for their ability to concentrate metals in their body tissues to dangerously poisonous levels (Kakulu & Osibanjo, 1988). The Minamata catastrophic disease of the 1950s and 1960s in Japan, caused by methyl mercury poisoning of people who consumed contaminated fish over a period of time is an example (Lars Jarup, 2003). Therefore, since they play an important role in human nutrition, fish need to be screened to ensure that unnecessarily high levels of the toxic heavy metals are not being transferred to man through them.
African catfish (*Clarias gariepinus*) is of great commercial importance because it is the most widely consumed freshwater fish in Nigeria (Olaifa *et al*., 2004). It is therefore a good choice to study its response to environmental contaminants, particularly the heavy metals. Eko-Ende dam is a major source of portable water to Ifelodun Local Government of Osun State, in the southwest of Nigeria, comprising of Ikirun and some other major towns and several other villages. It is also a veritable source of fish for the Local Government as well as the neighbouring Osogbo, the State capital. African catfish, *C. gariepinus*, is the most common and the most preferred fish from the dam. However, there has been a paucity of data concerning the heavy metal contents of

the fishes from the dam. Therefore, this work provides information on the heavy metal concentrations in the organs of African catfish, *C. gariepinus*, in an attempt to predict the safety of its consumption in the environment. It could also be used to establish a baseline for future studies of heavy metal pollution in South Western Nigeria.

MATERIALS AND METHODS

Fresh adult samples of *C. gariepinus* were purchased from fishermen at Eko-Ende dam site and brought immediately into the laboratory and kept frozen prior to analysis. The fish were dissected into the various organs. The fish organs were oven-dried at 105°C to constant weight, blended into fine powder and each kept in a plastic container and stored in a refrigerator at about -4°C prior to analysis. Each separate organ was digested using freshly prepared concentrated nitric acid and hydrogen peroxide (1:1 v/v) according to FAO methods (FAO/SIDA, 1983). Reagent blanks were prepared accordingly to test the purity of the reagents, while standards of the metals in solution were used to calibrate the instrument. The metals were determined using the atomic absorption spectrophotometer (AAS), according to the AOAC (1995). The results were expressed as means of triplicate determinations. Data analysis was by one way analysis of variance (ANOVA) to assess the significance at $p<0.05$ using student t-test.

RESULTS AND DISCUSSION

The mean concentrations of the heavy metals (Fe, Zn, Cu, Mn, Pb, Cd and As) in the various organs of *C. gariepinus* in this study are shown in Table 1.The results confirmed the varying degrees of accumulation of the heavy metals by different organs. The highest heavy metal concentrations were found in the liver, followed by the gills and the least generally being in the muscles. The general distribution of the metals in the organs was in the order liver > gills > kidney > heart > muscle except for Mn with the order liver > gills > kidney > muscle > heart. The liver is a target organ for the accumulation of heavy metals, and the higher levels of these metals in it relative to other organs may be attributed to the high coordination of metallothionein protein with the metals (Hogstrand and Haux, 1991). In addition, the liver is the principal organ responsible for the detoxification, transportation and storage of toxic substances and an active site of pathological effects induced by contamination. The gills are the respiratory sites and are directly in contact with water and pollutants that may be present in

Table 1: Heavy metal concentrations (mg/kg dry weight) in organs of *Clarias gariepinus* samples from Eko-Ende dam.

Metal	Liver	Heart	Gills	Muscle	Kidney
Zn	1.92±0.18	1.13±0.06	1.45±0.16	0.80±0.05	1.39±0.18
Cu	0.88±0.25	0.40±0.15	0.68±0.08	0.15±0.05	0.48±0.12
Mn	0.55±0.18	0.18±0.04	0.45±0.06	0.24±0.04	0.28±0.03
Fe	20.25±1.35	8.65±0.76	11.64±1.25	6.99±0.85	11.62±0.64
Cd	0.03±0.01	0.03±0.01	0.02±0.01	ND	0.01±0.01
Pb	ND	ND	ND	ND	ND
As	ND	ND	ND	ND	ND

Values are means (±SD) of triplicate determinations. ND = Not detected.

water. Thus, the concentrations of heavy metals in gills are a reflection of the concentration in the surrounding water. The high metal concentrations in the gills could be due to the metal complexing with the mucus that is impossible to remove completely from the lamellae before analysis (Heath, 1987).

Our results gave higher levels of heavy metals in the liver and gills relative to other organs. This is in agreement with the findings of others elsewhere (Zyadah, 1999; Farombi *et al*., 2007; Dimari *et al.*, 2008; Al-weher, 2008; Yilmaz, 2009; Uzairu *et al.*, 2009; Akan *et al.*, 2009) (see also Table 2). Since the liver is a target organ of accumulation for many metals, it is often considered a good monitor of water pollution with heavy metals since their concentrations have proportional relevance to those present in the environment (Yilmaz, 2009). The muscles had the lowest metal concentrations compared to other organs. This agrees with other peoples' findings in some other places (Canli & Kalay, 1998; Ekpo *et al*., 2008; Edem *et al.*, 2009; Yilmaz, 2009), showing that muscle is not an active tissue in accumulating heavy metals.

Iron was the most abundant of all the metals considered in this study, and Zn the second most abundant. The general decreasing order of metal accumulation in the organs (liver, gills, kidney and heart) was Fe > Zn > Cu > Mn > Cd except in the muscles which order was Fe > Zn > Mn > Cu > Cd. Lead and arsenic were not detected in any organ. It is generally accepted that heavy metal uptake occurs mainly from water, food and sediment. However, the efficiency may differ in relation to ecological needs, metabolism and the contamination gradients of water, food and sediment, as well as other factors such as salinity, temperature and interacting agents (Pagenkopf, 1983).

The higher levels of Fe and Zn in the fish organs relative to other metals could be due to the fact that these metals are naturally abundant in Nigerian soils which is the main source of metals in the surrounding water of the fish samples (Adefemi *et al.*, 2008); Kakulu & Osibanjo, 1988). In general, accumulation of the essential elements Zn, Cu, Fe and Mn were higher than the non-essential Pb, Cd and As in the fish organs. The essential elements play vital biochemical and physiological functions in fish. Zinc, for example, is regulated to maintain a certain homeostatic status in fish (Chen & Chen, 1999), while both Fe and Cu are components of the enzyme cytochrome oxidase which is involved in energy metabolism (NAS, 1976). But when in excess of the body needs of fish or man, these metals may constitute a major pollution source and pose a serious health risk (Onyia *et al*., 2007). Toxicity of iron, for example, may lead to heamochromatosis and, in severe cases, to thalassaemia (Hovinga *et al.*, 1993). Excessive intake of zinc may lead to diarrhea and vomiting, while toxicity to manganese leads to a syndrome called manganism which involves both psychiatric symptoms and features of Parkinson disease (Dobson *et al.*, 1994).

The non-essential heavy metals, such as lead and cadmium, have no biological function, but are rather detrimental to fish and human existence even at very low concentrations. Acute toxicity of cadmium, for example, may lead to high blood pressure, red blood cells destruction and kidney and testicular tissue destruction, while lead toxicity can reduce intelligence, delay motor development, impair memory and cause hearing problems (Sharma *et al.*, 2008).

From the results of this study, it is seen that fish from Eko-Ende dam is less polluted than those from many other locations in Nigeria, including those from Ogun River in the southwest, Lake Chad, Kubani River in Zaria, Alau dam in Maiduguri and the Niger Delta, (Table 2). The values were also lower than those from some other countries, such as from Jordan, Taiwan and Turkey (Table 2). This could be attributed to the location of the dam in a purely agricultural environment devoid of any major industrial activities.

In conclusion, the heavy metals in this study showed an uneven distribution in the organs of the fish, with the metals being more concentrated in the liver and the gills. They had their concentrations far below the FAO/WHO and IAEA maximum permissible levels (Table 2). With these findings, one may admit that the levels of the metals in the fish samples would be safe and not constitute any health hazards for the consumers. It is however important that continuous monitoring exercise be put in place to guide against excessive bioaccumulation of these metals and safeguard the safety, protection and well-being of the consumers.

Table 2.Heavy metal concentrations in fish (mg/kg) in studies from some other locations in Nigeria and other countries.

Location/ (Fish)	Organ	Zn	Cu	Mn	Fe	Cd	Pb	Reference
Ogun River, Nigeria	Liver	19.75	4.70	--	--	2.10	3.40	Farombi *et al.*, 2007 (*Clarias gariepinus)*
	Gill	20.35	4.55	--	--	2.05	2.40	
	kidney	19.05	5.00	--	--	0.69	3.35	
	Heart	8.96	2.19	--	--	0.25	1.69	
Alau Dam, Maiduguri, Nigeria	Liver	0.52	0.44	0.35	0.40	0.49	0.40	Dimari *et al.*, 2008 (*Tilapia gallier)*
	Gill	0.36	0.63	0.62	0.33	0.38	0.53	
	Intestine	0.15	0.36	0.14	0.34	0.09	0.12	
Okumeshi River, Delta State	Liver	--	--	0.49	--	0.31	0.01	Ekeanyanwu *et al*, 2010 *(Tilapia)*
	Gill	--	--	0.17	--	0.21	<0.01	
	Muscle	--	--	1.97	--	0.62	<0.01	
Kubani River, Zaria, Nigeria	Liver	49.56	19.31	--	--	0.21	0.28	Uzairu *et al.*, 2009 a. (*Clarias gariepinus)*
	Gill	20.05	1.87	--	--	0.31	0.12	
	Muscle	4.92	0.24	--	--	0.02	0.04	
b. (*Oreochromis niloticus)*	Liver	65.72	40.11	--	--	0.40	0.76	
	Gill	26.14	5.32	--	--	0.08	0.24	
	Muscle	7.61	1.15	--	--	0.02	0.02	
Lake Chad, Nigeria	Liver	0.54	0.52	0.32	0.34	0.22	0.32	Akan *et al.*, 2009 a. (*Tilapia zilli)*
	Gill	0.33	0.45	0.29	0.28	0.01	0.03	
	Kidney	0.12	0.31	0.13	0.15	0.10	0.01	
b. (*Clarias anguillaris*)	Liver	0.31	0.32	0.29	0.26	0.03	0.15	
	Gill	0.28	0.32	0.22	0.24	0.02	0.10	
	Kidney	0.13	0.21	0.11	0.12	0.01	0.02	
Henshaw Beach, Calabar, Nigeria	Liver	0.257	--	--	--	0.049	0.173	Edem *et al.*, 2009 (*Oreochromis niloticus)* (group A: 29cm size)
	Gills	0.198	--	--	--	0.038	0.133	
	Muscles	0.079	--	--	--	0.015	0.053	
Northern Jordan Valley, Jordan	Gill	40.12	9.12	--	--	0.77	--	Al-Weher,2008 (*Clarias lazera*)
	Muscle	30.13	3.04	--	--	0.24	--	
Köycegiz Lake–Mugla,Turkey.	Liver	136.9	114.3	9.64	--	0.44	1.02	Yilmaz,2009 (*Oreochromis niloticus)*
	Gill	104.8	7.34	63.44	--	0.11	0.96	
	Muscle	84.76	3.91	12.65	--	0.12	1.12	
Coastal Waters, Eastern Taiwan	Liver	33.83	5.58	--	--	0.52	0.21	Wen-Bin Huang, 2003 (mean for n = 81 fishes)
	Gill	18.12	1.45	--	--	0.27	0.32	
	Muscle	3.79	0.34	--	--	0.05	0.05	
FAO/WHO Limits		40	30			0.5	0.5	FAO/WHO, 1989.
IAEA – 407			3.28	11.0	146	0.18	0.12	Wyse *et al.*, 2005

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