

Full Length Research Article

HEAVY METAL CONTAMINATION OF *CLARIAS GARIEPINUS* FROM A LAKE AND FISH FARM IN IBADAN, NIGERIA.

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Adult Clarias gariepinus (African Catfish) were purchased from Eleiyeye Lake and Zartech fish farm in Ibadan. Water samples were also collected in February (dry season) and June (rainy season), 2002. Gill, bone, intestine, muscle and water samples were analyzed for five metals: manganese, copper, zinc, iron, and chromium by atomic absorption spectroscopy (AAS) in two separate experiments. In each case, two tissues were compared with the levels of the metals in water viz: Gill, bone, and water; intestine, muscle and water. Generally, lower concentrations of the metals were recorded in water than fish tissues. Higher concentrations of zinc than recommended by the Federal Environmental Protection Agency were recorded in the fish during the dry season. Iron was the dominant metal in the muscle while Chromium was the least. Significant differences ($p < 0.05$) were recorded in copper and zinc concentrations in the muscle, intestine and water during the dry and rainy seasons. In gill, bones and water, significant differences ($p < 0.05$) were only recorded for the two stations for copper during the rainy season and only zinc was significantly different ($p < 0.05$) in the dry season. It was concluded that though the heavy metals of interest were present in measurable quantities there were still within safe limits for consumption.

Keywords: Heavy metals, contamination, *Clarias gariepinus*, Lake, Fish farm, Ibadan.

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INTRODUCTION

There is an increasing concern regarding the roles and fates of trace metals in Nigerian environment. Much of this concern arises from the low level of available information on the concentration of these metals within the environment. The contamination of seafoods by trace metals is a potential problem to man. Aquatic organisms accumulate metals to concentrations many times higher than present in water. Trace metals are classified as 'light' or 'heavy' with densities less or greater than 5 g/cm^3 . The potentially toxic metals are lead, zinc, nickel, chromium, arsenic, selenium, vanadium, beryllium and barium.

Natural and anthropogenic activities result in gaseous emissions and wastewater discharges into air, water and land. When the substances in the emissions and effluent discharges in the environment are in very minute amounts or in low concentrations, are not toxic to plants and animals and have short residence time in the environment, they

are described as 'contaminants' (Odiete, 1999).

Bio-concentration is the net accumulation of a substance from water into an aquatic organism resulting from the simultaneous uptake and elimination of the substance. Fish and bivalve molluscs are used in bioaccumulation tests because they are higher trophic level organisms and are usually eaten by man. Tissues such as liver, kidney, muscle, viscera and whole organisms are analyzed to determine the concentration of the metals (Dublin-Green, 1994).

Fish is a valuable and cheap food item and source of protein to man. Eleiyeye water reservoir serves as a major source of portable water and fish in Ibadan. Fishing is carried out daily on the lake. Since there is no formal control of effluent discharge from industries and homes into the river, it is important to monitor the levels of metals in the reservoir in comparison with what obtains at a privately owned fish farm. In this study, *C. gariepinus* was chosen based on the social and economic values in Ibadan. The

concentration of zinc, iron, copper, manganese and chromium were measured in the gill, bone, muscle and intestine tissues of fish in order to assess the seafood consumption safety in Ibadan. It could also establish a baseline for future studies of heavy metal pollution.

Methodology

Water reservoir (Eleiyele), and a fish farm (Zartech farm) were chosen for this study. Eleiyele water reservoir is located on 07° 25' N and 03° 55' E. It has an altitude of 125 m and a catchment area of 323.7 km². The dam was constructed in 1942 and has a total storage capacity of 5.46 km³ with a maximum water elevation (at dam) being 9.0 km. The length of Eleiyele Lake is 2.4 km and has a water surface of 162 ha and an average depth of 6.0 m and total dissolved solids 174.7 mg/L. The source of water to the reservoir is river Ona. Zartech is a major agricultural enterprise in Ibadan whose operations include fish farming. It supplies about 3 tonnes of fish per day and is located at Oluyole Estate in Ibadan. The source of water to the farm is also river Ona.

Collection of Samples

Adult *C. gariepinus* were purchased from fishermen at Eleiyele Lake and Zartech farm in February and June 2002 (Dry and Wet seasons respectively). The average length and weight of the samples were 38 cm and 1kg from the Lake and fish farm respectively. Water samples were also collected in plastic containers, sealed and transferred to the laboratory in iced packs. The fish samples were frozen in the laboratory before analysis.

Digestion of samples:

The samples were digested in open beakers on a hot plate. 2g of each organ (wet weight) were weighed out in an open beaker and 10 ml of freshly prepared 1:1 nitric acid – hydrogen peroxide added. The beaker was covered with a watch glass till initial reaction subsided in about 1 hour. The beaker was placed in a water bath on a hot plate and the temperature gradually allowed to rise to 160° C and the content boiled gently for about 2 hours to reduce the volume to between 2 – 5 ml. The digests were allowed to cool and transferred to 25 ml volumetric flasks and made up to mark with de-ionized water (FAO/SIDA, 1993). The digests were kept in plastic bottles and later the heavy metal concentrations were determined using an atomic absorption spectrophotometer

(AAS). The actual concentration of each metal was calculated using the formula:
Actual concentration of metal in Sample = PPMR X Dilution factor

Where PPMR = AAS reading of Digest.
Dilution factor = $\frac{\text{Volume of digest used}}{\text{Weight of Sample digested}}$

The physico-chemical characteristics of the water measured were dissolved oxygen (D.O), pH and temperature. The dissolved oxygen was determined by Winkler's method (Boyd, 1979). The oxygen content of the water was obtained by calculation using the formula:

$$\text{D.O. content (mg/L)} = \frac{\text{Volume of original sample taken}}{\text{Volume of sample titrated}} \times A$$

Where A = volume of the thiosulphate used in titration.

An electrometric pH meter was used to measure pH. Water temperature was determined using a mercury-in-glass thermometer.

RESULTS

Results of the physicochemical Parameters:

The physico-chemical parameters of the water for dry wet seasons are recorded on table 1.

Table 1:

The Physico-chemical Parameters of Eleiyele Lake and Zartech pond water:

Parameter: Dissolved Oxygen

Parameter	Dry Season	Wet Season
Dissolved Oxygen (mg/L)		
Eleiyele lake	8.01	8.33
Zartech pond	7.11	7.72
pH		
Eleiyele lake	7.10	7.20
Zartech pond	6.50	6.80
Temperature (°C)		
Eleiyele lake	24	22
Zartech pond	25	24

The result of heavy metal analysis of organs and water:

Five metals: Manganese, copper, zinc iron and chromium were analyzed. The heavy metals were measured in gills and bones compared with the levels in water and also intestine and muscles in comparison with water in both rainy and dry seasons. The results are shown on tables 2 and 3.

Table 2:
Heavy Metal Content of Gills, Bone and Water in (wet and dry seasons)

Organ	Trace metal content									
	Eleiyele lake					Zartech pond				
	Mn	Cu	Zn	Fe	Cr	Mn	Cu	Zn	Fe	Cr
Wet Season										
Gill (ppm)	0.0504	0.0125	0.1168	0.3248	0.0112	0.0752	0.012	0.2	0.1208	0.0104
Bone (ppm)	0.0392	0.0192	0.132	0.184	0.0056	0.1704	0.016	0.28	0.3984	0.0248
Water (mg/L)	0	0	0.0024	0	0.0016	0	0	0	0.0216	0.0016
Dry Season										
Gill (ppm)	0.1152	0.0072	0.1104	0.16	0.0056	0.092	0.008	0.14	0.376	0.0088
Bone (ppm)	0.3968	0.012	1584	3360	0.0168	0.172	0.008	0.02	0.248	0.012
Water (mg/L)	0.02	0	0.0024	0.064	0	0.0176	0	0	0.064	0

Table 3:
Heavy metal content of intestine, muscle (wet and dry seasons)

Organ	Trace metal content									
	Eleiyele lake					Zartech farm				
	Mn	Cu	Zn	Fe	Cr	Mn	Cu	Zn	Fe	Cr
Wet season										
Intestine	1.73	0.16	2.25	2.06	0.19	0.21	0.21	1.48	2.32	0.04
Muscle	0.31	0.05	0.65	1.08	0.07	0.32	0.07	0.79	1.32	0.07
Water	0	0	0.024	0	0.0016	0	0.022	0	0.0216	0.0016
Dry season										
Intestine	0.79	0.16	1.88	2.2	0.03	1.48	0.13	1.5	6	0.03
Muscle	2.55	0.07	0.58	2.85	0.07	1.79	0.14	0.74	6.2	0.05
Water	0.02	0	0.024	0.064	0	0.0176	0	0	0.0064	0

These results were subjected to Analysis of variance. In the gill, bone and water. Significant differences ($p < 0.05$) were recorded in the concentrations of copper in the wet and zinc in the dry season between the locations. Intra-location differences were observed for zinc (at Eleiyele: dry and wet seasons) and manganese (Zartech: dry and wet seasons). In the muscle, intestine and water, there were significant differences ($p < 0.05$) in copper and iron concentrations during the dry and rainy seasons. Also within stations, significant differences ($p < 0.05$) were recorded in the concentrations of copper and zinc.

DISCUSSION

Bioaccumulation seemed to occur in tissues of *C. gariepinus* during this study as higher concentrations of metals were observed in fish tissues than the water in which they live. All heavy metals of interest were present in measurable quantities in gills, bones, intestines and muscle. Generally, lower concentrations of heavy metals occurred in gills and bones than in the intestines and muscles.

The absorption of metals is to a large extent a function of their chemical forms and properties. Pulmonary intake causes the most rapid absorption and distribution through the body via the circulatory system. Absorption through the intestinal tract is influenced by pH, rate of movement through the tract and presence of other materials. Combinations of these factors can either increase or decrease absorption. The form of metal can determine which organ is affected most. For instance, lipid-soluble elemental or organometallic mercury damages the brain and the nervous system whereas mercury ion may attack the kidneys (Manahan, 1992).

The mean manganese concentration in the intestine was 1.14 ppm during the dry season and 0.97 ppm in the rainy season. Higher concentrations of manganese were recorded in muscle tissue with mean Mn in muscle was 2.17 ppm in the dry season and 0.315 mg/L in wet season than in the intestine. No significant variation ($P > 0.05$) was recorded between stations and seasons in manganese concentrations in intestine and muscles. The mean manganese concentration in gills was 0.014 in the dry

season and 0.063 ppm in the wet season. The mean manganese concentrations in the bone in the dry and rainy seasons were 0.28 and 0.025 ppm respectively. Manganese was not detected in water during the rainy season but the mean manganese concentration in water was 0.115 ppm during the dry season. Generally the concentrations of manganese recorded in this study were lower than the 5 mg/L Mn recommended by the Federal Environmental Protection Agency (FEPA, 1991) in drinking water

Copper is found in water as a trace element less than 5 µL/L (Alabaster and Lloyd, 1982). The mean concentrations of copper recorded during this study in the dry and wet seasons respectively were: 0.145 and 0.185 ppm in the intestine and 0.105 and 0.06 in the muscle; 0.0076 and 0.0123 in the gill; 0.01 and 0.02 in bone. Copper was not detected in the water during this study at both locations. There were significant differences ($P < 0.05$) between the concentration of copper in water and fish tissues. The levels of copper in this study were less than the 1 mg/L recommended (FEPA, 1991).

The mean concentration of zinc recorded in this study in the dry and wet seasons for the organs respectively were: intestine 1.69 and 1.87 ppm; muscle 0.66 and 0.72 ppm; gill 0.126 and 0.158 ppm; bone 0.09 and 0.206 ppm; water 0.015 and 0.015. Iron 4.1 and 2.19 ppm in intestine 4.53 and 1.195 in muscle, 0.268 and 0.223 in gill and bone 0.292 and 0.291 and in water 0.4 and 0.135 ppm. Chromium 0.03 and 0.115 in intestine, 0.06 and 0.07 in muscle, 0.007 and 0.011 in gill; 0.07 in muscle, 0.007 and 0.014 and 0.015 ppm in bone and 0.02 and 0.0 in water. The concentrations of Zinc in the dry season were higher than the 1 mg/L recommended by FEPA (1991).

Iron was the dominant metal measured during this study. This observation was similar to the observation of other workers (Okoye, 1991a; Asuquo et al, 1999). It has also been observed that iron is the dominant metal in the muscle of *C. gariepinus* (Adeyeye et al; 1996). Chromium was the least abundant metal recorded. The concentration of chromium recorded were generally within the <1 mg/L recommended.

This study shows that the heavy metals of interest though found in measurable quantities are still within safe limits for consumption. Efforts should however be concentrated on ensuring that these

concentrations are not exceeded. Zinc, iron, copper, chromium and manganese are essential in human diet. They all play significant roles in metabolic processes. In view of the importance of fish to diet of man, it is necessary that biological monitoring of the water and fish meant for consumption should be done regularly to ensure continuous safety of food. Safe disposal of domestic sewage and industrial effluents should be practiced and where possible recycled to avoid these metals and other contaminants from going into the environment. Laws enacted to protect our environment should be enforced.

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