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Full Length Research Paper

Heavy metals contamination of *Chrysichthys nigrodigitatus* and *Lates niloticus* in Ikere Gorge, Oyo state, Nigeria

Adeosun, F. I.[1]*, Omoniyi, I. T.[1], Akegbejo-Samsons, Y.[1] and Olujimi, O. O[2]

[1]Department of Aquaculture and Fisheries Management, University of Agriculture, PMB 2240, Abeokuta, Nigeria.
[2]Cape Peninsula University of Technology, Cape Town, South Africa.

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This study investigates the presence of heavy metal contamination of *Chrysichthys nigrodigitatus* and *Lates niloticus.* Adult *C. nigrodigitatus* and *L. niloticus* were obtained from fishermen in Ikere Gorge, Oyo state, Nigeria. Water samples were also collected during the wet and dry seasons of the year in the same locality. The presence of five metals were analyzed in both fish and water. Iron, copper, zinc, lead and manganese were investigated by atomic absorption spectrosocopy (AAS) in two separate experiments. In each case, four tissues; gills, bone, intestine and muscle were compared with the level of metals in the water. Lower concentrations of metals were recorded in water than in fish. Lower concentration of the metals found in fish and water was less than that recommended by the World Health Organisation (WHO) guideline for maximum concentration recorded in the tissue of the two samples. Iron was found to be dominant in the intestine of *C. nigrodigitatus*, while manganese was found to be highest in the bone of *L. niloticus*, copper recorded the least of all the metals. There is significant difference (P < 0.05) in heavy metals concentration in the gill of *C. niloticus* and water, as well as the concentration in the intestine of *L. niloticus* and water. It was concluded that though the heavy metals of interest were present in measurable quantities, they were still within safe limits for consumption.

Key words: Heavy metals, fish, gorge, contamination.

INTRODUCTION

The hydrosphere is one of the major components of man's environment and habitat for aquatic organisms which have its qualities (both physical and chemical) been determined to a greater extent by its underlying earth crust, surface run-off from catchments areas, effluent discharges and gaseous emissions. One of these qualities as determined by these factors is the level of heavy metals in water. The metals are chemical elements that have relatively high density, which are toxic and poisonous at low concentration, e.g. iron (Fe), copper (Cu), zinc (Zn) and lead (Pb). They are classified as "light" or "heavy" with densities less or greater than 5 g/cm3. There is an increasing concern regarding the rates of heavy metals contamination in Nigerian aquatic environment. Much of this concern arises from the low level of information on the concentration of these heavy metals within the environment. Fish which is a valuable and cheap food item as well as source of animal protein to man tends to accumulate these heavy metal in their body to the detriment of consumers health (Omoniyi et al., 2006).

Bio-accumulation of heavy metals in fish can be at least three orders of magnitude greater than the same elements in aqueous phase because trace elements (heavy metals) often sorbs to particles surface (Maret and Skinner, 1998). Another reason for higher concentration of heavy metals in fish tissues than what is in aqueous phase is through the feeding on aquatic organisms that consume mercury in the form of methylmercury and store it in their body. When fish eat these organisms, the methy-lmercury is not excreted, but remain in body tissues. The older fish hence tends to have higher concentration of heavy metals. This indicates that animals at

*Corresponding author. E-mail: adeosunfi@yahoo.com

higher trophic level of food chain tend to have more concentration of heavy metals in their tissue than those at lower trophic level (Smol, 2002).

Bio-accumulation of heavy metals is dangerous to human health as lead, cadmium, cobalt and nickel affect the formation of blood cells. Heavy metals toxicity from the consumption of metal polluted fishes can cause malfunctions of livers, kidneys, circulatory systems and movement of nerve signals. Heavy metals in human body also play a role in the development of cancers (Smol, 2002). This study is carried out to investigate the presence of heavy metal contamination of *Chrysichthys nigrodigitatus* and *Lates niloticus* in Ikere Gorge, Oyo state, Nigeria.

MATERIALS AND METHODS

Background of the site

Ikere gorge is one of the 9 dams owned by Ogun/Osun River Basin Development Authority (O-ORBDA). O-ORBDA is one of the 11 River Basin and Rural Development Authorities in Nigeria. These Authorities are under the Federal Ministry of Water Resources and Rural Development Authority of Nigeria. Ogun Osun River Basin Development Authority has its jurisdiction covering land area of 66.264 square kilometers; this is extended throughout the whole of Oyo, Ogun and Lagos state. River Basin Authorities were established in Nigeria to develop and manage the water resources within the covering area of individual one (Authority). Ikere Gorge (one of the dam being managed by O-ORBDA), is located within the latitude 3° 401N and 3° 501N, and longitude 8° 101 E and 8° 201 E. It is found in the southwestern zone of Nigeria, about 30 km northeast of Iseyin in Oyo state and about 8 km from Ikere village. The maximum water level of the dam is 273 m, while the minimum water level is 266 m. The main dam crest elevation is 277 m and the gross capacity of the dam is 565 million cubic meter (mcm), this makes it habitable for big species of fish like *L. niloticus*. There is a power station (though not completed) capable of supplying a force adequate enough to turn turbine engines to supply 6 megawatts of electricity, (turbines not yet installed). The Gorge is having service spillway as well as auxiliary spillway of 272 m wide. Ikere Gorge is fed with the major incoming water of River Wawa and River Ogun, the desired water level is maintained through the operation of service spillway and the penstock.

Sample collection

Adult *C. nigrodigitatus* and *L. niloticus* were obtained from fishermen at Ikere Gorge in April, 2006. The adult fish species were put in sterile polythene bags and taken in icebox to the laboratory where they were washed with water to remove dirts. The fish were packed into clean nitric acid treated prior to subsequent treatments. All the fish samples were individually stored in deep freezer at -10℃. The fish were allowed to thaw, dissected to separate gills, bone, intestine and muscles and also extracted for each species and kept for digestion and analysis of heavy metals: Fe, Cu, Zn, Pb and Mn using atomic absorption spectrophotometer.

Digestion of sample

The specimens were blotted using filters paper and oven dried at 105℃ in a Gallenkamp oven to a constant weight. The gills, bone, intestine and muscles were ground separately for each specimen into powder with the aid of pestle and mortar. The milled specimens of gills, bone, intestine and muscles were further dried to constant weight and 0.5 g of each specimen was taken with the aid of sensitive Mettler balance (Toledo B3002 Delta Range model) for digestion. The 0.5 g of each samples were put into 50 ml conical flask each containing 20 ml of concentrated HNO_3, 2 ml of concentrated H_2SO_4 and 4 ml of perchloric acid (a catalyst). The samples were transferred to hot plates in a fume cupboard and heated for one hour at 200℃ after which the temperature was reduced to 70℃ and digestion was allowed to continue. Occasional black fumes were observed in the solutions, indicating the presence of fat. The sample, which showed black fumes were further acidified with 10 ml of HNO_3. The digestion continued until the white fumes of perchloric acid disappeared leaving a clear, yellowish solution, which were allowed to cool and then, filtered. The filtrate in the standard volumetric flask was made up to 50 ml mark with distilled water. The presence and amount of Cu, Fe, Mn, Pb and Zn were determined with the aid of atomic absorption spectrophotometer (Buck Scientific VGP Model 210).

RESULTS

Iron (Fe), copper (Cu), zinc (Zn), lead (Pb) and manganese (Mn) were analyzed. The level of heavy metal concentration was measured in gill, bone, intestine and muscle compared with the level in water and the results are shown in Tables 1 and 2.

Tables 1 and 2 show the results of analysis of variance of data collected from atomic absorption spectrophotometer for heavy metal concentration in each tissue of the two fish species sampled (*C. nigrodigitatus* and *L. niloticus*). The alpha (α) risk or level of significance used was 5% or $P < 0.05$. Data on heavy metal concentration in gill, bone, intestine and muscle of *C. nigrodigitatus* and *L. niloticus* show that different letters are statistically significant in rows ($P < 0.05$). Guideline and maximum acceptable concentration for metals and other inorganic pollutant in drinking waters in mg/l is shown in Table 3 (FAO, 1984).

DISCUSSION

In the present study, it was observed that the concentration of Fe in the intestine of *C. nigrodigitatus* is significantly higher than its concentration in tissue and water, while there is no significant difference between the concentration of Fe in the gill and muscle of *C. nigrodigitatus* and water. Concentration of Fe in the bone of *C. nigrodigitatus* is significantly lower than other tissues of the same species and in the bone of *L. niloticus* compared with other tissues. Fe is found to be highest in the intestine, gill and muscle. This might be due to the fact that the aforementioned regions were rich in blood and Fe is a major component of heamoglobin in the blood (Omoniyi et al., 2006).

Copper concentration in the gill, bone and muscle of *L. niloticus* shows no significant difference ($P > 0.05$) in the fish parts studied and water body, however its concentration

Table 1. Heavy metal concentration in gill, bone, intestine and muscle of *C. nigrodigitatus* and water sample (dry season).

Metal	Gill (ug/g)	Bone (ug/g)	Intestine (ug/g)	Muscle (ug/g)	Water (ppm)
Fe	0.754 ± 0.012^{b}	0.316 ± 0.001^{c}	1.947 ± 0.027^{a}	0.739 ± 0.011^{b}	0.764 ± 0.001^{b}
Cu	0.024 ± 0.002^{b}	0.033 ± 0.001^{c}	0.039 ± 0.000^{b}	0.008 ± 0.001^{a}	0.204 ± 0. 002^{a}
Zn	0.292 ± 0.000^{b}	0.564 ± 0.037^{a}	0.257 ± 0.009^{b}	0.243 ± 0.004^{b}	0.060 ± 0.001^{c}
Pb	0.545 ± 0.445^{b}	0.860 ± 0.030^{ab}	0.615 ± 0.025^{ab}	0.625 ± 0.015^{ab}	1.315 ± 0.025^{a}
Mn	0.169 ± 0.007^{c}	0.634 ± 0.34^{a}	0.128 ± 0.006^{c}	0.417 ± 0.001^{b}	0.058 ± 0.001^{d}

Table 2. Heavy metal concentration in gill, bone, intestine and muscle of *L. niloticus* and water sample (wet season).

Metal	Gill (ug/g)	Bone (ug/g)	Intestine (ug/g)	Muscle (ug/g)	Water (ppm)
Fe	0.407 ± 0.001^{c}	0.192 ± 0.000^{a}	0.343 ± 0.002^{a}	0.493 ± 0.001^{b}	0.764 ± 0.001^{b}
Cu	0.024 ± 0.000^{a}	0.022 ± 0.001^{a}	0.036 ± 0.002^{b}	0.024 ± 0.001^{a}	0.204 ± 0. 002^{a}
Zn	0.648 ± 0.002^{a}	0.711 ± 0.002^{b}	0.450 ± 0.001^{c}	0.227 ± 0.005^{d}	0.060 ± 0.001^{c}
Pb	0.127 ± 0.001^{a}	1.170 ± 0.170^{ab}	0.935 ± 0.005^{bc}	0.840 ± 0.000^{c}	1.315 ± 0.025^{a}
Mn	0.781 ± 0.001^{b}	1.837 ± 0.001^{a}	0.215 ± 0.002^{d}	0.372 ± 0.002^{c}	0.058 ± 0.001^{a}

Table 3. World Health Organisation (WHO) guideline maximum concentration in water.

Metal	EC/WHO	Canada	USA
Fe	50 (w)	300	50
Mn	20	50	50
Cd	5 (w)	5	10
Cr	50 (w)	50	50
Pb	50 (w)	10	5
Hg	1 (w)	1	-
Cu	3000 (100 at work)	1000	1000
Zn	5000	5000	5000
As	50 (w)	25	50
Ba	100	1000	-

Ec = 80/778/EEC quality of water for human consumption; W = FAO/WHO 1984 guideline value.

tion in intestine only shows significant difference in all other tissues. *C. nigrodigitatus* shows significant difference ($P < 0.05$) in copper concentration in bone than other tissues.

The concentration of zinc is significantly higher in bone of *C. nigrodigitatus* than all other tissue of same species examined, while it was significantly higher in the gill of *L. niloticus* than in other tissues. *L. niloticus* lives in highly oxygenated water (especially turbulent waters and around water fall), which could be an indicator for its high demand of dissolved oxygen. Thus, a lot of water to pass through its gill, and since zinc is relatively soluble in water and available in almost all freshwater, it easily gets in touch with the gills. Zinc inhibited growth in the zebra fish *Brachydamus revio* and zinc produced cytoplasmic abnormalities, which leads to growth inhibition in stickleback fish (Mathiessen and Brafield, 1973; Speranza et al., 1977; Freedman, 1989). This could be another reason for high level of zinc in the gill of *L. niloticus* than in gill of *C. nigrodigitatus*. Manganese is stored more in the bone of both sample fish species with concentration that is significantly higher than those of gill, intestine and muscle. Accumulations of zinc and manganese metals in bones are relatively higher than water concentration of both metals as shown in the result. This conforms with Olaifa et al. (2004) which showed that aquatic organisms accumulate metals in concentrations that are many times higher than when present in water.

The higher concentration of lead (Pb) recorded in the bone of both species could be as a result of its ability to substitute calcium in the body, particularly in bone. This is possible because Pb atom is similar in size and shape to calcium atom (Smol, 2002). The present investigation showed that there was no relationship between the accumulation pattern of different metals in the different fishes. This is in accordance with the findings of Cross et al. (1973) and Wiener and Giesy (1979). The results show that the highest tissue concentration of heavy metals among the tissues of *C. nigrodigitatus* was found in the intestine, while the gill shows the lowest concentration. Highest concentration in heavy metal was found in the bone of *L. niloticus* among other tissues examined and the lowest concentration was in the muscle. These findings agree with the result of Manahan (1992) that lower concentrations of heavy metals occurred in gills and bones than in the intestines and muscles.

The metal, iron was found to have the highest concentration in the tissues of *C. nigrodigitatus*, while copper concentration was found to be the lowest. In *L . niloticus*, manganese was found to be the highest, while copper was the lowest.

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).

Conclusion and recommendation

All the tissues examined in both species of fish from Ikere Gorge had heavy metal concentration that is lower than the specified WHO (1984) consumption limits. The concentration of Pb in water was found to be the highest in water, followed by Fe, this could be as a result of fungicide spillage from agricultural practices. The concentration of heavy metals in these tissues shows that they are at save level for human consumption. More importantly, the vital part of fish for consumption is the muscle, and it was found to accumulate lowest concentrations of heavy metals among all targeted tissues examined.

Efforts should however be concentrated on ensuring that these concentrations are not exceeded. Zinc, iron, copper, lead 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. Hence, consumption of *C. nigrodigitatus* and *L. niloticus* from Ikere Gorge is save for human consumption.

Other fish species of commercial important have to be examined as well for heavy metals contamination to ascertain save limit for human consumption and the activities at the upper-course of the Gorge should be kept under strict surveillance as they are capable of increasing the heavy metals discharge into the Gorge (for example mining activities), especially as population increases.

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