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Seasonal Variation in the Bioaccumulation of Heavy Metals in the Tissues of *Oreochromis niloticus* and *Chrysichthys nigrodigitatus* in Lagos Lagoon Southwest Nigeria

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Abstract: The uptake and bioaccumulation of metals in Nile tilapia, *Oreochromis niloticus* and Bagrid catfish, *Chrysichthys nigrodigitatus* were monitored to assess the pollution status in Lagos lagoon. Fish samples were collected at designated points on the lagoon over an eight month period covering both rainy and dry seasons and target organs such as gill, bone and flesh were analyzed for eight metals: manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), lead (Pb), cobalt (Co), cadmium (Cd) and nickel (Ni) using a Pye Unicam 960 atomic absorption spectrophotometer (AAS) with deuterium correction. Metal concentration in *O. niloticus* occurred in the order: Fe>Zn>Mn>Cu>Pb>Ni>Co>Cd while in *C. nigrodigitatus*, the order was Fe>Mn>Zn>Cu>Co>Ni>Pb>Cd. Generally, higher concentrations of metals were recorded in rainy season while concentration in tissues followed the order: gill>bone>flesh. However, in *O. niloticus*, Pb, Co and Ni and in *C. nigrodigitatus*, Pb and Co had their highest concentration in bone.

Key words: Bioaccumulation · Heavy metals · Lagos lagoon · Gill · Bone flesh

INTRODUCTION

The accumulation of toxic metals to hazardous levels in aquatic biota has become a problem of increasing concern [1-4]. Excessive pollution of surface waters could lead to health hazards in man, either through drinking of water and/or consumption of contaminated fish [5]. Although human activities have always impacted on coastal areas, it was not until the advent of industrialisation that it began to threaten marine life [6]. It has been observed that relatively small biomass relatively small biomass in aquatic environments generally occurs at a greater variety of trophic levels. This shows strong correlation to the particular sensitivity of aquatic systems with regards to pollution influences. Unfortunately, this distinctive trophic structure enhances accumulation of xenophobic and poisonous substances [7]. The problem was further worsened since rivers carry their pollutants (either dissolved, colloidal of or particulate forms) to estuarine and finally to coastal oceans where harmful substances enter the food chain and become concentrated in fish and other edible organisms particularly in near shore areas [8].

Bioconcentration is the net accumulation of a pollutant from water into an aquatic organism resulting from the simultaneous uptake and elimination of the pollutant [9]. Fish and bivalve molluscs are used in bioaccumulation tests because their organs such as liver, gonads, kidney and gill have a tendency to accumulate enhanced levels of heavy metals than the muscle [10]. However, as was earlier pointed out [11], liver tissues of fishes accumulate relatively high levels of trace metals because the liver is a primary organ for storage and detoxification of these metal toxicants [12]. It is in this light that they have been used for many years to determine the pollution status of water and are thus regarded as excellent biological markers of metals in aquatic ecosystems [13-16]. Besides, they are also been extensively used in the study of physiological behaviour of heavy metals in body organs [17,18]. Attempt to measure the presence and effects of pollutants especially the metals in rivers and oceans, have attracted a great deal of interest.

Much has been documented about the sources, occurrences and toxicity of heavy metals [19-21]. There were enhanced levels of Pb, Cu and Zn in

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Oreochromis niloticus from River Delimi [22]. Elevated levels of Hg were reported for *Chrysichthys nigrodigitatus* and *O. niloticus* from Niger Delta region [23].

MATERIALS AND METHODS

Field survey was undertaken monthly at Bonny Camp, Oko-Baba and Oworonsoki between July 2007 and February 2008. *Chrysichthys nigrodigitatus* and *Oreochromis niloticus* were collected from the fish landings of fishers at Ebute-Eleja, around Oworonsoki for analysis. After capture each fish was individually weighed and total length measured. The fish were then dissected on a polythene work-surface, using stainless steel dissection instruments (Heit and Klusek, 1982) whilst wearing surgical gloves. Fish samples were dissected in the laboratory where the gill, liver, bone and muscle tissue were removed from each fish and frozen for metal analysis. Metal concentrations were measured using a Pye Unicam 960 atomic absorption spectrophotometer (AAS) following the procedures described in [23]. Analysis of Variance (ANOVA) was used to determined differences between various sets of data.

RESULTS

The seasonal variation in the mean concentration of eight metals in tissues of *O. niloticus* and *C. nigrodigitatus* are presented in Figures 1 and 2. There was a higher concentration of magnesium in the gill and bones of *Oreochromis niloticus* in dry season while in the flesh, the metal was observed to be higher in the rainy season. In *Chrysichthys nigrodigitatus* there was higher concentration of magnesium in all the three organs during the rainy season than in the dry season.

Gill, bone and flesh tissue of *O. niloticus* all contained relatively higher levels of Fe during the rainy season than in dry season. In *C. Nigrodigitatus* also, the three organs had a higher concentration of Iron during the rainy season than in dry season.

In *O. niloticus*, the gill had a high concentration of Zn during the rainy season than in dry season, but the bone and flesh were observed to have higher concentrations of Zn in the dry season than in rainy season. However for *C. nigrodigitatus*, the three organs exhibited a higher concentration of Zn during the rainy season than in dry season.

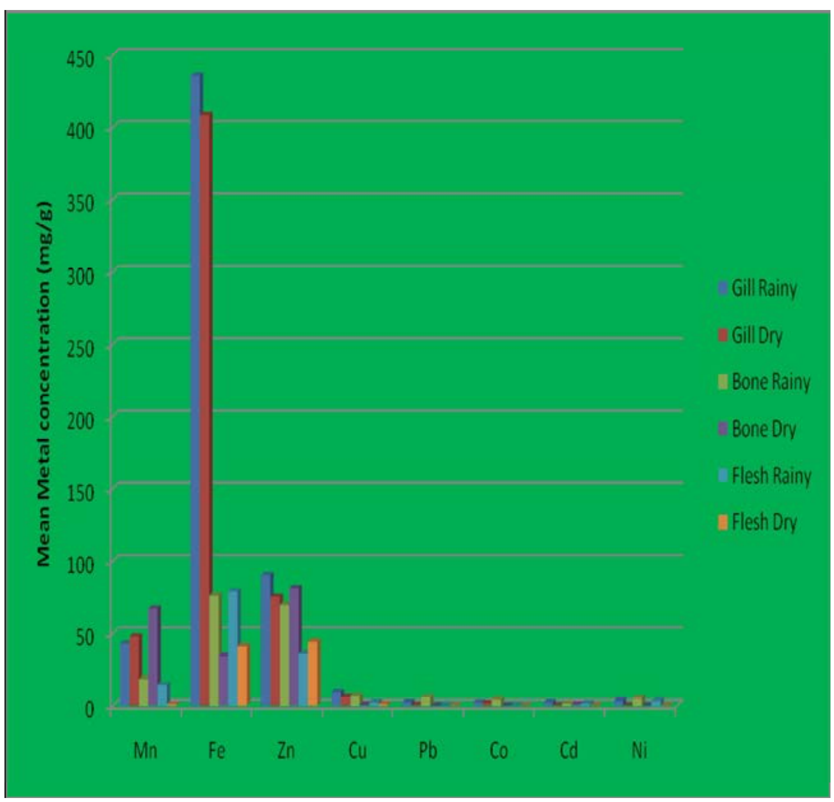

Fig. 1: Seasonal variations in mean metal concentration (µg•g-1 dry mass) in tissues of *Oreochromis niloticus* from Lagos lagoon, southwest Nigeria

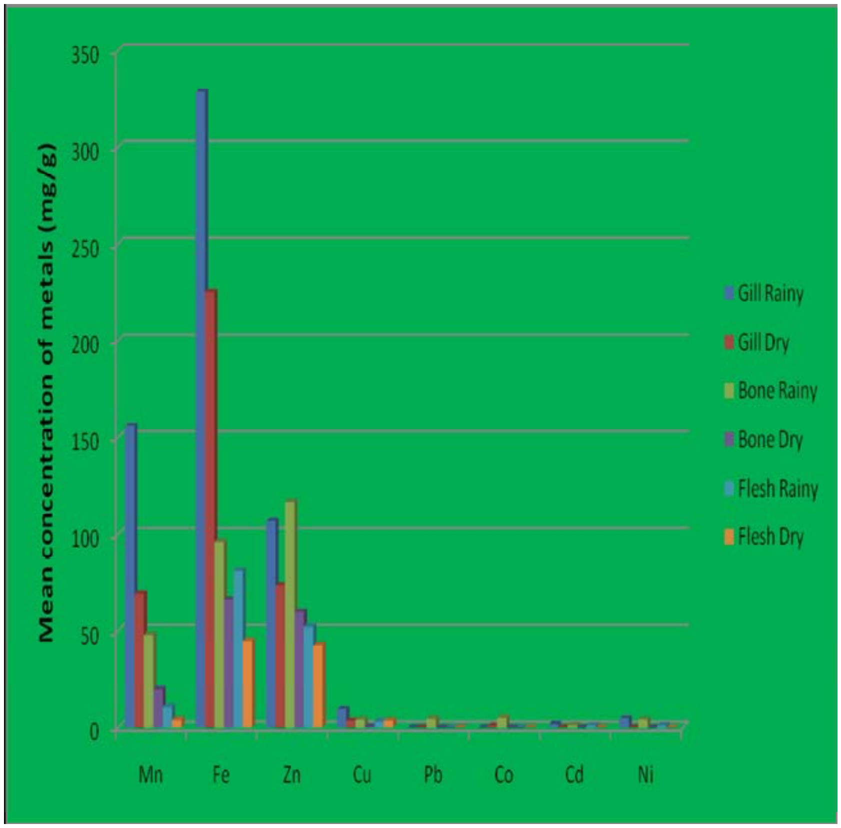

Fig. 2: Seasonal variations in mean metal concentration (µg•g-1 dry mass) in tissues of *Chrysichthys nigrodigitatus* from Lagos lagoon, southwest Nigeria

O. niloticus during the rainy season accumulated more copper (Cu) in the gill, bones and flesh than in dry season. *C. nigrodigitatus* too accumulated higher levels of copper in their gill and bones during the rainy season than in the dry season with their flesh having a higherconcentration in the dry season.

Pb concentration in *O. niloticus* during the rainy season was higher in gill and bone than during the dry season while flesh had traces of Pb concentration during the dry season with none in rainy season. However in *C. nigrodigitatus,* the gill and flesh had traces of Pb in dry season with none in the than in rainy season, while the bone had a high concentration of Pb in rainy season with none in dry season.

There was no uptake of cobalt (Co) in the flesh of *O. niloticus* during both in dry and rainy seasons. In the gill, uptake of Co was higher during rainy season than in dry season. Similarly, there was no uptake of Co in bone during dry season while significant amount of Co was found in the bone during rainy season. Similarly, in *C. nigrodigitatus* there was no uptake of Co in flesh during both seasons. In the gill however, uptake was higher during dry season than in rainy season whereas in bones uptake was only observed during rainy season.

Gill, bone and flesh tissues of *O. niloticus* all contained relatively high levels of Cd during the rainy season. In dry season, except for flesh where it is absent, there was appreciable amount in bone and traces in gill. Similarly, in *C. nigrodigitatus*, the gill, bone and flesh contained high concentration of Cd during rainy season while there was no uptake of this metal during the dry season.

In both *O. niloticus* and *C. nigrodigitatus,* there was a high concentration of Ni in gill, bone and flesh during the rainy season whereas in the dry season there was no trace of the metal in the three organs.

DISCUSSION

The mean concentrations of Mn in gill, bone and flesh of *O. noloticus* varied from a minimum of 0.98mg/kg in flesh to a maximum of 67.23mg/kg in bone and in

C. nigrodigitatus, varied from a minimum of 4.20mg/kg in flesh to a maximum of 156.18mg/kg in gill. Mn accumulation was found to be highest in gill, followed by the bone and then the flesh. Mn has been reported to be taken up directly through the gill or indirectly from food and ingested sediments via gut [27]. High Mn levels in gill can possibly also be ascribed to the fact that the gill is used as an extraction route for this metal [28].

In *O. niloticus*, the mean concentrations of Fe in gill, bone and flesh varied from a minimum of 34.32mg/kg in bone to a maximum of 435.75mg/kg in gill and in *C. nigrodigitatus*, it varied from a minimum of 44.85mg/kg in flesh to a maximum of 324.50mg/kg in gill. Fe accumulation was found to be highest in gill, followed by the bone and then the flesh.

Zinc levels vary from a minimum of 35.83mg/kg in flesh to a maximum of 90.10mg/kg in gill in *O. niloticus* and a minimum of 42.60mg/kg in flesh to a maximum of 116.77mg/kg in bone in *C. nigrodigitatus.* Accumulation was found to be highest in gill, followed by the bones and then the flesh.

The concentrations of copper in the gill, bone and flesh of *O. niloticus* varied from a minimum of 0.69mg/kg in bone to a maximum of 9.28mg/kg in gill and in *C. nigrodigitatus*, varied from a minimum of 0.46mg/kg in bone to a maximum of 9.61mg/kg in gill. Copper accumulation was found to be highest in gill, followed by bone and then the flesh. The high Cu level in gill tissue can possibly be due to the fact that fish gill play a distinct role in metal uptake from the environment since they are in direct contact with the contaminated aquatic medium.

In *O. niloticus*, the mean concentrations of Pb in the gill, bone and flesh varied from a minimum of 0mg/g to a maximum uptake of 5.75mg/kg in bone and in *C. nigrodigitatus*, it also varied from 0mg/g to a maximum uptake of 4.75mg/kg in bone. Lead accumulation was found to be highest in bone, followed by gill and the flesh. The high levels of Pb in bone suggested that uptake was predominantly through the gut.

Co levels varied from minimum of 0mg/g to a maximum of 4.25mg/kg in bone of *O. niloticus* and a minimum of 0mg/g to a maximum of 5.25mg/kg in bone of *C. nigrodigitatus*. Accumulation was found to be highest in bone, followed by the gill with 0mg/g in flesh at all.

The mean concentration of Cd in the gill, bone and flesh of *O. niloticus* varied from 0mg/g to a maximum of 2.14mg/kg in gill. Accumulation of Cd was found to be highest in gill, followed by bone and the flesh. The high levels in the gill showed that the main uptake route was through gill. Cd absorption via gill has been reported [29,30]. It has been observed to cause damage to fish gill [18].

Ni concentration in gill, bone and flesh of *O. niloticus* varied from 0mg/g to a maximum of 5.27mg/kg in bone and in *C. nigrodigitatus* varied from 0mg/g to a maximum of 4.91mg/kg in gill. Accumulation was found to be the highest in bone, followed by gill and then the flesh.

When fishes are exposed to elevated metal levels in an aquatic environment, they can absorb the bioavailable metals directly from the environment via the gill and skin or through the ingestion of contaminated water and food [23]. Metals in fish are then transported by the blood stream which brings it into contact with the various organs and tissues [24]. Physiological differences and the position of each tissue in the fish can also influence the bioaccumulation of a particular have been reported to be a function of the length and weight of the fish species [25,26].

The concentration of Mn, Fe, Zn, Cu, Pb, Co, Cd and Ni were higher in the tissues of *C. nigrodigitatus* during the rainy season than during the dry season. This might be due to more rapid run-offs into the lagoon from fertilizer applied in farmlands and rock surfaces. However, *O. niloticus* recorded higher concentrations of Fe, Cu, Pb, Co, Cd and Ni in their tissues during the rainy season than in dry season while higher concentrations of Mn and Zn were recorded in their tissues during the dry season than during rainy season.

This investigation of the bioaccumulation of heavy metals gave a good indication of the present state of metal contamination of both *O. niloticus* and *C. nigrodigitatus* in the Lagos lagoon. Presently, consumption of these two fish species from Lagos lagoon, is high and may obviously not lead to immediate poisoning. However, long term bioaccumulation through food chain is a major concern.

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