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Original Article

Bioconcentration of Mercury, Lead and Cadmium in the bones and muscles of *Citharinus citharaus* and *Synodontis clarias* from the Amassoma Axis of River Nun, Niger Delta, Nigeria.

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Abstract

Fish is a major source of animal protein to humans and an input in the production of value added products such as animals feed. Activities of man on the environment, and natural processes, often contaminate the aquatic ecosystem causing pollution and subsequent bioaccumulation of heavy metals in the tissues of fishes. This study evaluated the bioconcentration of some toxic heavy metals in the muscle and bone of *Citharinus citharaus* and *Synodontis clarias* from the Amassoma Axis of River Nun, Niger Delta, Nigeria. Standard analytical procedure was employed. The concentration of cadmium and lead from *Synodontis clarias* ranged from 0.014 - 0.015mg/kg and 0.005 - 0.007 mg/kg respectively in the muscle and 0.017 - 0.020mg/kg and 0.015 - 0.019mg/kg respectively in the bones. On the other hand, in *Cithrinus citharus,* the cadmium, lead and mercury concentration ranged from 0.015 - 0.016mg/kg, 0.005 - 0.007mg/kg and 0.001 - 0.002mg/kg respectively in the muscles and 0.024 - 0.030mg/kg, 0.024 - 0.028mg/kg and 0.001 - 0.002mg/kg respectively in the bones. The analysis of variance showed that there were no significant differences (P>0.05) among most of the fish samples studied. The heavy metals were in the order of mercury<lead <cadmium in both the muscles and the bones of both fishes. The consumption of these fishes therefore, may pose little or no health threat with regard to heavy metal contamination.

1. Introduction

Fish is a major source of animal protein, fatty acids and other essential elements needed by living organisms including humans [1, 2]. Fish is a paraphyletic organism consisting of gills, and lacks limbs and digits, including hagfish, lampreys, and cartilaginous and bony fish [3]. Fish are aquatic organisms. Typically, fishes are at the top of the aquatic food chain and therefore, metals tend to accumulate in their tissues to concentrations many times higher than that present in either water or sediment [1].

The heavy metals enter the environment principally through anthropogenic activities and to a lesser extent natural processes in the Niger Delta region with the exception iron, which is found in abundance in the region probably due to the geology of the area. Most non essential heavy metals enter the aquatic ecosystem through the deposition of materials containing such metals in the water ways. For instance, Srivastav *et al* [5] stated that mining, smelting, refining, gasoline, battery manufacturing, electrical wiring, soldering, painting, ceramic glazing, and making of stained glass could release lead into the environment, and subsequently into the aquatic ecosystem. In the aquatic ecosystem, heavy metals could pose a threat to aquatic life due to their persistence, bioaccumulation and biomagnification along the food chain, and toxicity to fish. As a result of bioaccumulation and biomagnifications in fish, fishes are considered as bioindicators for heavy metal pollution [5]. Generally, metals are potential contaminants of aquatic ecosystems due to their toxic effects on living organisms [1, 6, 7].

Bioaccumulation and magnification in fish could result from the intake of non essential metals from its ecosystem through food and respiration processes [3, 8] and when the concentration accumulated exceed the threshold limit, such fish is considered unsafe for human consumption as it may pose a threat to health of consumers of such fish [3]. This could be attributed to the fact that heavy metals are non degradable [3]. Typically, metals are found in the environment including soil and water. Heavy metals can be classified into essential (zinc, iron, manganese, copper) and non essential (cadmium, lead, mercury, arsenic, cadmium) with regard to their biological activities. However, most of these non essential heavy metals are useful in the industrial sector. For instance, lead is used in the production of lead battery, coloured inks and paint preparation[9].

Some common fresh water fish such as *Citharinus citharaus* (which belong to Citharinidae family) and *Synodontis clarias* (which belong to Mochokidae family) from River Nun are usually harvested by artisanal fishermen. These fishes are often sold to intending customers and sometimes eaten by the fishermen and their house hold. Despite the massive deposition of wastes into the Amassoma Axis of River Nun, information on the bioconcentration of heavy metals in fish is scarce in literature. Therefore, this study is aimed at assessing the bioconcentration of heavy metals (mercury, lead and cadmium) in the bones and muscles of *Citharinus citharaus* and *Synodontis clarias* from the Amassoma Axis of River Nun, Niger Delta, Nigeria.

2. Materials and methods

2.1 Sample collection and preparation

Triplicate samples of *Syndontis clarias* and *Citharinus citharaus* harvested from River Nun, Amassoma Axis were bought from five different fishermen between April and July 2014. The fishes were transported to the laboratory in an ice box, where they were washed with running tap water. The fishes were dried in oven at 175°C for 5 hours. Thereafter, the muscles were separated from the bones. Each of the fish tissues i.e. bones and muscles were ground using mortar and pestle. The samples were stored in Ziploc bags at room temperature prior to heavy metal analysis. Similarly, triplicate water and sediment samples were collected from 5 stations along River Nun, Amassoma axis with a distance of 250 meters between each sampling point and the other. The sediment samples were air dried and filtered before analysis.

2.2 Laboratory Analysis

The heavy metals (cadmium, mercury and lead) contents of the water, sediment and fish tissues (bones and muscles) were analyzed using Atomic Absorption Spectrophotometer (AAS) (APHA 301A) [10]. The pH was analyzed using portable pH meter (Hanna instrument HI9820).

2.3 Statistical Analysis

SPSS software version 16 was used for the statistical analysis. The data were expressed as Mean ± standard error. A one-way analysis of variance was carried out at P = 0.05, and mean separation was carried out using Tukey HSD Test.

3. Results and discussion

Tables 1 and 2 present the concentration of mercury, lead and cadmium in *Synodontis clarias* and *Cithrinus citharus* respectively, harvested from River Nun, Amassoma axis, Nigeria. In *Synodontis clarias,* the bioconcentration of cadmium and lead ranged from 0.014 - 0.015mg/kg and 0.005 - 0.007 mg/kg respectively in the muscles and 0.017 - 0.020mg/kg and 0.015 - 0.019mg/kg respectively in the bones. However, in both the muscles and the bones, the concentration of mercury was <0.001. Basically there were no significant variations (P>0.05) among the fishes studied. Similarly, the concentration of cadmium, lead and mercury in *Cithrinus citharus* from River Nun ranged from 0.015 - 0.016mg/kg, 0.005 - 0.007mg/kg and 0.001 - 0.002mg/kg respectively in the muscles and 0.024 - 0.030mg/kg, 0.024 - 0.028mg/kg and 0.001 - 0.002mg/kg respectively in the bones. Similarly, there was no significant difference (P>0.05) among the fish samples studied (Table 2). The low concentration of these non essential heavy metals in the bones and muscles of the fish samples is an indication of low concentration of toxic metals in the River Nun, Amassoma axises. However, the pH, mercury, lead and cadmium from River Nun ranged from 6.437 - 6.567, 0.015 - 0.018 mg/l, 0.940 – 2.573 mg/l and 0.007 - 0.008mg/l respectively without significant variation (P>0.05) across the sampling locations with the exception of lead concentration (Table 3). Typically, acidification of water affects bioaccumulation potentials in fisheries. Therefore, the near neutral pH may be an indication of absence of toxic metals in the water and sediment of the studied area (Table 4). The concentration of mercury and lead in the sediment ranged from 0.012 - 0.028 mg/kg and 0.010 - 0.013mg/kg, while the concentration of cadmium was <0.001 mg/kg. There was no significant variation (P>0.05) in the sediment values across the sampling points with the exception of mercury. The concentration of the heavy metals were in the order of mercury<lead <cadmium in both muscles and bones for both fish species.

Table 1: Bioconcentration of some non essential heavy metals in the bone and muscles of *Synodontis clarias* from River Nun, Nigeria

Location	Muscles			Bones		
	Cadmium, mg/kg	Lead, mg/kg	Mercury, mg/kg	Cadmium, mg/kg	Lead, mg/kg	Mercury, mg/kg
1	0.015±0.001a	0.006±0.000a	0.001±0.000a	0.020±0.001a	0.016±0.001a	0.001±0.000a
2	0.014±0.002a	0.005±0.000a	0.001±0.000a	0.018±0.003a	0.019±0.001a	0.001±0.000a
3	0.014±0.002a	0.006±0.001a	0.001±0.000a	0.018±0.001a	0.015±0.001a	0.001±0.000a
4	0.014±0.001a	0.007±0.001a	0.001±0.000a	0.017±0.001a	0.016±0.001a	0.001±0.000a
5	0.014±0.002a	0.006±0.001a	0.001±0.000a	0.017±0.001a	0.015±0.002a	0.001±0.000a

Along the column the same alphabets indicate no significant differences at *P*>0.05 according to the Tukey HSD Statistics; Each value is expressed as mean ± standard error (n = 3)

Table 2: Bioconcentration of some non essential heavy metals in the bone and muscles of *Synodontis clarias* from River Nun, Nigeria

Location	Muscles			Bones		
	Cadmium, mg/kg	Lead, mg/kg	Mercury, mg/kg	Cadmium, mg/kg	Lead, mg/kg	Mercury, mg/kg
1	0.015±0.001a	0.005±0.000a	0.002±0.000a	0.027±0.002a	0.028±0.002a	0.002±0.000b
2	0.015±0.001a	0.005±0.001a	0.002±0.000a	0.024±0.002a	0.028±0.001a	0.0013±0.000ab
3	0.015±0.001a	0.005±0.001a	0.002±0.000a	0.027±0.001a	0.025±0.001a	0.001±0.000a
4	0.016±0.001a	0.005±0.000a	0.002±0.000a	0.030±0.001a	0.024±0.002a	0.001±0.000a
5	0.016±0.002a	0.007±0.002a	0.001±0.000a	0.026±0.002a	0.024±0.002a	0.002±0.000b

Along the column the same alphabelts indicate no significant differences at *P*>0.05 according to the Tukey HSD Statistics; Each value is expressed as mean ± standard error (n = 3)

The heavy metals concentrations obtained in this study were slightly lower than previous reports for different species of fish. Wokoma [11] reported the concentration of lead in tissue of *Psuedotolithus elongatus, Mugil cephalus* and *Chrisichthyes nigrodigitatus* from Sombreiro River located in Rivers State as 0.23mg/kg, 0.17mg/kg and 0.21 mg/kg respectively. Sambo *et al*[12] reported the concentration of lead in the flesh *Oreochromics niloticus* from Ibrahim Adamu Lake, Jigawa state, Nigeria as 0.27mg/kg, while the level in the river sample is 0.81mg/l. Opaluwa et al [13] reported the concentration of lead and cadmium from UKE Stream, Nasarawa State, Nigeria from different tissues of *Synodontis schall* respectively as 0.021mg/g and 0.005mg/g (head), 0.014mg.g and 0.015mg/g (gills), 0.011 mg/g and 0.026 mg/g (intestine) and 0.012 and 0.001 mg/g (flesh), while in *Clarias garepinus*, the levels of lead and cadmium were respectively recorded as 0.031 mg/g and 0.005mg/g (head), 0.022 mg/g and 0.016mg/g (gills), 0.012mg/g and 0.025mg/g (intestine) and 0.013 mg/g and 0.001mg/g (flesh) and the corresponding water and sediment concentration were respectively recorded as 0.040mg/l and 0.095mg/g (lead) and 0.023 and 0.035mg/g (cadmium). The authors reported that mercury was not found in the fish tissues, water and mercury. Ekeanyanwu *et al* [8] reported cadmium and lead concentrations respectively to be in the range of 0.04 – 0.62mg/kg and <0.01mg/kg in the tissues of tilapia fish from Okumeshi river; 1.32 mg/kg and o.45 mg/kg (sediment) and 0.030mg/l and 0.01mg/l (water sample). Anim-Gyampo *et al* [14] reported cadmium and lead concentration as 0.00mg/kg and 0.365 mg/kg respectively (gills), 0.035 mg/kg and 0.375 mg/kg respectively (muscles); while 0.03mgl and 0.004 mg/l respectively were the concentrations in the water and 4.45mg/kg and 0.36 mg/kg respectively were found in the sediment samples.

The slight variation between the findings in this study and those of previous reports could be attributed to the type of anthropogenic activities around the rivers studied, type of wastes deposited into the surface water and / or leached into the aquatic ecosystem through soil erosion. Also, the bioaccumulation potentials of different fish species as well as their level of tolerance could be important factors. The low concentration of these non essential metals in the bones and muscles of these fish species studied suggested that there may be little or no potential health hazard arising from their consumption with regard to cadmium, lead and mercury contamination.

Table 3: pH and heavy metals (mercury, lead and cadmium) of water from River Nun, Amassoma axis, Nigeria

Location	pH	Mercury, mg/l	Lead, mg/l	Cadmium, mg/l
Downstream 1	6.567±0.088a	0.018±0.001a	2.000±0.058ab	0.008±0.000a
Downstream 2	6.557±0.012a	0.015±0.002a	1.913±0.009b	0.008±0.000a
Mid stream	6.437±0.015a	0.016±0.001a	1.813±0.009b	0.007±0.00a
Upstream 1	6.460±0.021a	0.017±0.001a	0.940±0.021a	0.008±0.001a
Upstream 2	6.440±0.006a	0.016±0.001a	2.573±0.273b	0.007±0.001

Along the column the same alphabets indicate no significant differences at $P>0.05$ according to the Tukey HSD Statistics; Each value is expressed as mean ± standard error (n = 3).

Table 3: Heavy metals (mercury, lead and cadmium) of sediment from River Nun, Amassoma axis, Nigeria

Location	Mercury, mg/kg	Lead, mg/kg	Cadmium, mg/kg
Downstream 1	0.026±0.001ab	0.011±0.001a	0.001±0.000a
Downstream 2	0.012±0.000a	0.010±0.001a	0.001±0.000a
Mid stream	0.024±0.001ab	0.011±0.001a	0.001±0.000a
Upstream 1	0.028±0.001b	0.012±0.001a	0.001±0.000a
Upstream 2	0.025±0.003ab	0.013±0.002a	0.001±0.000a

Along the column the same alphabets indicate no significant differences at $P>0.05$ according to the Tukey HSD Statistics; Each value is expressed as mean ± standard error (n = 3)

4. Conclusion

Fishing is a major occupation in Bayelsa state, central Niger Delta, probably due to the presence of water bodies including rivers, creeks and creeklets. These aquatic ecosystems harbor several fish species, which are sources of animal protein. In Amassoma, the residents deposit municipal wastes in the water ways (i.e River Nun). This study investigated the concentration of lead, cadium and mercury in the bones and muscles of two freshwater fish species (*Citharinus citharaus and Synodontis clarias*). The study found that low concentrations of these metals were found in the bones and muscles of the fish species, as well as the water and sediment samples of River Nun. Therefore, the consumption of these fish species may not constitute health hazard to their consumers.

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