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Assessment of heavy metals in tissues of dried *Clarias gariepinus* and *Oreochromis niloticus* purchased from Anyigba major market, Kogi state, Nigeria

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Abstract
Heavy metals contaminate soils, water bodies, and also the ambient environment. Dried fish, as in other foodstuffs is sold on flat trays and open baskets, which results in direct exposure to the environment. This study was aimed at assessing the heavy metal compositions of fish muscles in two dried fish species; *Clarias garipinus* and *Orechromis niloticus* purchased from Anyigba major market, Kogi State, Nigeria. Flame Atomic Absorption Spectrophotometry was used for heavy metal (cadmium, Cd; lead, Pb; chromium, Cr and copper, Cu) analysis. Data obtained were subjected to simple statistics (Anova). The mean concentration of Cr in the two dried fish species was above the maximum permissible limits as per the WHO/EPA guideline standards comparison. While the mean concentration of other metals in the fish species were below WHO/EPA limits. The possibility of Cr poisoning from prolong consumption of dried fish from Anyigba major market is inferred.

Keywords: Heavy Metals, Pollution, Catfish, Tilapia, Anyigba

Introduction

Heavy metal is any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations (Ngumbu, 2014) [2]. Some heavy metals include mercury, cadmium, arsenic, chromium, thallium and lead. As trace elements, some heavy metals (e.g. copper, iron, zinc, manganese and selenium) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning (Lenntech, 2014) [16]. Heavy metals can enter the human food through water, air, soil, plants and animals. The pollution of the environment by heavy metals is viewed as an international problem because of its effects.

In recent years, the pollution of aquatic environment with heavy metals has become a worldwide problem because of their potential toxic effect and also most of them accumulate in tissues and organs of aquatic organism (Gledhill *et al.*, 1997). However, the amount of absorption and bioaccumulation of the heavy metals depends on ecological, physical, chemical and biological condition and the kind of element and physiology of organisms (Jaffer *et al.*, 1988) [5].

Heavy metals are considered the most important form of pollution of the aquatic environment because of their toxicity and accumulation by marine organisms (Eletta *et al.*, 2003; Malik, 2004; Obasohan *et al.*, 2006 and Igwemmar *et al.*, 2013) [4, 5, 6, 7, 4]. There is increasing concern about the quality of foods in several parts of the world. The determination of toxic elements in food has prompted studies on toxicological effect of these elements in food.

Fish as an important component of the human diet, is generally appreciated as one of the healthiest and often times referred to as the “cheapest” source of protein, as its amino acid compositions are richer in Cysteine than most of the other sources of protein (Eletta *et al.*, 2003) [4].

Fish contains many essential nutrients such as zinc, calcium, and selenium, which are necessary for the normal functioning of the body (El-Moselhy, *et al.*, 2014; Thurstan & Roberts, 2014) [15, 13]. Regardless of all the beneficial factors of dried fish, they are also known to possess a bio-accumulative property, which can cause a build-up of metals within their tissues. This accumulation of metals may occur through contamination of water bodies which serve as habitat to the fish as well as from elemental heavy metals, which is mainly caused by anthropogenic activities and processing methods (Anim *et al*., 2013).

The presence of toxic heavy metals in fish can invalidate their beneficial effects. Several unfavorable effects of heavy metals to human health have been for a long time (Gonzaloz and Mendez, 2008). This includes serious threats like renal failure, liver damage, cardiovascular disease and even death (Albusaidi *et al*., 2011). Thus many local and international monitoring programs have been established in other to assess the quality of fish for human consumption (Meche *et al.*, 2010) [14]. This study was aimed to ascertain the levels of some heavy metals in tissues of dried Tilapia Fish (*Oreochromis niloticus*) and dried Catfish (*Clarias gariepinus*) purchased from Anyigba major market, Kogi State.

Materials and Methods

Study Area

Anyigba is located between longitude 7° 12' East of the Greenwich meridian and latitude 7° 36' North of the Equator in Dekina local government area of Kogi state Nigeria. Kogi state (7°.30'N, 6°.42E) (7.500°N, 6.700°E) is located in the central region of Nigeria. Kogi is characterized by both rainy and dry seasons, with rainy season and dry season lasting from April to October and November to March respectively.

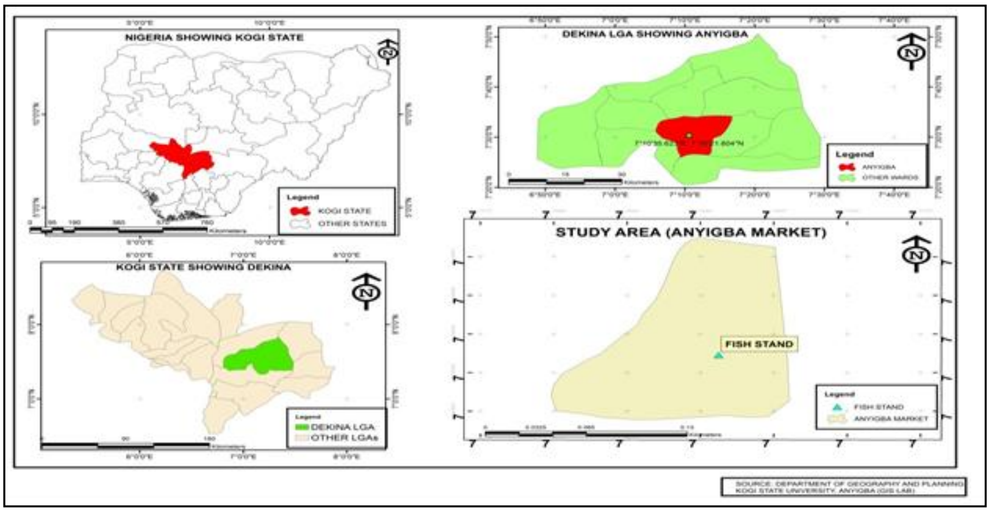

Fig 1: Map showing study area

Sample collection

Two dried fish species in three replicates each namely, Tilapia (*Oreochromis niloticus*) and Catfish (*Claris gariepinus*) were randomly purchased from Ayingba major market.

Laboratory analysis of sample

Organs from the fish were dried in an oven at 105^{0}C for 24h to constant weight and milled with a mortar and pestle. The samples were transferred into dry labeled plastic containers and stored in a desiccator until required for digestion. A procedure similar to that described by Poldoski (1980) was used to digest the samples. Each of the dried powdered fish samples (1 g) was weighed and transferred into 250 mL round bottled flask, to each of this, a mixture of 10 mL of concentrated HNO_3 (65%) and 10 mL of H_2O_2 (30%) was added. The flasks were covered with a watch glass and left to stand for 1 hour. Each of the flasks was then gently heated at 160 ºC in a sand bath on a hot plate till reduction of volume to about 5 ml. The digest was allowed to cool and transferred to 25 ml volumetric flasks and made up to mark with de-ionized water. The digest were kept in Plastic bottles for heavy metal analysis using Atomic absorption spectrophotometer (Olaifa *et al*., 2004). Heavy metals analysis was done using a computerized Varian Atomic Absorption Spectrophotometer (Model Spectra AA-240FS) at University of Ibadan Central Laboratory. Blank solutions were prepared in similar manner as for the samples.

Statistical Analysis

The results obtained were subjected to statistical evaluation. Parameters evaluated were grand mean, standard deviation (SD) and coefficient of variance percentage (CV %)

Results

Table 1 shows the mean metal concentrations, grand mean, standard deviation and coefficient of variance percent in the body parts (head, gills, eyes and the muscle) of dried African catfish (*Clarias gariepienus*) measured in mg kg^{-1}. The grand mean concentration of metals determined ranged from 0.19 – 0.97 mg kg^{-1}. The metals determined were Pb, Cr, Cd, and Cu with grand mean concentrations of 0.19, 0.66, 0.41, and 0.97 (mgkg^{-1}) respectively.

Table 1: Results of heavy metal concentration in the body parts of *Clarias gariepienus* (mgkg^{-1})

Parameter	Pb	Cr	Cd	Cu
Muscles	0.03	BDL	0.34	BDL
Head	0.14	0.39	0.35	0.59
Eyes	0.33	0.37	0.33	BDL
Gill	0.27	1.52	0.74	1.68
Bone	0.18	0.34	0.31	0.65
Grand mean	0.19	0.66	0.41	0.97
S.D	0.12	0.58	0.18	0.61
CV %	0.61	0.88	0.44	0.62

SD standard deviation; CV % coefficient of variance percent; BDL below detection limit

Table 2 shows the mean metal concentrations, grand mean, standard deviation and coefficient of variance percent in the body parts (head, gills, eyes and the muscle) of dried African Tilapia fish *(Oreochromis niloticus*) measured in mg kg^{-1}. The grand mean concentration of metals determined ranged from 0.11–0.68 mg kg^{-1}. The metals determined were Pb, Cr, Cd, and Cu with grand mean concentrations of 0.11, 0.68, 0.38, and 0.60 (mgkg^{-1}) respectively.

Table 2: Results of heavy metal concentration in the body parts of *Oreochromis niloticus* (mg kg^{-1})

Parameter	Pb	Cr	Cd	Cu
Muscles	0.05	BDL	0.31	0.01
Head	0.11	0.36	0.32	BDL
Eyes	0.07	0.24	0.29	0.03
Gill	0.14	1.75	0.69	1.76
Bone	0.19	0.36	0.27	0.58
Grand mean	0.11	0.68	0.38	0.60
S.D	0.06	0.71	0.18	0.82
CV %	0.50	1.06	0.47	1.38

SD Standard Deviation; CV % Coefficient of Variance percent; BDL Below Detection Limit

Table 3 shows the National and International Standards of maximum permissible limit of heavy metals in fish.

Table 3: National and International Standards

Metals	Fish (mgkg^{-1})	
	EPA WHO	
Pb	0.05	2.0
Cr	1.0	0.6
Cd	-	2.0
Cu	0.05	3.0

***Source*:** Rohasliney *et al.,* 2014.

Discussion

The study was aimed at investigating the level of heavy metals in two species of dried fish; namely, Catfish (*Clarias gariepienus)* and Tilapia fish (*Oreochromis niloticus)* purchased from Anyigba major market, Kogi State. Heavy metal contamination of fish can occur through pollution of the aquatic environment, as well as through anthropogenic sources; ambient exposure to metallic dust particles. The former can result in bioaccumulation of metals whilst the latter results in direct contamination. Consequently, many researchers have investigated the concentration levels of various heavy metals such as cadmium (Cd), copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb), Chromium (Cr), Arsenic (As), Mercury (Hg), Zinc (Zn) and Magnesium (Mg) in different fish species (Ekpo *et al*., 2008; Diop *et al*., 2014; Leung *et al*., 2014; Jayaprakash *et al*., 2015) [9, 10, 11, 21].

In this study, concentrations of Copper (Cu), Cadmium (Cd), Chromium (Cr) and Lead (Pb) in two dried fish species; Catfish (*Clarias gariepienus*) and Tilapia (*Oreochromis niloticus*) were analyzed. In Catfish (*Clarias gariepinus*), copper (Cu) had the highest metal concentration value which ranged from 0.59-1.68 mg kg^{-1} with a grand mean of 0.97 mg kg^{-1} which was above EPA maximum permissible limits and within WHO maximum permissible. This was in agreement of an earlier work done by Expo *et al.* (2013). Lead (Pb) had the least concentration and it ranged from 0.03-0.33 mg kg^{-1} with a grand mean of 0.19 mg kg^{-1} which was below WHO and EPA maximum permissible limit. This result agrees with that obtained for the analysis of the levels of metals in organs of *Clarias lazera* from river Nasarawa by Aremu *et al*. (2007) [17]. The gill had the highest metal concentration value of mean concentrations; 0.27, 1.52, 0.74 and 1.68 mg kg^{-1} of Lead (Pb), Chromium(Cr), Cadmium(Cd) and Copper (Cu) respectively and muscles with the least heavy metal mean concentrations; 0.03 and 0.34 mgkg^{-1} of Lead (Pb) and Cadmium (Cd) respectively while chromium(Cr) and copper(Cu) were below detection limit. This result is also in agreement with what was reported by Aremu *et al*. (2007) [17].

In Tilapia fish (*Oreochromis niloticus*), Chromium (Cr) had the highest value of metal concentration ranging from 0.24-1.75 mg kg^{-1} with a grand mean of 0.68 mg kg^{-1} which was above EPA and WHO maximum permissible limits. This was similar to report by Adata *et al*. (2015) [18] of some heavy metals detected in samples of selected fin and shell fishes from Bodo and Kaa in Ogoni-land that were above the maximum permissible limits as recommended by the EPA, United Nations Environment Program (UNEP), World Health Organization (WHO). Lead (Pb) also had the least metal concentration in Tilapia fish; it ranged from 0.05-0.19 mg kg^{-1} with a grand mean of 0.11 mg kg^{-1}. Also, the gill had the highest value of heavy metal mean concentrations; 0.14, 1.75, 0.69 and 1.76 mg kg^{-1} of Lead (Pb), Chromium (Cr), Cadmium (Cd) and Copper (Cu) respectively. The muscles had the lowest heavy metal concentration with means; 0.05, 0.31 and 0.01 mgkg^{-1} of lead (Pb), Cadmium (Cd) and copper (Cu) respectively and chromium (Cr) below detection limit. This was in line with results of Ibrahim *et al*. (2014) and conpolat (2013).

In general, Catfish (*Clarias gariepienus)* had the highest value of heavy metal concentration compared to the metal concentration values of Tilapia fish (*Oreochromis niloticus)*. The high concentration of these metals in Catfish could be attributed to the fact that it is a typical bottom dweller unlike Tilapia fish which is mostly found in the shores. Bottom feeders are known to pick up particulate matter more than the surface feeders (Okoye 1989; Asaolu *et al.*, 1997). Accumulation of heavy metals in different fish species depends on the bioavailability of metal concentration in the abiotic components of their habitat, their feeding habits, ecological needs, metabolism, age, size of the fish and its processing (Peakall *et al.*, 2003; Marcovecchio, 2004) [26, 27]. Salaudeen *et al.* (2016) [16] in a related experiment observed that the gills of Catfish and Tilapia fish had the highest values of heavy metals concentration.

The level of cadmium, copper and lead of both fish samples were below the international standard and chromium of both species are above international standard. The highest heavy metal concentrations were found in the gills and bones followed by the head and the least concentration was in the eyes and muscle. The general trend of distribution of the metals in the organs were in the order, gills>bone>head>eyes>muscle. Lower levels of metals in the muscles compared to the gills and bone of fish reported in this work is comparable to the earlier work of Ebenezer and Eremasi (2012) [29], who observed lower levels of copper, lead, cadmium and nickel in the muscles of *Tilapia zilli*, compared to its gills, and also Javed and Usmani (2011) [20], who reported a similar order of accumulation of heavy metals in the tissues of different fishes, with least accumulation of metals in the muscles.

The gills are the respiratory sites and are directly in contact with water and pollutants that may be present in water. Thus, the concentrations of heavy metals in gills are a reflection of the concentrations in the surrounding water. The high metal concentrations in the gills could be due to the metal completing with the mucus that is impossible to remove completely from the lamellae before analysis (Heath, 1987) [30].

In general, accumulation of the essential element, Copper is higher than the non-essential lead, cadmium and chromium in the fish organs. The higher level of copper in the fish organs relative to the other metals could be due to the fact that the metal is naturally abundant in Nigeria soil which is the main source of metals in the surrounding water of the fish samples (Adefemi *et al.*, 2008). The concentrations of all the metals were generally higher in the non-edible parts of the fish (gills) than in the muscle. This result is in consonance with the reports of Yamazaki *et al.* (1996) [31].

Conclusion

The concentrations of heavy metals determined in samples of the two fish species were quite variable. The heavy metal residues in the tissues of both species exhibited different patterns of accumulation and distribution among the selected tissues. Chromium (Cr) found in the fish samples were above the maximum permissible limits as per the WHO/EPA guideline standards comparison.

In fish, gills are considered to be the dominant site for contaminant uptake because of their anatomical and/or physiological properties that maximize absorption efficiency from water. However, it was evident from this study that, gill was the site of maximum accumulation for the elements while muscle and eyes were the overall sites of least metal accumulation. However, the gills are mostly not consumed by people, so consumption of the dried fish purchased from Anyigba major market do not pose serious health threat.

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