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Heavy metal concentration in selected fish species from Eleyele reservoir Ibadan Oyo State South-western Nigeria

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Heavy metal concentrations (lead, cadmium, zinc, copper, chromium and manganese) in selected fish species from Eleyele reservoir Ibadan Oyo State South-Western Nigeria were investigated. A sample each of catfish (*Clarias gariepinus*), Africa pike *(Hepsetus odoe*) and tilapia fish (*Oreochromis niloticus*) from Eleyele lake Ibadan Oyo state were collected from fish farmers at the landing site early in the morning using standard procedure and transported to the laboratory within 30 minutes for laboratory analysis. Heavy metal concentration in the flesh of the fish species and water sample were analysed using atomic absorption spectrophotometer. There existed significant difference (p<0.05) in the concentration of heavy metals in fish flesh of various fish species with that of herbivorous fish (Tilapia fish) being the highest followed by omnivorous fish (catfish), followed by piscivorous fish (*H. odoe*), while that of the water body was the lowest. It was concluded that fish could be considered bio-indicator of environmental contamination within the aquatic ecosystem; it also indicates that fish could be useful in estimating bioavailability of metal to freshwater biota.

Key words: Heavy and trace metal, *Clarias gariepinus*, *Hepsetus odoe, Oreochromis niloticus,* Eleyele reservoir.

INTRODUCTION

Heavy metal comprises a number of elements which are manganese, chromium lead, cadmium, etc. (Mazvila, 2001), but these metals are also the most important source of necessary for living organisms: that is, iron, zinc, copper, pollution (Chovanec et al., 2003; Popek et al., 2008). The subject of heavy metal is receiving increasing popularity in food industry due to high incidence of contamination in agricultural and seafood

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products (Mohammad et al., 2011). Heavy metal affects freshwater organisms and induces certain harmful modifications at histological and morphological levels, also decreases the growth and developmental rates resulting in increase of death rate and the decrease of birth rate (Authman, 2008). Their potential toxic effects are given by the presence in water solution at concentrations exceeding certain threshold levels and their long persistence in the aquatic ecosystems and their bioaccumulation and biomagnification in the food webs (Naeem et al., 2011). Metal accumulation in fish tissues poses a direct threat for human being (Papagiannis et al., 2004). The distribution of metals varies between fish species, depending on age, development status and other physiological factors (Kagie and Schaffer, 1998). The ingestion of food is an obvious means of exposure to metals, not only because many metals are natural components of food stuffs, but also environmental contamination and contamination during processing (Voegborlo et al., 1999). Heavy metals having penetrated into human being through food chains might cause various disturbances or serious diseases (Idzelis et al., 2007). Once heavy metals are ingested, numerous health problems will take place. Lead may cause learning disabilities, impaired protein and hemoglobin synthesis and shorten the lifespan of red blood cells which leads to severe anemia (hypochromic microcytic anemia) in children (Sultana et al., 1998). The most common toxic effects of cadmium in human is renal failure, accumulation in the bone resulting in calcium loss and malfunctioning of peripheral and central nervous system (Schroeder et al., 1965; Castro et al., 2008). Nickel has different undesirable effects on human health such as impairing the biological activity of cells, lung and nasal cancer in long-term exposure; respiratory, nervous and digestive disorders and also psychological problems will be increased (Sultana and Rao, 1998). Zinc causes slow growth in children, reduced fertility, dry mouth, headache and nausea (Castro et al., 2008). Although fish can be effective in preventing cardiovascular disease (CVD), the fish found in waters with heavy metals may increase the incidence of some illnesses such as cancer (Capar and Yess, 1996). Therefore investigation of the heavy metals in fishes becomes important to estimate freshwater pollution and the risk potential of human consumption (Dural et al., 2007). This study therefore evaluates the presence of heavy metals in three commercial fishes from selected water bodies in Ibadan metropolis.

MATERIALS AND METHOD

The study area

Eleyele reservoir

The study location Eleyele Reservoir is located in north-eastern part of Ibadan, Southwestern Nigeria within longitude N07025'00" and N07027'00" and Latitude E03050'00" and E03053'00" (Figure 1). The study site is surrounded by Eleyele neighborhood in the south, Apete in the east and Awotan in the north. Eleyele wetland is a modified natural riverine wetland type with area of about 100 km2 including the catchment area. The elevation is relatively low ranging between 100- 150 m above sea level and surrounded by quartz-ridge hills toward the downstream section where the Eleyele dam barrage is located. A number of stream channels serve as feeding / recharge streams to the Eleyele wetland basin. In 1942, the quest to create a modern water supply system to meet the challenge of water scarcity for the emerging Ibadan metropolis led to the construction of Eleyele Dam on the main River Ona with a reservoir storage capacity of 29.5 million litres (Tijani et al., 2001).

Sample collection

A sample each of catfish (*C. gariepinus*), African pike *(Hepsetus odoe*) and tilapia fish (*O. niloticus*) (Figure 2) from Eleyele lake Ibadan Oyo state were bought from fish farmers at the landing site by 8.00 am, the fish were collected inside an ice box and transported to SMO laboratory Joyce B road Ibadan, Oyo State, Nigeria within 30 min for laboratory analysis. Sample of the water body in which these fish were sourced was also collected in water sampling bottle using a standard procedures described by Welz and Sperling (1999): the sampling bottles were conditioned by washing with detergent solution that is metal free and non-ionic and finally rinsing several times with distilled water. The sampling bottles were rinsed with the dam water first before the sample were finally collected. The heavy metal concentration of the fish species and the water sample were analyzed in triplicate using the following analytical procedure:

Digestion of fish samples

1 g of sample was weighed into a 50 ml digestion tube, 20 ml of acid mixture H_2SO_4, HNO_3, $HClO_4$ (2:1:1) were added to the sample and set in the appropriate hole of the digestion block to digest to a clear colourless solution. The digest was cooled down and carefully washed with deionized water into a 50 ml volumetric flask and made up to mark. The element digest was used to read for the level of the trace metals on the Atomic Absorption Spectrophotometer at a wavelength and allow cathode lamp related to each trace metal.

RESULTS AND DISCUSSION

Table 1 shows heavy metal concentration (mg/l) in fish species sampled from Eleyele Lake, Ibadan, Oyo State, Nigeria. The result of this study indicates that there was significant difference ($P<0.05$) in the concentration of lead (Pb) present in the different fish species and the water body; the lead concentration in the water body was the lowest with mean value of 0.2730 ± 0.05% while that of African pike was the highest with mean value 0.663 ±0.02%. The levels of lead in these fish samples were less than those recommended by European commission (EC) 2001 guideline and FAO, as reported by Sivaperumal et al. (2007) that the allowable level of lead in fish, is 0.4 and 0.5 mg/kg respectively. Furthermore, there was significant difference ($p<0.05$) in the concentration of cadmium (Cd) present in different fish species with the cadmium concentration in tilapia body being the lowest with the mean value of 0.073 ±0.02%

Figure 1. Map of the study area. Source: Tijani et al. (2001).

Table 1. Heavy metal concentration (mg/l) in fish species sampled from Eleyele lake, Ibadan, Oyo State, Nigeria.

Fish	Pb	Cd	Zn	Cu	Cr	Mn
Tilapia	0.393 ± 0. 04[c]	0.073 ± 0.02[b]	0.442 ± 0.83[b]	0.236 ± 0.11[a]	0.273 ± 0.05[c]	0.008 ± 0.13[d]
Catfish	0.463 ± 0.12[b]	0.123 ± 0.04[a]	0.464 ± 0.03[a]	0.108 ± 0.32[b]	0.173 ± 0.02[d]	0.012 ± 0.02[c]
African pike	0.663 ± 0.02[a]	0.093 ± 0.12[b]	0.235 ± 0.13[c]	0.042 ± 0.22[d]	0.325 ± 0.22[b]	0.162 ± 0.24[a]
Water	0.273 ± 0.05[d]	0.833 ± 0.02[b]	0.093 ± 0.12[d]	0.097 ± 0.02[c]	0.113 ± 0.03[a]	0.074 ± 0.33[b]

Column means with different superscripts are significantly different (P<0.05) from one another.

while that of water is the highest with the mean value of 0.833 ± 0.02%. The values obtained for cadmium present in fish samples in this study is far less than those reported in Egypt and Saudi Arabia as reported by Voegborlo et al. (1999) when they determined the amount of cadmium in the tuna fish; the amount of cadmium in tuna was 0.32 and 0.35 μg g^{-1} in each sample respectively.

However, prevention of cadmium in Eleyele water body should be encouraged so as to prevent its bioaccumulation because when cadmium accumulates in the human body, it may induce kidney dysfunction, skeletal damage and reproductive deficiencies (Mohammad et al., 2011). There was also significant difference (P<0.05) in the concentration of zinc (Zn) present in different fish species with the zinc concentration in water being the lowest with the main value of 0.09317±0.12%. There was significant difference (P<0.5) in the copper (Cu) concentration with that of *H. odoe* been the lowest with the mean value of 0.042±0.22% while the copper concentration in tilapia fish is the highest with the mean value of 0.236±0.11. This agrees with the opinion of Bordajandi et al. (2003) that diet has a remarkable role in the bioconcentration process for some metals, mainly for the Cu and Zn. Protasowicki et al. (1983) also reported that feeding strategy influenced the content of Cu and Zn in fish.

The result also indicates that there was significant different (P<0.5) in the chromium (Cr) concentration present in different fish species with the chromium concentration in water been the lowest (0.11273±0.03) while that of African pike was the highest (0.3253±0.22). Also, there exists significant difference (P<0.05) in the

Catfish (*Clarias gariepinus*)

African pike (*Hepsetus odoe*)

Tilapia fish (*Oreochromis niloticus*)

Figure 2. Fish samples used for the study.

manganese (Mn) concentration present in different fish species with the manganese concentration in tilapia fish been the lowest (0.008±0.13) while that of African pike was the highest (0.162±0.24). Similar manganese range of 0.14 - 3.36 mg/kg for muscle of fish was reported by Turkmen and Ciminli (2007). This study indicate that heavy metals concentration in different fish species differs; this in line with the opinion of Atuanya et al. (2011) that concentration of heavy metals varies with variation in fish species. This study also indicate that mineral content of herbivorous fish (Tillapia fish) is highest followed by ominiovorous fish (catfish) followed by piscivorous African pike (*H. odoe*), while that of the water body was lowest. This agrees with the report of Farkas et al. (2000) that the concentrations of element in fish body could be related primarily to their feeding habits.

Burger et al. (2002) also reported that fishes are good indicators for heavy metal contamination in aquatic systems because they occupy different trophic levels with different sizes and ages. Figure 3 shows heavy metal concentration in fish species sampled from Eleyele lake, Ibadan Oyo State Nigeria.

Transfer factor (TF)

The transfer factor in fish tissues from the aquatic ecosystem was calculated according to Kalfakakour and Akrida-Demertzi (2000), Rasheed (2001) and Anim-Gyampo et al. (2013):

$$\mathrm{TF} = \frac{\text{Metal concentration in tissue}}{\text{Metal concentration in water}}$$

Table 2 shows heavy metal concentration (mg/l) in the water of Eleyele reservoir. The result of this study indicates that the mean heavy metal concentrations in raw water from Eleyele reservoir follow an increasing order of Mn< Zn<Cu<Cr < Pb < Cd. This result trend was similar to what was reported in the work of Anim-Gyampo et al. (2013).

The heavy metal concentrations obtained from the raw water with the exception of Zn and Cu exceeded the various raw water quality guidelines (WHO, 2003; USEPA, 1986). The concentrations of Pb, Cd and Cr (0.273, 0.833 and 0.113 mg/l) exceeded all the raw water guideline values, while Mn (0.074 mg/l) exceeded the guideline value of USEPA (1986).

The transfer factor is as presented in Table 3 which indicates that the concentration of heavy metals in the tissue was more than the concentration of the heavy metals in the water body with exceptions of Cd and in all the fish samples; Cu in African pike and Mn in tilapia and catfish. This result is in consonance with the report of Anim-Gyampo et al. (2013) that the mean heavy metal concentrations in tissues of the fish were higher than

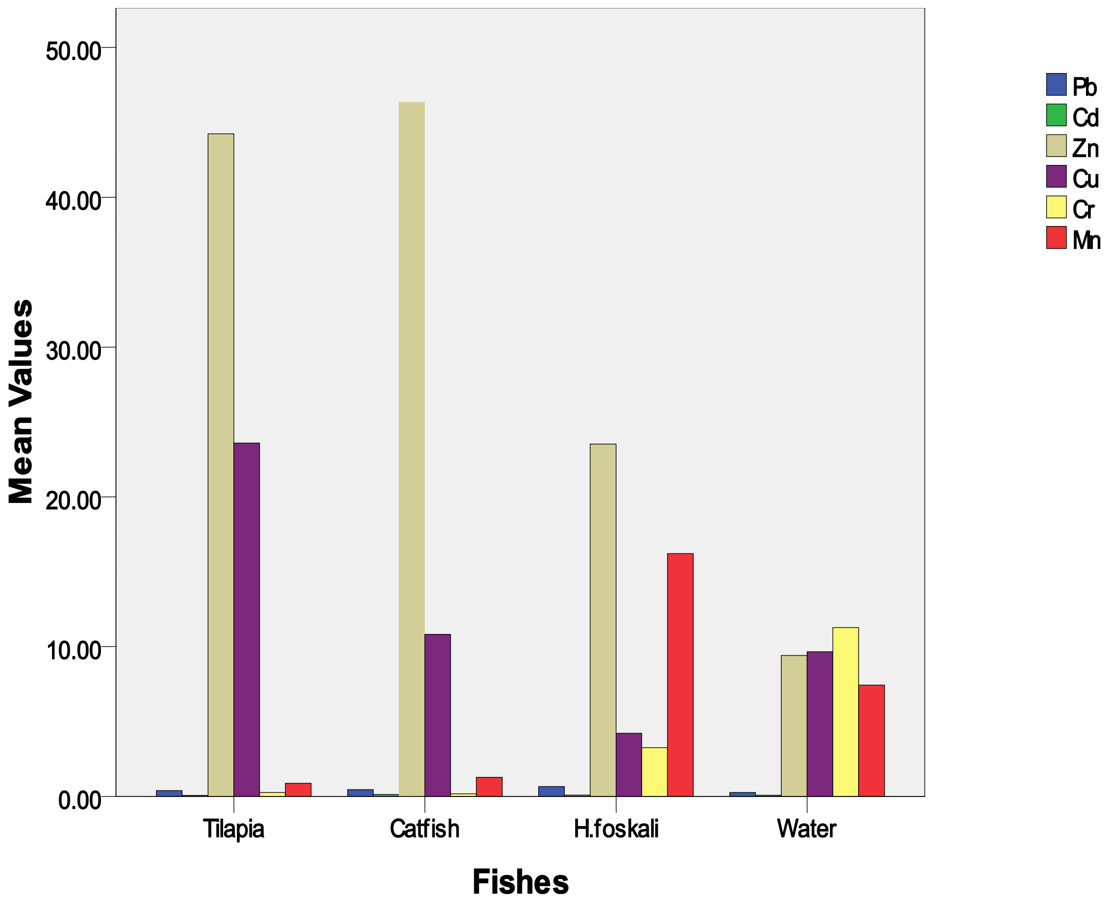

Figure 3. Chart showing heavy metal concentration in fish species sampled from Eleyele Lake, Ibadan Oyo State Nigeria.

Table 2. Mean heavy metal concentration (mg/l) in the Water of Eleyele reservoir.

Guideline	Pb	Cd	Zn	Cu	Cr	Mn	Reference
WHO	0.01	0.010	0.50	2.25	0.05	0.50	WHO,2003
USEPA	0.11	0.010	0.50	2.25	0.10	0.02	USEPA,1986
Water	0.273	0.833	0.093	0.097	0.113	0.074	This study

Table 3. Transfer factor (water/muscle) in different fish species.

Fish species	Pb	Cd	Zn	Cu	Cr	Mn
Tilapia	1.44	0.09	4.75	2.43	2.42	0.11
Catfish	1.70	0.15	4.99	1.11	1.53	0.16
African pike	2.43	0.12	2.53	0.43	2.96	2.19
WHO	0.005	0.003	5.0	2.00	0.15	0.50

metal concentration in raw water. Similarly, Chale (2002) also reported that heavy metal concentration in fish tissue is higher than that of water.

Conclusion

The result of this study supplied valuable information on the heavy metal level of some fish species in Eleyele lake Ibadan Oyo State Nigeria. The values obtain for heavy and trace metals in this study were below the limits in muscle tissue for fish proposed by EU commission Regulation (2001). The study indicates that fish could be considered bio-indicator of environmental contamination within the aquatic ecosystem. It also indicates that fish could be useful in estimating bioavailability of metal to freshwater biota. It is therefore recommended that heavy metal pollution of the rivers and lakes by Industries in Ibadan should be checked by relevant authorities so as to guarantee food safety and minimize environmental pollution.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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