

Full Length Research Paper

Heavy metal pollution in benthic fishes from Kiri Dam in Guyuk local government area of Adamawa State, Nigeria

Milam, C.^{1*}, Maina, H. M.¹, Onyia, L. U.² and Ozoemena, P. E.¹

¹Department of Chemistry, Federal University of Technology P.M.B. 2076, Yola, Adamawa State, Nigeria.

²Department of Fisheries, Federal University of Technology P.M.B. 2076, Yola, Adamawa State, Nigeria.

Accepted 14 May, 2012

Heavy metal concentrations in lungfish (*Polypterus annectens*), African carp (*Heterotis niloticus*) and catfish (*Clarotes laticeps*) in Kiri Dam in the Guyuk local government area, Adamawa State, Nigeria were studied. The concentrations of lead (Pb), cadmium (Cd), copper (Cu), zinc (Zn), nickel (Ni) and iron (Fe) were determined. These metals concentrations were measured by inductively coupled plasma-optical emission spectrometry (ICP-OES) in order to assess the fish contamination with these metals. The gills, muscles, bones and intestines were analysed for each heavy metal. This research shows that catfish had the highest heavy metals concentrations. Catfish Pb concentrations were 0.832, 0.480, 0.661 and 0.810 mg/L in the gills, muscles, bones and intestine, respectively. The gills accumulated the highest level of these metals in *C. laticeps* compared to the other species. Lungfish and African carp had higher concentrations of Cd in the examined parts of their bodies. Based on the results, it is apparent that the metal levels in all the fish species were below the recommended concentrations for human consumption, indicating that the study area is relatively less polluted with heavy metals.

Key words: Heavy metals, pollution, fishes, Kiri Dam, Nigeria.

INTRODUCTION

Fish constitute an important source of protein for many people throughout the world and fish consumption has increased in importance among health-conscious people because it provides a healthy and low cholesterol sources of protein and other nutrients (Burger and Gechfeld, 2005; Agusa et al., 2005). Heavy metals such as copper (Cu) and zinc (Zn) are essential for fish metabolism while some others such as lead (Pb) have no known role in biological systems. For the normal metabolism of fish, the essential metals must be taken up from water, food or sediment. However, similar to the route of essential metals, non-essential ones are also taken up by fish and accumulate in their tissues (Canli and Atli, 2003; Turkmen et al., 2005; Dural et al., 2007).

It has been recognised for many years that the concentrations of metals found in coastal areas, whether they are

in the dissolved or particulate phase may be derived from a variety of anthropogenic and natural sources (Dalman et al., 2006).

Human beings have been exposed to heavy metal toxins for an immeasurable amount of time. The industrialization of the world has dramatically increased the overall environmental "load" of heavy metal toxins to the point that our societies are dependent on industrialization for proper functioning.

In Nigeria, the levels of toxic and non-biodegradable heavy metals in fish samples have been reported for some dams and lakes including Kainji Lake (Jimoh et al., 2004), Oguta Lake, Asa Dam, Ilorin; Ureje Dam, Ekiti State; Alau Dam, Maiduguri; Kusalla Dam, Kano State (Adeyeye and Ayoola, 2010) among others. Thus, despite the valuable nutritional constituents of fish, their notoriety in the ability to concentrate toxic and non-biodegradable heavy metals in their body tissues (Adeyeye and Ayoola, 2010) calls for an adequate assessment of the metal levels in them at regular intervals, so as to safeguard the safety of the consumers.

*Correspondence author. E-mail: charlesmilam@yahoo.com.
Tel: 08136034222.

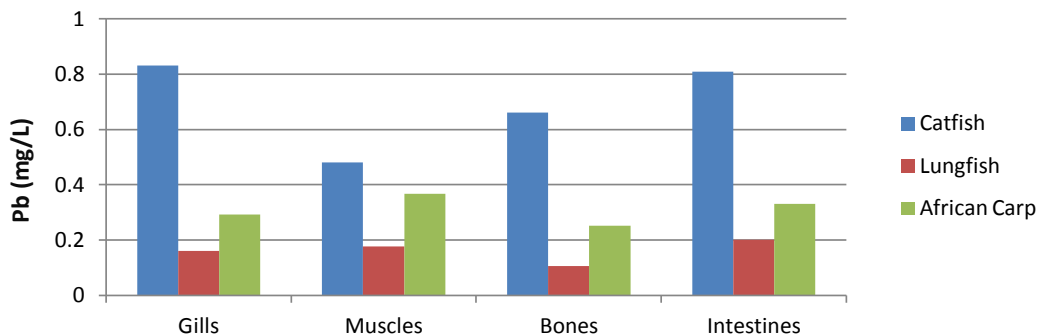


Figure 1. Concentrations of lead (Pb) in tissues of benthic fish.

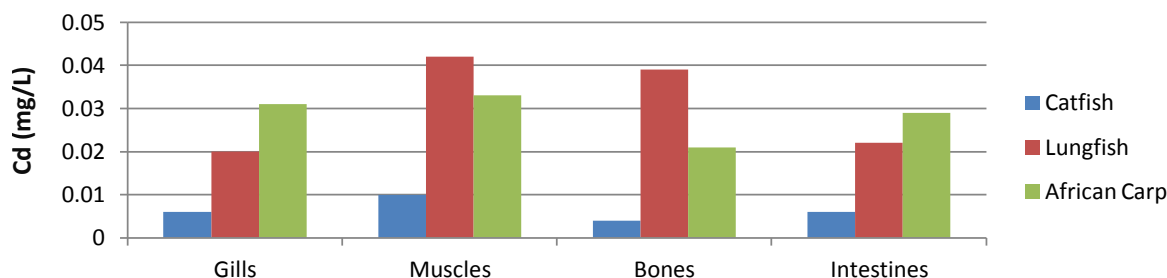


Figure 2. Concentrations of cadmium (Cd) in tissues of benthic fish.

The objectives of this study was to assess levels of heavy metal contaminations of fish from the dam and determine the benefits or otherwise to the consumers around the dam.

MATERIALS AND METHODS

Sampling area

The Kiri Dam is in Guyuk local government area of Adamawa State in the northeast of Nigeria, damming the Gongola River. It is a 1.2 km long and 20 m high zoned embankment with an internal clay blanket. It is located at latitude 9.6797°N and longitude 12.014°E near the town of Kiri in the southern senatorial zone of the state. The dam was largely completed in 1982. The reservoir has a capacity of 615 million m³.

The dam was built to supply electricity and irrigation needs of the Savannah Sugar Company (SSC) at Numan, a large-scale sugarcane plantation and processing company.

The conceived objectives of this dam are hydroelectric power generation of about 35 MW and irrigation agriculture of about 32,000 ha.

A daily water supply for domestic and industrial use to SSC and environs from the reservoir, which include the sugar plantation, fisheries production, flood control and flow regulation along the Gongola and Benue Rivers (Tukur and Mubi, 2002).

Sample preparation and analysis

A total of nine samples (three samples each of lungfish-*Polypterus annectens*, African carp-*Heterotis niloticus* and catfish-*Clariotes*

laticeps), respectively were bought from fishermen at the various dam sites. The fish samples were thoroughly washed and rinsed with deionized water to remove adhering contaminants. The fish samples were transported to the laboratory in ice flakes in coolers. The lengths and weights of the fish samples were recorded.

The gills and muscles were dissected out and placed in separate Petri dishes. The gills and muscle samples were dried in an oven and then digested according to methods described by Van Loon (1980) and Du preez and Steyn (1992). Liver, intestine and gill in fish are more often recommended as environmental indicator organs of water pollution than any other fish organs. Muscle parts were tested as it is the part that is consumed by public (Zauke et al., 1999; Agusa et al., 2005).

Samples of gills, bone, intestine and dorsal muscles weighing 0.5 g was transferred into a digestion tube containing 35 ml of a mixture of nitric and perchloric acid (6+1) and were left overnight at room temperature. In the next day, the samples were placed on a hot plate at 135°C for 2 h. Care was exercised with fatty material to maintain excess nitric acid until most of the organic matter is destroyed. The colourless liquor formed was evaporated to dryness slowly (avoiding prolonged baking), cooled and dissolved in 5 ml of 20% nitric acid and diluted to 25 ml mark in a graduated cylinder with ultrapure water (MilliQ, Millipore, USA). All digested samples were analyzed in duplicate using inductively coupled plasma-optical emission spectrometry (ICP-OES) (Perkin Elmer Model, 2003).

In all metal determinations, analytical blanks were prepared in a similar manner like the samples. All glassware was carefully cleaned with a solution of 10% nitric acid for 4 h followed by thorough rinsing with deionized water.

RESULTS AND DISCUSSION

Figures 1 to 6 show the concentration of Pb, cadmium (Cd),

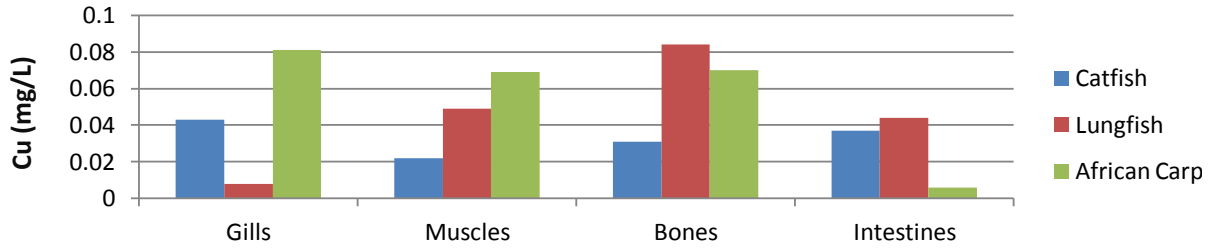


Figure 3. Concentrations of copper (Cu) in tissues of benthic fish.

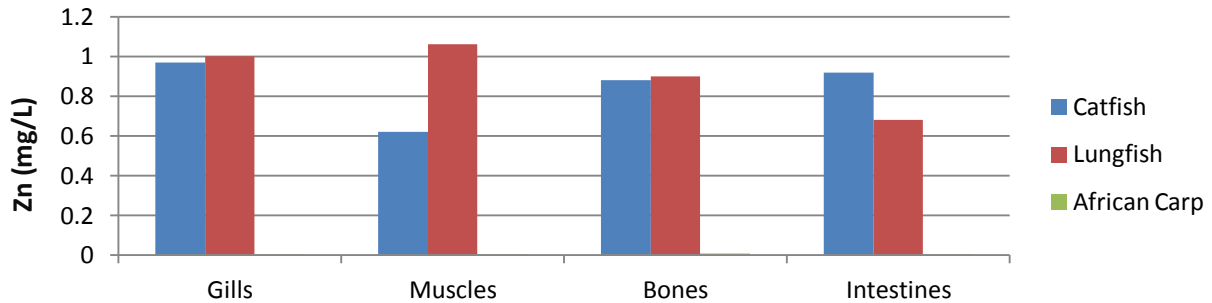


Figure 4. Concentrations of zinc (Zn) in tissues of benthic fish.

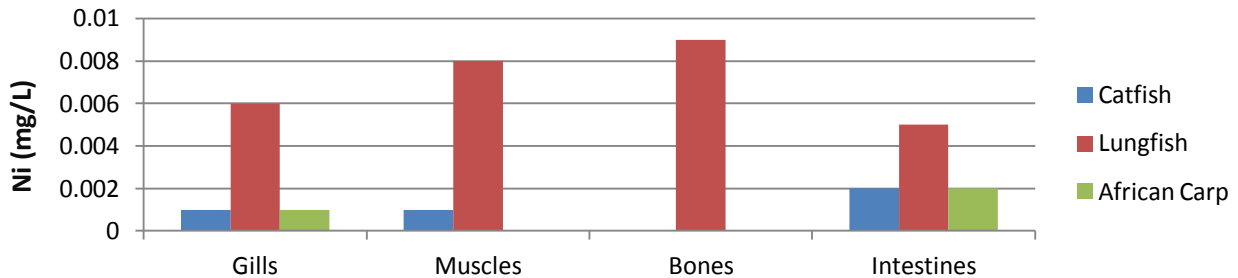


Figure 5. Concentrations of nickel (Ni) in tissues of benthic fish.

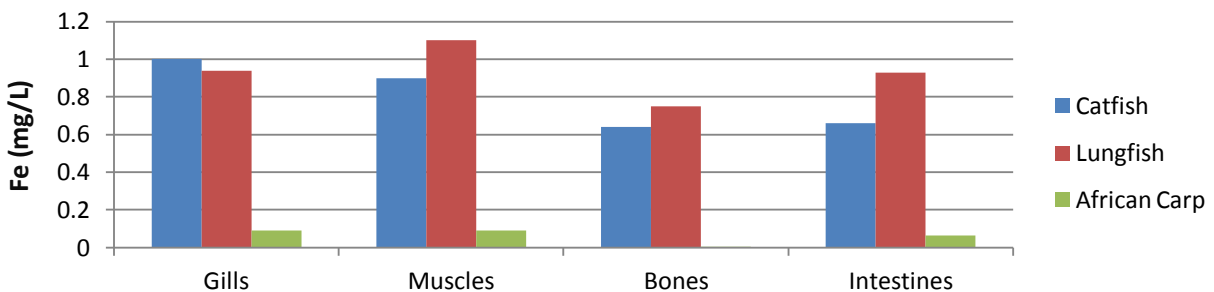


Figure 6. Concentrations of iron (Fe) in tissues of benthic fish.

Cu, Zn, nickel (Ni) and iron (Fe) detected in the gills, muscles, bones and intestines of different tissues of three fish species collected from Kiri Dam in Guyuk local government area of Adamawa state. The concentrations

of Cu and Ni were below the limits of detection in all samples. The levels of Cu and Ni found in the fish species were below the permissible limits (Cu 3.0 mg/kg, Ni 0.9 mg/kg, Pb. 2 mg/kg, Cd 0.2 mg/kg, Fe 4.5 mg/kg

and Zn 10 mg/kg) proposed by World Health organisation (WHO, 1996). The result of this study reveals that Cu and Ni do not present any health risk to the consumers of these fish species in the catchment.

Pb was detected in the gills (0.85 mg/L), intestine (0.81 mg/L) and bones (0.661 mg/L) of catfish at higher concentration and was found in the gills, muscles, bones and intestines of African carp and lungfish at lower concentration. The distribution of Pb in the organs of the fish species follows the order: gills > intestines > bones > muscles for catfish (*C. laticeps*).

Pb is a natural element in the marine eco-system. It is present at low concentrations in clean seawater, sediments and tissue of marine plants and animals. Although, fish bio-accumulates Pb from seawater in proportion to its concentration in solution, Pb is not very bioavailable or toxic to marine animals (Dalman et al., 2006).

The studies of some authors indicated different concentrations of heavy metals in different fish species. The heavy metal concentrations in the fish were attributed to chemical characteristics of water from which fish were sampled, ecological differences, metabolism and feeding patterns of fish (Al-Saleh and Shinwari, 2002; Ozturk et al., 2009; Yilmaz, 2003). In rivers, fish are often at the top of the food chain and have the tendency to concentrate heavy metals from water (Mansour and Sidky, 2002). Therefore, bioaccumulation of metals in fish can be considered as an index of metal pollution in aquatic ecosystems (Forstner and Wittmann, 1981; Jimoh et al., 2004; Karadede and Unlu, 2007). That could be a useful tool to study the biological role of metals present at higher concentration in fish (Dural et al., 2007).

Cu and Cd were recorded in all the fish species in the samples at lower concentration though it is more pronounced in the gills and bones of lungfish. This is because of the essential nature of Cu in the growth and development of bones. Cu and Cd are essential elements and are carefully regulated by physiological mechanisms in most organisms. Many studies have demonstrated that diet is the most important route of Cu accumulation in aquatic animals (Sindayigaya et al., 1994).

Zn was also found present in all the fish samples collected from the dam. The highest concentration of Zn was detected in the gills, muscles, intestines and bones of catfish and lungfish. Just like Fe, it was more pronounced in the muscles of lungfish which could be due to its ability to survive in muddy water or mud sediment with heavy metal pollutant for a given long period and thus, polluting the body of this fish.

This result also confirmed the alarming effect of this fish on human health when compared to the world standard (0.1 mg/L). The lowest concentration of Zn was recorded in the gills, muscles, bones and intestines of African carp. The distribution of Zn in the organs of the fish species follows the order: muscles > gills > intestines > bones for lungfish and catfish. This result agrees with the work of Milam and Onyia (2007), that *Clarias* (gills) had the highest level of Zn in Lake Geriyo in Adamawa

State, Nigeria. In the same work, it was discovered that tilapia (gills) had the highest Zn level among pelagic fishes in Lake Geriyo in Nigeria.

Ni was detected at quite low concentration in the samples collected from the Kiri Dam. The analyses for this metal in some samples were below instrument detection (0.006, 0.008 and 0.0085 mg/L). The lowest concentration of Ni was recorded in catfish and African carp while the highest concentration was recorded in lungfish. No concentration was recorded in the bone of catfish, muscles and bone of African carp which is due to low deposition of Ni in the environment. These results were lower than what Adeyeye and Ayoola (2010) obtained from Ikosi Dam Ogbomoso, Nigeria.

Ni normally occurs at very low levels in the environment. The average concentration of Ni is usually less than 10 ppb in rivers and lakes; while soil concentrations are usually 80 ppm (FAO, 1983). Massey (1972) proposed that exposing rock strata to weathering and erosion results in higher concentration of Ni in receiving streams. Ni may be present generally in the soil around the river and as much is leached into the water time after. This could be the reason for the presence of Ni in Kiri Dam and as found in its fish.

In summary, the concentration of heavy metals increases in the following order: Fe>Zn>Pb>Cu>Cd>Ni.

Conclusion

This study shows that Pb, Cd, Cu, Zn, Ni and Fe are present in all fish species collected from Kiri Dam in Guyuk local government area of Adamawa State. It was discovered that the gills of fish contained higher concentration of heavy metals compared to their muscles (flesh). Thus, it is therefore advisable not to consume the gills of fish so as to reduce the risk of heavy metals consumption from contaminated fish.

Lungfish which is the least available fish was observed to have the highest concentrations of heavy metals especially in their muscles. This may likely be due to their ability to survive in muddy water or dwell in sediment for a particular period of time (that is, during the dry season). For the time being, if there is an option to buy fresh fish, for consumption, in all the species analyzed in this study area, lungfish should be the last option.

ACKNOWLEDGEMENT

We want to acknowledge the Technologists of the Department of Chemistry, Federal University of Technology Yola, for their contributions towards the success of this research.

REFERENCES

- Adeyeye EI, Ayoola PB (2010). Proximate composition, mineral and heavy metal contents of some freshwater fishes from Ikosi Dam, Ogbomoso, Nigeria. *Electron. J. Environ. Agric. Food Chem.* 10(9):

- 2883-2890
- Agusa T, Kunto G, Yasunaga H, Iwata A, Subramanian A, Tanabe S (2005). Concentrations of trace elements in marine fish and its risk assessment in Malaysia. *Mar. Pollut. Bull.* 51:896-911.
- Al-Saleh I, Shinwari N (2002). Preliminary report on the levels of elements in four fish species from the Arabian Gulf of Saudi Arabia. *Chemosphere* 48(7):749-755.
- Burger J, Gschfeld M (2005). Heavy metals in commercial fish in New Jersey. *Environ. Res.* 99:403-412.
- Canli M, Atli G (2003). The relationship between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six Mediterranean fish species. *Environ. Pollut.* 121:129-136.
- Dalman O, Ahmet D, Ahmet B (2006). Determination of heavy metal (Cd, Pb) and trace elements (Cu, Zn) in South Eastern Aegean sea (Turkey) by atomic absorption spectrometry. *Food Chem.* 95:157-162.
- Du Preez HH, Steyn GJ (1992). A preliminary Investigation of the concentration of selected metals in the tissues and organs of the tigerfish (*Hydrocynus vittatus*) from the Olifants River, Kruger National Park, South Africa. *Water SA*. 18(2):131-136.
- Dural M, Göksu MZL, Özak AA (2007). Investigation of heavy metal levels in economically important fish species captured from the tuzla lagoon. *Food Chem.*, 102: 415-421. Annual Conference of Fisheries Society of Nigeria, Ilorin, Nigeria. 29th Nov.-3rd Dec. 2004.
- FAO (1983). Compilation of legal limits for hazardous substance in fish and fishery products FAO Fishery circular, p. 464
- Forstner LA, Wittmann GTW (1981). *Metal pollution in aquatic environment*. Springer-Verlag, Berlin, Heidelberg, New York, p. 486.
- Jimoh LA, Amoo IA, Adebayo MA (2004). Evaluation of the burdens of heavy metals in five commercially important fishes from different locations in Kainji Lake. 19th.
- Karadede H, Unlu E (2007). Concentrations of some heavy metals in water, sediment, fish and some benthic organisms from Tigris River, Turkey. *Environ. Monit. Assess.* 131:323-337.
- Massey HJ (1972). Copper, Nickel and Zinc released from acid and coal-mine. Spoil materials in eastern Kentucky. *Soil Sci.* 113(3):206-212.
- Mansour SA, Sidky MM (2002). Ecotoxicological studies, 3. Heavy metals contaminating water and fish from Fayoum Governorate Egypt. *Food Chem.* 78:15-22.
- Milam C, Onyia LU (2007). Comparative Investigation of heavy metals in pelagic and benthic fishes from Upper River Benue, Yola Adamawa State, Nigeria. *J. Res. Phys. Sci.* 3(4):7-11.
- Ozturk M, Ozozen G, Minareci, O, Minareci E (2009). Determination of heavy metals in fish, water and sediments of Avsar Dam Lake in Turkey. *Iran. J. Environ. Health Sci. Eng.* 6(2):73-80.
- Sindayigaya E, Cauwenbergh RV, Robberecht H, Deelstra H (1994). Copper, zinc, manganese, iron, lead, cadmium, mercury and arsenic in fish from Lake Tanganyika, Burundi. *Sci. Total Environ.* 144:103-115.
- Turkmen A, Turkmen M, Tepe Y, Akyurt I (2005). Heavy metals in three commercially valuable fish species from Iskenderun bay, northern east Mediterranean sea, Turkey *Food Chem.* 91:167-172.
- Tukur AL, Mubi AM (2002). Impact of Kiri Dam on the lower reaches of River Gongola, Nigeria. *Geo J. Kluwer Academic Publishers Netherlands*, 56:93-96.
- Van Loon GW (1980). *Analytical Atomic absorption spectroscopy. Selected metals* Academic Press, New York.
- World Health Organization (1996). Revision of the WHO Guidelines for drinking water quality. Vol. 2 Health criteria and other supporting information. World Health Organization, Geneva.
- Yilmaz AB (2003). Levels of heavy metals (Fe, Cu, Ni, Cr, Pb and Zn) in tissue of *Mugil cephalus* and *Trachurus mediterraneus* from Iskenderun Bay. *Turk. Environ. Res.* 92:277-281.
- Zauke GP, Savinov VM, Ritterhoff J, Savinova T (1999). Heavy metals in fish from the Barents Sea (summer 1994). *Sci. Total Environ.* 227: 161-173.