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Bioaccumulation Factors for Heavy Metals in the Muscles and Organ Tissues of Three Fish species from Baga, Lake Chad, Nigerian Sector.

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Abstract: This study deals with bioaccumulation factors for heavy metals: Cadmium, (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Manganese (Mn), and Zinc (Zn) in the Muscles and Organ tissues of three fish species, *Clarias gariepinus,* (*C. gariepinus*) and *Oreochromis nilotians* (*O.niloticus*), and Water from Baga, Lake Chad, Nigerian Sector. The aim of this study was to determine the bioaccumulation factors (BAFs) for heavy metals in the Muscles and Organ tissues of three fish species. The concentrations of heavy metals in the Muscles and Organ tissues were determined using energy dispersive X-rays florescence (EDXRF) and Atomic Absorption Spectrophotometer (AAS) was used to determine the heavy metals in water. The BAFs for heavy metals for heavy metals in the Muscles of three fish species are depicted in this pattern Cr> Pb> Cd> Mn> Zn> Cu. The presence of heavy metals in fish species are of great importance when their concentrations are not above the maximum permissible limits sets by World Health Organization (WHO). The essential heavy metals are accumulated with greater amount. The BAFs in the Muscles of Fish species are Cu (1446.00) and Zn (3240.00), and in the Organ tissues, Zn (1330.00) and Cu (1574.00). The values for the non-essential heavy metals are Cd (10.00) and Pb (11.60) in the Muscles and Cd (200.00) and Pb (4.20) in the Organ tissues of fish species.

[I, Jonathan B. Y, Madu A. A. and Ibrahim, S. **Bioaccumulation Factors for Heavy Metals in the Muscles and Organ Tissues of Three Fish species from Baga, Lake Chad, Nigerian Sector.** *Researcher* 2020;12(6):34-37]. ISSN 1553-9865 (print); ISSN 2163-8950 (online). http://www.sciencepub.net/researcher. 6. doi:10.7537/marsrsj120620.06.

Keyword: Bioaccumulation Heavy Metal Fish; Muscles and Organ tissues; Lake

1. Introduction

The aquatic pollution by heavy metals is a serious hazard of great concern. Heavy metals enter the environment through the natural and anthropogenic sources. The natural sources consist of the following, weathering of rocks and sold, and volcanic eruptions, while the anthropogenic sources include municipal and industrial wastes, the applications of the phosphate fertilizers, pesticides and surface storm runoff (Yilmag, 2009). Heavy metals, as a result of their persistence and their non-biodegradable nature in the aquatic ecosystem, they are being accumulated in water, sediment and in fish species, through bio concentration via the food chain process. The bioaccumulation of high concentrations of heavy metals by fish species can have a negative health effect on aquatic biota (fish) and man. Fish species can accumulate heavy metals in their Muscles, Organ (soft tissues) and hard tissues (Abdel-Baki *et al.,* 2011).

Heavy metals are grouped as essential and non-essential heavy metals, examples of essential heavy metals are Mn, Fe, Cu and Zn. The essential heavy metals are important in living organisms. The examples of non-essential heavy metals are Cd, Hg and Pb, they have no known biological importance in living organisms. The essential heavy metals can also be toxic when consumed in high doses (concentrations) (Ramirez, 2013). The bioaccumulation factors (BAFs) is the continuous increase in the concentration of a pollutant in an organism or parts of the same organism which appears as the rate of intake exceeds the organisms capacity to remove the pollutant from the body, or BAFs is the ratio of a particular heavy metal concentration in the biota (fish) to the concentration of that heavy metal in the water column (IUPAC, 1993). BAFs is assessed in alliance with the concentration of the soluble heavy metal in the water in which the different fish species occupy. BAFs takes into consideration uptake from food also. Bioaccumulation in fish species include two routes of uptake, aqueous uptake of water-borne chemicals (heavy metals), and the dietary uptake by ingestion of polluted food particles. BAFs is a combination of bio concentration and bio magnification. The aim of this study was to determine the bioaccumulation factors for heavy metals in the Muscles and Organ tissues of three fish species obtained from Baga, Lake Chad, Nigerian sector.

2. Material and Methods

This study was conducted at Baga, Nigerian Sector of Laka Chad. Baga is in Kukawa Local Government Area of Borno State. Baga lies on latitude *12^{0}55'* N and longitude *13^{0}35'* E. the major economic activities of the population in Baga are stock breeding, fishing and agriculture.

The sampling site is Dumba.

Fish Sampling and Heavy Metal Analysis.

Three species of fish, *C. gariepinus, H. niloticus* and *O.niloticus* were though from the local fisherman at the bank of Dumba, Lake Chad and they were transported to the laboratory for further analysis in a plastic bag. The fish samples were washed with water in the laboratory and the scales of *H.niloticus* and *O.niloticus* were removed with stainless steel knife. After which the three fish samples were dissected each differently to remove the Muscles, Gills, Liver and Kidney using stainless steel dissector. After the dissection, the muscles, gills, liver and kidney were separately transferred to separate petri dishes and they were air-dried each until a constant weight was obtained for each sample (Ozturik *et al.,* 2009).

The dried muscles, gills, liver and kidney for each of the three fish species were ground separately to powder with mortar and pestle to grain size of less than 125mm and they were each homogenized. A quantity of 0.50g of powdered for each of the muscles, gills, liver and kidney were separately mixed with three drops of organic binder for each fish samples, and they were pressed with 10 tons hydraulic press for each muscles, gills, liver and kidney of the three fish species to produce pellets of 19mm diameter. The resulting pellets for each of the muscles, gills, liver and kidney were used to analyzed heavy metals in the fish samples (Bernard *et al.,* 2020).

Water Sampling and Heavy Metal Analysis.

Water sample was collected from the sampling site (Dumba) of the Lake. A 5.00 litre of sampling plastics bottle was used to collect water from four different points of the sampling site. Pre-cleaned sampling bottle was immersed about 20cm below the water surface, about 5.00 litre of water was collected at four different points within the same sampling site. All the water samples collected from the four different points were mixed in a plastic bucket to form a representative water sample. One litre of water sample was taken from the representative water and was transferred into a polyethylene bottle, the water sample was acidified with 5cm^3 of 10% HNO^3, it was then placed in an ice bag and was transported to the laboratory for further analysis.

Water sample was digested according to (APHA, 2005). 100cm^3 of water sample was transferred into a 125cm^3 comical flask. 5cm^3 of concentrated HNO^3 and a few boiling chips was added. The solution was boiled slowly, and it was evaporated on a hot plate to about 2cm^3, before precipitation occurs heating and addition of conc. HNO_3 was continued until a light coloured clear solution was obtained (digestion completed). The sample was not allowed to dry during the digestion. The wall of the flask was washed with distilled water and the solution was filtered. The filtrate was transferred into a 50cm^3 volumetric flask with two 5cm^3 portions of water, cooled and diluted to the mark and mixed thoroughly. Portions of this solution was used for heavy metal determination, using AAS.

3. Results

Table 1: Bioaccumulation Factors for Heavy Metals in the Muscles of three fishes from Baga, Lake Chad, Nigerian Sector.

Fish Species	Heavy Metals					
	Cd	Cr	Cu	Mn	Pb	Zn
C.gariepinus	1.00	7.12	$<10^{-8}$	39.74	4.37	781.67
H. niloticus	2.00	3.57	1446.0	26.54	11.60	3240.00
O. nilotcus	10.00	2.76	435.00	39.33	2.50	1983.66

>10^{-}8: less than detection limit

The BAFs in the Muscles of the three fish species ranged between, Cd (1.00 to 10.00); Cr (2.76 to 7.12); Cu (435.00 to 1446.00); Mn (26.54 to 39.74); Pb (2.50 to 11.60) and Zn (781.00 to 3240.00). The highest BAF was, Zn (3240.00) and it was detected in *H. niloticus,* while, the lowest BAFs of the Muscles of the three fish species was, Cd (1.00) and it was observed in *C. gariepinus.* Bioaccumulation factors for heavy metals in the Muscles of three fishes from Baga, Lake Chad, Nigerian Sector is presented in Table 1.

In the Organ tissues, (gills, liver and kidney) of the three fish species, the BAFs ranged between, Cd (1.00 to 200.00); Cr (0.60 to 3.50); Cu (560.00 to 1574.00). Mn (28.00 to 1116.00); Pb (1.05 to 4.20) and Zn (312.00 to 1330.00). The highest BAFs in the Organ tissues of the three fish species was, Cu (1574.00), and it was detected in the liver of *C.*

gariepinus, while, the lowest BAFs in the Organ tissues of the three fish species was, Cr (0.66), it was obtained in the gills of *O.niloticus*. The BAFs for heavy metals in the Organ tissues of three fishes from Baga, Lake Chad, Nigerian Sector is presented in Table 2.

Table 2: Bioaccumulation Factors for Heavy Metals in the Organ Tissues of three fishes from Baga, Lake Chad, Nigerian Sector.

Fish Species/Organ Tissues	**Heavy Metals**						
		Cd	Cr	Cu	Mn	Pb	Zn
	Liver	200.00	3.50	1574.00	32.16	4.20	390.00
C.gariepinus	Gills	2.00	1.60	871.00	44.91	2.86	312.75
	Kidney	120.00	1.50	680.00	71.20	3.80	398.75
	Liver	1.00	2.00	115.00	42.22	1.72	1220.00
H. nilotcus	Gills	2.00	3.45	884.80	28.00	2.01	1330.00
	Kidney	10.00	2.23	1022.00	40.00	3.03	475.00
	Liver	45.00	2.57	1450.00	116.00	1.05	151.00
O. niloticus	Gills	10.00	0.60	881.00	66.00	1.64	151.00
	Kidney	10.00	2.43	560.00	46.37	1.30	1130.00

4. Discussion

Bioaccumulation factor shows how much a fish species can concentrate heavy metals over that of a particular aquatic environment concentration. In this study, consideration was made between fish and water. Fish species can accumulate bulky heavy metals due to a number of factors such as fetching habits, age, size and physiological needs, and the important role played by each heavy metals (Kamaruzzaman *et al;* 2010). The result of this study indicated that the three fish species examined bio-concentrated heavy metals from the water of the lake, since the BAFs are all greater than one. In the Muscles of the studied fish species, the BAFs for heavy metals varied between, (1.00 to 3240.00), the highest BAF was, Zn (3240.00), followed by Cu (1446.00), and were detected in *H. niloticus,* while the lowest BAF was, Cd (1.00), which was observed in *C. gariepinus*. This could be attributed with the feeding habits of the fish species as well as size, age and sex. The BAFs for heavy metals in the Muscles of the three fish species occurs in this order Cd>Cr>Pb>Mn>Cu>Zn.

In the Organ tissues of the studies three fish species, the BAFs for heavy metals varied between, (0.60 to 1574.00), the highest was, Cu (1574.00) and Zn (1330.00), and it was detected in the liver of *C.gariepinus* and the gills of *H. niloticus,* while the lowest BAF was recorded in the gills of *O. niloticus.* In this study, the BAfs for heavy metal in the studied fish species were higher in the Organ tissues of the three fish species than in the Muscles, with exception of Zn (3240.00) in the Muscles. This could be due to the reality that, liver, gills and kidney are mostly responsible for heavy metal metabolism.

The essential heavy metals, especially Cu and Zn are accumulated with higher potency in fish species. This result agrees with that of Rejomon (2005). The high elevations of BAFs in fish species may be due to the evidence that heavy metals dissolves more in lipids content rather than in aqueous environment. Organisms generally have internal system that allow them to regulate their uptake, essential heavy metals and to control the presence of other metals. Therefore, if the concentration of an essential heavy metals in an aquatic vicinity is very low and the organism requires more, it will earnestly accumulate that heavy metal, which would result in an elevated BAF. The non-essential heavy metals like Cd and Pb are Bio-accumulated least effectively, at the same time the essential heavy metals like Cu and Zn are bio-accumulated with a higher efficiency in the three fish species studied. The essential heavy metals like Fc, Cu and Zn, have important biochemical functions in living organisms which grant the enzymes system to function outside interference. The reasons for the differences in BAFs for heavy metals in the three fish species studied could be attributed to the different feeding habits, size, age, sex and the physiology needs of the fish species and the availability of the heavy metals in the sampling site (Rejoman *et al.,* 2010).

BAFs are used for wildlife and human exposure evaluation as well as remediation assessment of heavy metals contaminated. These results indicated that fish species may have concentrated and biomagnified heavy metals many times above the levels existing in the water. The other reasons for the differences of heavy metals being accumulated by fish species are season of capture of fish species, anthropogenic sources and storm runoffs. Due to the pollution of water bodies by industrial and domestic wastes, increase in heavy metals concentration levels is in escapable (Ozgur *et al.,* 2016). The observation of heavy metals concentrations in fish species is appropriate for determining the impact of heavy metals contamination in the water bodies and the health risk associated to the consumption of contaminated fish species from these water bodies. If the BAFs for heavy metals in fish species is greater than one, (1.00), it means that the fish species have accumulated the heavy metals from water. This result agrees with (Rashed, 2001).

Conclusion

The results of this study indicated a clear differences in the levels of BAFs for heavy metals between the Muscles and Organ tissues of the three fish species studied, in general, the lowest BAFs for heavy metals were detected in the Muscles of fish species, while the Organ tissues recorded the highest BAFs for heavy metals in the three fish species studied. In the muscles, Zn (3240.00) and Cu (1446.00) were the highest BAFs and were detected in *H. niloticus.* The lowest BAF was Cd (1.00), and it was observed in *C. gariepinus.* In the organ tissues, the highest BAFs, CU (1574.00) and Zn (1330.00) and were detected in the liver of *C. gariepinus* and in the gills of *H. niloticus,* while the lowest were, Cr (0.60) and Cd (1.00) in the gills of *O. niloticus* and in the liver of *H. niloticus.*

Acknowledgement

I'm very grateful to prof. H.M Maina of Chemistry department Modibbo Adama University of Technology, Yola for his support and encouragement, I would also like to thank the laboratory technologist at centre for energy research and training Zaria.

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6/20/2020